GIS-BASED DETERMINATION OF SUITABLE AGRICULTURAL AREAS AND COMPARISON WITH CURRENT LAND USE, THE CASE STUDY OF İZMİR

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İZMİR

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ABSTRACT

GIS-BASED DETERMINATION OF SUITABLE AGRICULTURAL AREAS AND COMPARISON WITH CURRENT LAND USE, THE CASE STUDY OF İZMİR

Agricultural production is the main source of life for humanity. In order to the protection and proper use of agricultural lands are of great importance. İzmir has a high potential in terms of agricultural areas. There are three basin areas within the provincial borders and fertile agricultural areas where the continuity of agricultural production can be ensured. With the effect of urbanization and population growth, the settlements expanded towards agricultural areas. For the correct use, sustainability and efficiency of agricultural lands, the most suitable areas in terms of agricultural production should be analyzed correctly.

This study was carried out to determine the most suitable areas for agriculture in İzmir. The study considers a Geographic Information System GIS-based approach. The combination of multi-criteria decision analysis (MCDA) and GIS can be used in the process of generating solutions for complex planning problems. In the first stage of the study, the criteria were weightlessly overlayed, and a result map was obtained. In the second stage, weights were obtained for each criterion using the Analytical Hierarchy Process (AHP). Suitability analyzes for the study area were obtained by weighted overlay analysis using GIS. Environmental characteristics, soil characteristics and economic factors were taken into account while performing the suitability analysis for agricultural areas. The same criteria were used for both suitability analyses. As a result of the comparison between the two maps, a resultant map obtained by the weighted overlay method was found to be more reliable, and the results were compared with the current situation. In the current situation comparison, Great Lowland Protection Areas, 1/100000 Scaled Environmental Plan, and Law No. 5403 are discussed. When the comparisons were made, the areas that differed with the current situation were determined. It is seen that the agricultural lands obtained as a result of the suitability analysis are spread over wider areas compared to the current situation.

Keywords: *Agricultural Areas, Suitability Analysis, Analytical Hierarchy Process (AHP), Multi-Criteria Decision Analysis (MCDA), Geographic Information Systems (GIS)*

ÖZET

UYGUN TARIM ALANLARININ CBS TABANLI BELİRLENMESİ VE MEVCUT ARAZİ KULLANIMI İLE KARŞILAŞTIRILMASI, İZMİR ÖRNEĞİ

Tarımal üretim insanlığın temel yaşam kaynağıdır. Tarım alanlarının korunması ve uygun biçimde kullanılması büyük önem arz etmektedir. İzmir tarımsal alan açısından yüksek potansiyele sahiptir. İl sınırları içerisinde bulunan üç adet havza alanı ve tarımsal üretimin devamlılığının sağlanabileceği verimli tarım alanları bulunmaktadır. Kentleşmenin ve nüfus artışının etkisiyle yerleşmeler tarım alanlarına doğru genişlemiştir. Tarım alanlarının doğru kullanılması, sürdürülebilirliği ve verimliliği adına tarımsal üretim açısından en uygun alanların, doğru analiz edilebilmesi gerekir.

Bu çalışma İzmir'de tarım için en uygun alanları belirlemek amacıyla gerçekleştirilmiştir. Çalışma Coğrafi Bilgi Sistemleri (CBS) tabanlı bir yaklaşımı ele almaktadır. Çok kriterli karar anaizi (ÇKKA) ve CBS'nin bir arada kullanılması karmaşık planlama problemleri için çözüm üretme sürecinde kullanılabilir. Çalışmanın ilk aşamasında kriterler ağırlıksız olarak çakıştırılmış ve bir sonuç haritası elde edilmiştir. İkinci aşamada ise Analitik Hiyerarşi Süreci (AHS) kullanılarak her bir kriter için ağırlıklar elde edilmiştir. Çalışma alanı için uygunluk analizleri CBS kullanılarak ağırlıklı çakıştırma analizi ile elde edilmiştir. Tarım alanları için uygunluk analizi yapılırken çevresel özellikler, toprak özellikleri ve ekonomik etmenler dikkate alınmıştır. Her iki uygunluk analizi için aynı kriterler kullanılmıştır. İki harita arasında yapılan karşılaştırma sonucunda ağırlık çakıştırma yöntemi ile elde edilen harita daha güvenilir bulunmuş, sonuçlar mevcut durum ile karşılaştırılmıştır. Mevcut durum karşılaştırmasında Büyük Ova Koruma Alanları, 1/100000 ölçekli Çevre Düzeni Planı, ve 5403 sayılı kanun ele alınmıştır. Karşılaştırmalar yapıldığında mevcut durum ile farklılaşan alanlar tespit edilmiştir. Uygunluk analizi sonucunda elde edilen tarım alanlarının mevcut duruma göre daha geniş alanlara yayılmış olduğu görülmektedir.

Anahtar Kelimeler: *Tarım Alanları, Uygunluk Analizi, Analitik Hiyerarşi Süreci (AHS), Çoklu Kriterli Karar Analizi (ÇKKA) Coğrafi Bilgi Sistemleri (CBS).*

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LIST OF ABBREVIATIONS

AHP: Analytical Hierarchy Process

AHS: Analitik Hiyerarşi Süreci

CBS: Coğrafi Bilgi Sistemleri

CI: Consistency Index

CR: Consistency Ratio

CORINE: Coordination of Information on the Environment

ÇKKA: Çok Kriterli Karar Analizi

DEM: Digital Elevation Model

DSİ: Devlet Su işleri Genel Müdürlüğü

EEA: European Economic Area

FAO: Food and Agriculture Organization of the United Nations

GIS: Geographic Information System

GDM: General Directorate of Meteorology

GDSW: General Directorate of State Water Works

GSG: Great Soil Groups

IDW: Inverse Distance Weighted

İDA: İzmir Development Agency

İMM: İzmir Metropolitan Municipality

LUCC: Land Use Capability Class

LUCSC: Land Use Capability Sub-Class

LULC: Land Use Land Cover

MAF: Ministry of Agriculture and Forestry

MCDA: Multi-Criteria Decision Analysis

MEUCC: Ministry of Environment, Urbanization and Climate Change

OIZ: Organizational Industrial Zone

PDAF: Provincial Directorate of Agriculture and Forestry

RCI: Random Consistency Index

RI: Random Index

TURKSTAT: Turkish Statistical Institute

TÜİK: Türkiye İstatistik Kurumu

USDA: United States Department of Agriculture

USGS: United States Geological Survey

CHAPTER 1

INTRODUCTION

İzmir is a province with high potential in terms of agricultural production and agricultural areas. Agricultural production has been among the important resources of our country from past to present. In our country, there is a transformation of agricultural areas with the pressure of urban development and industrialization. Considering the three basins within the borders of the İzmir, the province has a high potential in terms of agricultural production and agricultural areas. The correct analyses and decisions can be made to determine the agricultural areas that should be protected from the pressure of urbanization.

This study aims to determine the agricultural areas that need to be protected within the study area with appropriate criteria. More than one criterion should be considered to determine suitable agricultural areas. These criteria were determined in order to evaluate agricultural lands in terms of soil characteristics, environmental characteristics and economic characteristics. While selecting and classifying the criteria, general suitability levels for agricultural areas are discussed. It should be taken into account that the criteria and classifications will differ in any product-based study.

Accordingly, 1) great soil groups, 2) distance to streams, 3) distance to irrigation, dams, and lakes 4) soil depth, 5) precipitation, 6) temperature, 7) slope, 8) aspect, 9) elevation, 10) land use capability sub-class, 11) distance to main road and 12) distance to settlements were evaluated by using multi-criteria method. Weights were determined using the pairwise comparison method, and their suitability for agricultural areas was assigned according to their importance. AHP was used to estimate the weights or relative importance of the criteria by pairwise comparison methods.

As a result, suitable areas for agricultural areas were determined with five suitable classes, from particularly suitable to unsuitable, by weighted overlay analysis as a multi-criteria decision-making method in ArcGIS. The evaluation was made by comparing the completed suitability map with the current situation, laws, and plans.

The problems and structure of the thesis are explained in the following headings.

1.1. Problem Definition

The determination of agricultural areas was carried out by legal regulations. In these legal regulations, agricultural areas were determined using certain criteria. Other land capabilities should also be considered according to their importance when determining agricultural areas. This study attempts to address and evaluate the following issues:

1. What kind of criteria should be considered when performing suitability analysis for agricultural areas?

2. Which methods can be applied while performing land-use suitability analysis?

3. Which land characteristics are considered in planning and legal legislation while determining agricultural areas?

4. Are the definitions of agricultural areas in the current plans and legal regulations sufficient to determine/protect suitable agricultural areas?

5. What suggestions can be made to determine suitable agricultural areas?

1.2. Thesis Structure

The thesis consists of six chapters. The chapters are briefly explained in the following:

The first chapter explains the relationship among Urban Planning-Agriculture, Agricultural Land Use Planning, Planning-Geographic Information Systems, and land-Use suitability analysis-Geographic Information Systems. It includes the Multi-Criteria Decision-Making Model and the Analytical Hierarchy Process. It talks about the literature studies on determination of agricultural lands and the methods used in these studies.

The second chapter gives general information about the study area. It tries to explain the demographic characteristics of the study area, climate structure, land cover, previous planning studies related to the study area, and legal regulations related to agricultural areas.

The third chapter includes collecting, processing, and analyzing raw data and explaining twelve criteria. In this section, the selected criteria are evaluated comprehensively. The criterion weights are determined, and the application of the analytical hierarchy process with the multi-criteria decision-making approach is observed. The analysis method of the criteria includes thematic maps and quantitative data.

The fourth chapter contains the suitability map obtained from the analysis. The numeric data of the area is described in this section. The suitability analysis for agricultural land use is compared with plans, legal regulations, and current land use.

The final chapter concludes and discusses the overall result of the study. This chapter includes the evaluation and recommendations perspectives of legal and planning for agricultural areas.

CHAPTER 2

LITERATURE REVIEW

2.1. Urban Planning and Agriculture

Agricultural lands are the primary resource for humans today. Urban settlements and cities are overgrowing and developing towards agricultural resources. Migration from rural areas to urban centers increases the rate of urbanization. Due to this migration, population growth in urban areas causes a linear increase in the need for agricultural products, which are still the primary source today. This urbanization trend, realized by migration, creates pressure on natural areas with urban growth and population growth (Redwood,2009).

Natural and agricultural areas are under threat from urban development. Urban areas are developing towards agricultural areas, and as a result of this relationship between cities and agricultural areas, low-density settlements emerge. Agricultural areas become fragmented lands in this process (Gallent and Shaw, 2007). This situation has caused abandoned farmlands in Mediterranean cities (EEA, 2006). This change in rural areas creates changes in terms of land use and socioeconomic terms. Apart from the disappearance of open spaces and rural viewscape over time, the cultural heritage brought by rural life has also changed. (La Rosa et al., 2014).

As a result of the urbanization process experienced in the Ile-de-France region, agricultural areas have started to be included in the master plans of the region over time. Agricultural land use in the Ile-de-France region has undergone significant changes under the influence of globalization. In the process of globalization, modern cities started to grow, and agricultural areas were moved to the periphery of urban areas. In this process, where urban growth is unstoppable, urban life has spread to the periphery over time. Agricultural usage areas were not mentioned in the first master plan made in the region. Still, over time, the issues of planning the urban periphery were discussed first in the use of open areas and then in the plans. The green belt determined around the region in the 90s is a border that prevents the city from spreading to agricultural areas. The issue of protecting agricultural areas has been made possible by urban planning (Vidal and Fleury, 2008).

The continued growth of cities and agriculture are two issues in constant conflict with each other. The effect of the legal regulations of the decision-makers in protecting open spaces and their reuse for agricultural purposes is essential (Drescher, 2001). Rapid growth and rising land prices in the city center pose a threat to agricultural areas and prime lands. Comprehensive policies are required to protect primary soils for agricultural purposes. Education and research play an important role in the sustainability of agriculture and the protection of agricultural areas. Educating planners and decision-makers about the sustainability of agricultural areas is an important priority (University of California, 2022).

2.2. Agricultural Land Use Planning

According to the Food and Agriculture Organization of the United Nations, the definition of agricultural land use planning is the "*systematic assessment of land and water potential, alternatives for land use and economic and social conditions for the purpose of selecting agricultural land use which is sustainable for farmers, without degrading the environment*" (FAO, 1996).

The issue of climate change plays a vital role in planning the future of agricultural land use. This means agricultural land use cannot be planned with past experience (Bonfante and Bouma, 2015). Agricultural land-use planning is an essential socioeconomic issue. The leading targets can be expressed as sustainable growth in production and an increase in productivity (Pilehforooshha et al., 2014)

2.3. Geographic Information Systems and Planning

Geographic information systems (GIS) are a powerful tool for local governments in strategic planning. It simplifies the analysis process between geographic data and datasets. Data sets from GIS are used in many areas such as tourism, medicine, education, forestry, environment, including city and regional planning. The first use of GIS was in the inventory study of a project carried out in 1968 to define the types and sizes of land use in Canada. GIS has also become widespread over time in the planning area, such as comprehensive planning, zoning, land use planning, transportation planning, urbanization, and planning of natural areas and the environment (Warnecke et al. 1998).

Land use planning is the process of making decisions about the land use of an area using multiple inputs, data sets, and types. Traditional planning involves using many printed information, such as aerial photos, topographic maps, floodplains, vegetation, and soil characteristics. Each data set has a critical role in the final decision. Traditional methods of collecting and overlaying this data can sometimes take more than ten years. While there are constantly developing and growing urban areas, the plans' sustainability becomes a problem because of the time loss. The digitalization of printed information and its integrated use with GIS accelerates the planning process. GIS is an essential tool for planners to simultaneously process and visualize multiple layers (Coleman Williams and Galbraith, 2000).

Planning approaches have developed under the titles of Technical and Scientific Rationalism, Political Advocacy, Communicative Planning, and Fair City and Multiculturalism since the 1960s. With the development of planning approaches, the techniques used in GIS have also evolved. The planning process has become more complex over time and has become a democratic and communicative process rather than a technical one. The need for advanced and complex GIS techniques has increased as the planning process has become more sophisticated. The emergence of multiculturalism theories and GIS becoming more accessible and available to planners coincide with the same period. Planners and politicians have started to prefer GIS to resolve conflicts that arise in land planning (Dawwas, 2014).

2.4. Geographic Information Systems and Land Suitability Analysis

The concept of land use connotes different meanings when evaluated at different scales. When assessed at a large scale, the land is considered a resource, and land use is regarded as the use of resources. When the concept of land use is considered on an urban scale, it means determining its potential for various fields of activity (Chapin and Kaiser, 1995).

Land-use suitability analysis is a tool for the determination of land use trends over time. Planners and managers analyze the site is analyzed for suitability by planners and managers by considering location, environmental aspects, and development actions.

These analyzes can then be mapped in a variety of ways. Public officials and private developers can use these maps to make land-use decisions (Collins et al., 2001).

In land-use suitability analysis, overlay techniques made in the late nineteenth and early twentieth centuries form the basis of GIS-based approaches. GIS-based Land-use suitability analysis can be called the process of analyzing raw data and transforming it into meaningful information. Raw data is interpreted and analyzed to produce significant input during planning. These data are converted into information for the main planning problem (Malczewski, 2004). Three basic approaches can be mentioned in GIS-based land-use suitability analysis. These approaches can be as follows; (i) computer-assisted overlay mapping, (ii) multicriteria evaluation methods, and (iii) AI methods (Collins et al., 2001).

Table 2.1 GIS Development
(Source: Malczewski, 2004)

GIS development	**Perspectives of planning**	**Land-use suitability analysis**
Invitation (1950s - 1970s)	Scientific	Computer-assisted overlay mapping
Integration (the 1980s)	Political	Cartographic modeling/MCDA
Proliferation (the 1990s)	Participatory / collective design	MCDA AI/Geocomputation
		Internet/Multimedia/Visualization

The main purpose of this study is to perform land suitability analyses using GIS tools in agricultural land use planning. Agricultural land suitability analysis for the province of Izmir will be carried out on a GIS-based basis with a multi-criteria approach. Environmental factors will be taken into account in the study. Criteria and weights will be determined for the study, and the most suitable areas for agricultural areas will be decided. GIS is an important tool for multi-criteria decision-making and land-use suitability analysis.

2.4.1. Multi-Criteria Decision Modeling

According to Malczewski, *"GIS-based MCDA can be thought of as a process that combines and transforms spatial and aspatial data (input) into a resultant decision* *(output)."* (Malczewski, 1999). Two issues are important in the spatial MCDA process. The first is the capabilities of GIS in data collection, storage, retrieval, and analysis, and the second is the unification of Geographic data and the preferences of decision-makers in a single output. A series of multi-criteria applications can be performed in the GIS environment for land-use suitability analysis. These applications can be classified as multi-objective and multi-criteria decision-making methods (Malczewski, 1999). While multi-objective approaches are for mathematical programming, multi-attribute decision-making is a data-oriented approach (Malczewski, 2004).

The multi-criteria decision-making approach generally consists of five steps. Firstly, a problem definition is made, alternatives are created, and criteria are determined. Then, weights to be given to these criteria are assigned. In the third step, an evaluation matrix is created (Figure 2.1.). After the evaluation matrix, the appropriate method is selected, and the final step is the presentation of the alternatives (Saaty, 1987).

Criteria $C_1, C_2, \ldots, C_n$
Weights $W_1, W_2, \ldots, W_n$
Alternatives

$$\begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{bmatrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Figure 2.1 Evaluation Matrix

(Source: Source: Saaty, 1987)

The use of MCDA, together with GIS, is a powerful spatial decision support system that provides the opportunity to produce land suitability analyses (Bozdağ et al., 2016). This study tries to apply the GIS-based multi-criteria decision approach to determine land-use suitability for agricultural areas.

2.4.2. Analytic Hierarchy Process Method

The analytical hierarchy process (AHP) was developed by T.L.Saaty between 1971 and 1975. AHP is a general theory for making measurements. It is used to construct ratio scales for pairwise comparisons. When making these comparisons, rankings can be taken using actual measurements or relative preferences. AHP's application areas generally come to the fore in multi-criteria decision making, planning, and conflict resolution. AHP is a framework used to reach a synthesis or conclusion by considering more than one criterion (Saaty, 1987).

AHP is an analytical tool used to set priorities. AHP is used to rank tangible and intangible criteria by comparing them with each other. Pairwise comparison matrices are created by creating a hierarchy between the criteria. Each element can be weighed against the other on another level, and the whole scheme is mathematically interconnected. AHP and MCDM are the most widely used methods for evaluating multiple criteria (Chang et al., 2008).

Table 2.2 Saaty's Scale of Relative Importance

(Source: Saaty, 1987)

Intensity of importance on an absolute scale	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored, and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

AHP is an analytical process consisting of nine steps. These nine steps used to solve the problems are as follows.

Step 1: Define the problem

Step 2: Develop a hierarchy model

Step 3: Construct a pairwise comparison matrix

Step 4: Perform judgement for pairwise comparison

Step 5: Synthesizing the pairwise comparison

Step 6: Perform consistency verification

Step 7: Steps 3–6 are performed for all levels in the hierarchy model

Step 8: Develop overall priority ranking

Step 9: Selection of the most suitable method (Velmurugan et al., 2011)

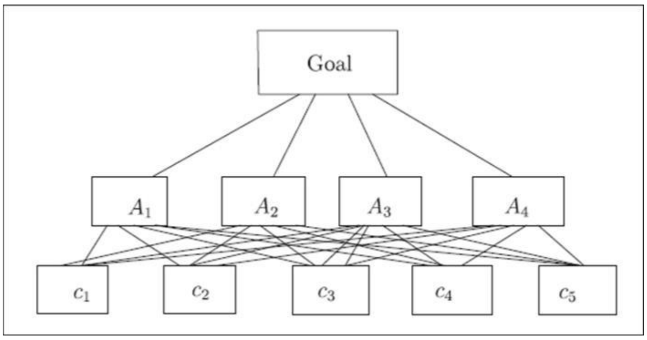


Figure 2.2 Hierarchical AHP Model

(Source: Thomas L. Saaty and Vargas, 2012)

Suitability analysis systematically identifies and rating potentials for uses in a land (Javadian et al. 2011). The combined use of AHP and GIS has recently come to the fore in land use analysis. In the last decade, AHP and GIS-based land-use suitability analyses have been frequently encountered (Bozdağ et al., 2016). The AHP method is also widely used in suitability analysis for agricultural land use (Akıncı et al., 2013). This study tries to apply the GIS-based analytical hierarchy process to determine the land-use suitability of agricultural areas.

2.5. Literature Review of Previous Studies on Determination of Suitable Agricultural Land Use

Natural areas are regularly decreasing over time. In the face of this situation, effective policies are not implemented for the areas that need to be protected. For plan decisions to be made accurately and effectively, the most appropriate land uses must be carefully determined. In this context, the necessary natural and cultural criteria should be discussed in detail (Zengin and Yılmaz, 2008). Determining the most suitable areas in rural and urban areas is a method that can prevent inappropriate use. Especially in our country, inappropriate uses and unplanned developments cause a decrease in agricultural areas. For this reason, it is necessary to determine the criteria of the most suitable areas for agriculture (Demir et al., 2011).

AHP is the most widely used GIS technique for assessing suitable agricultural areas. As a result of the literature review, ten articles were examined in more detail. Among these studies, Wang (1994) used the Artificial Neural Networks method while determining the most suitable areas for agriculture. In Bandyopadhyay et al. (2009) Suitble agricultural areas was obtained by calculating the land suitability potential (LSP) index for each criteria and integrating the index with GIS. In other articles examined in detail, it is seen that the method used to determine the weights is the AHP method.

Table 2.3 Articles Examined in Detail About Suitability of Agricultural Land Use

Articles Examined in Detail About Suitability of Agricultural Land Use	
1	Akıncı et al., (2013) 1
2	Yalew et al., (2016) 2
3	Ahmed et al., (2016) 3
4	Bozdağ et al., (2016) 4
5	Bandyopadhyay et al. (2009) 5
6	Wang (1994) 6
7	Feizizadeh and Blaschke (2012) 7
8	Pramanik (2016) 8
9	Everest et al. (2020) 9
10	Zoleker and Bhagat (2015) 10

As a result of the literature review, it is seen that the criteria under the titles of soil characteristics, topography, climate characteristics and water resources are considered in determining the most suitable areas for agricultural areas.

It is sufficient to consider certain criteria in determining the areas suitable for agricultural production. Since only “the areas where vegetative production can be practiced” will be considered and “no evaluation has been made for a specific agricultural product”, some criteria may be ignored. Criteria that may be sufficient only in determining the most suitable areas for agricultural production, great soil groups, land use capability classes, land use capability sub-class, soil depth, slope, elevation, erosion, and other soil properties. (Akıncı et al., 2013).

Table 2.4 Criteria in Suitability of Agricultural Land Use

Criteria in Suitability of Agricultural Land Use	1	2	3	4	5	6	7	8	9	10
Slope	■	■	■	■	■	■	■	■	■	■
Soil Depth	■	■			■	■			■	■
Soil Moisture						■		■		■
Soil Aeration						■				
Soil Fertility						■	■			■
Soil Texture			■			■				■
Temperature						■	■			
Land Use	■	■		■						■
Accessibility						■				
Aspect	■			■			■	■	■	
Salinity						■	■			
Soil Type	■	■			■	■		■		
Erosion	■								■	■
Elevation	■	■	■	■			■	■	■	
Land Use Capability Class	■				■			■	■	■
Soil Water Content		■								
Distance to Town		■								
Distance to Water		■						■		
Transportation		■					■	■		
Precipitation			■	■			■	■		
Drainage						■		■		■

As a result of the research, it has been determined that the most suitable method for the suitability analysis for agricultural areas is GIS-based MCDM. The weights to be obtained for overlaying the criteria in the GIS interface will be obtained by the AHP method. The definitions of the criteria were carried out according to the literature review, and the scale difference between the previous studies and this study was considered. In addition to the criteria that may be sufficient to determine suitable agricultural areas, temperature, precipitation, aspect, distance to main streams, distance to main road, distance to settlements, and distance to irrigation, dams, and lakes criteria were also integrated into the study due to the characteristics of the study area.

CHAPTER 3

CASE STUDY AREA: İZMİR

İzmir is a metropolitan city located west of Anatolia and in the middle of the Aegean Region. There is a 629 km coastline to the Aegean Sea. İzmir has a border with Aydın in the south, Balıkesir in the north, and Manisa in the west. The total area of the city is approximately 1,201,478 ha. The İzmir province is located between 37°45' and 39°15' north latitudes and 26°15' and 28°20' east longitudes (Provincial Directorate of Agriculture and Forestry, 2013).

The mountains in İzmir are perpendicular to the Aegean Sea. The location of the mountains caused the formation of east-west oriented valley systems. There are three water basins within the borders of İzmir province. These basins are the Bakırçay basin located between the Kınık-Dikili districts in the north, the western part of Gediz Basin on the Emiralem Menemen-Çiğli axis in the west, and the Küçük Menderes Basin in the south (Provincial Directorate of Agriculture and Forestry, 2013).

The İzmir province has different land and soil characteristics. Depending on this difference, diversity is observed in agricultural and natural vegetation (Provincial Directorate of Agriculture, 2013). İzmir is a province with high agricultural potential with its climate that allows the product diversity, fertile plains, and water resources. İzmir is generally above Turkey's average yield and quality in agricultural production (IDA, 2013).

In recent years, a decrease has been observed in agriculture, forest, and pasture areas in İzmir due to the pressure of settlement areas, industrial areas, and other factors. There has been a limited decrease in agriculture and forest areas and more in pasture areas. A significant increase is observed in non-agricultural areas (IDA, 2013).

İzmir has been chosen as a study area because it has high agricultural potential with its climate that allows product diversity, fertile plains, and water resources. Yet, there is a decrease in agricultural areas. It is important to conduct a suitability analysis for agricultural areas in a metropolitan city like İzmir, where the agricultural potential is high. Still, the non-agricultural areas are decreasing due to the pressure of urbanization and industry.

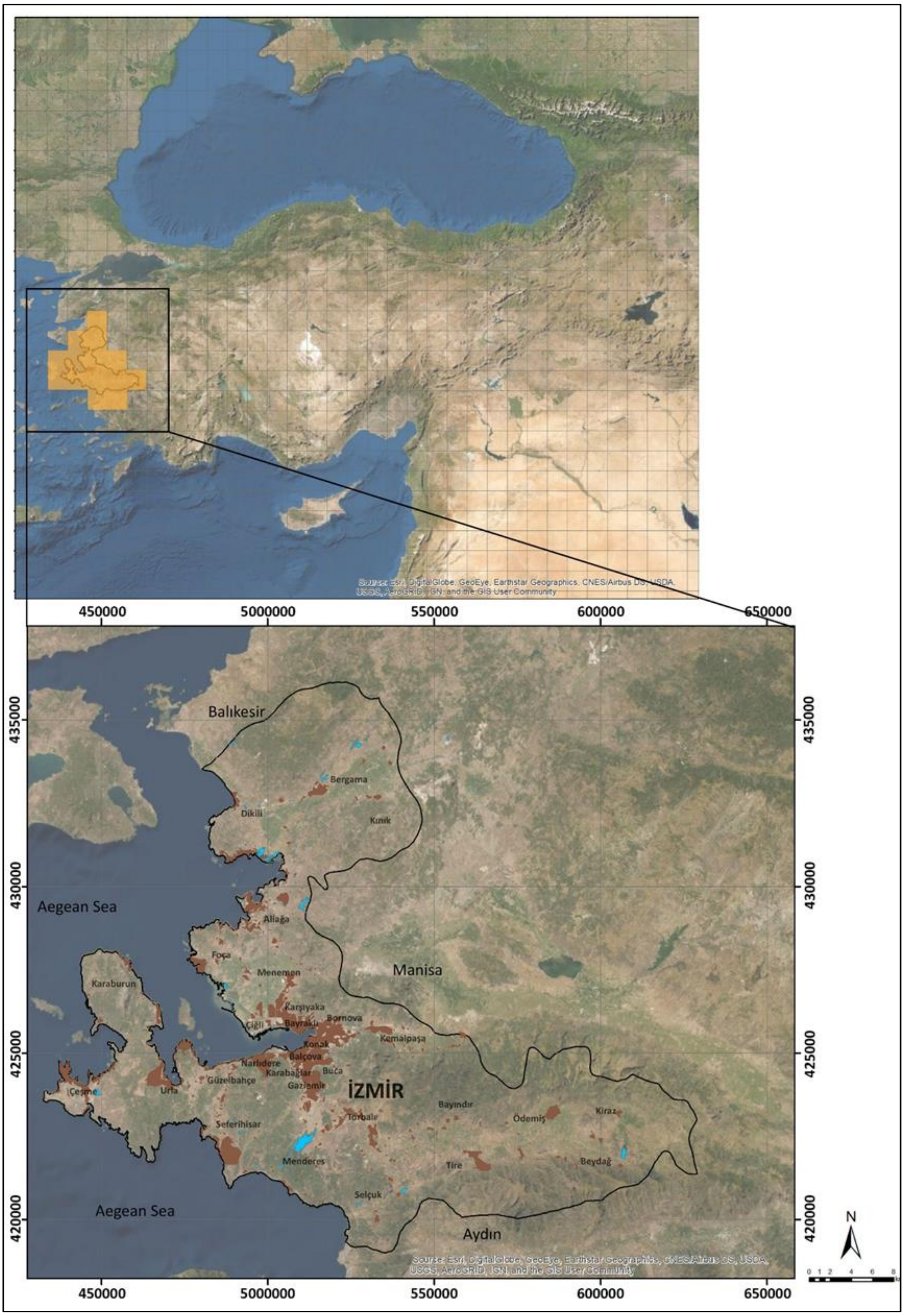


Figure 3.1 The Study Area Location

(Source: ESRI)

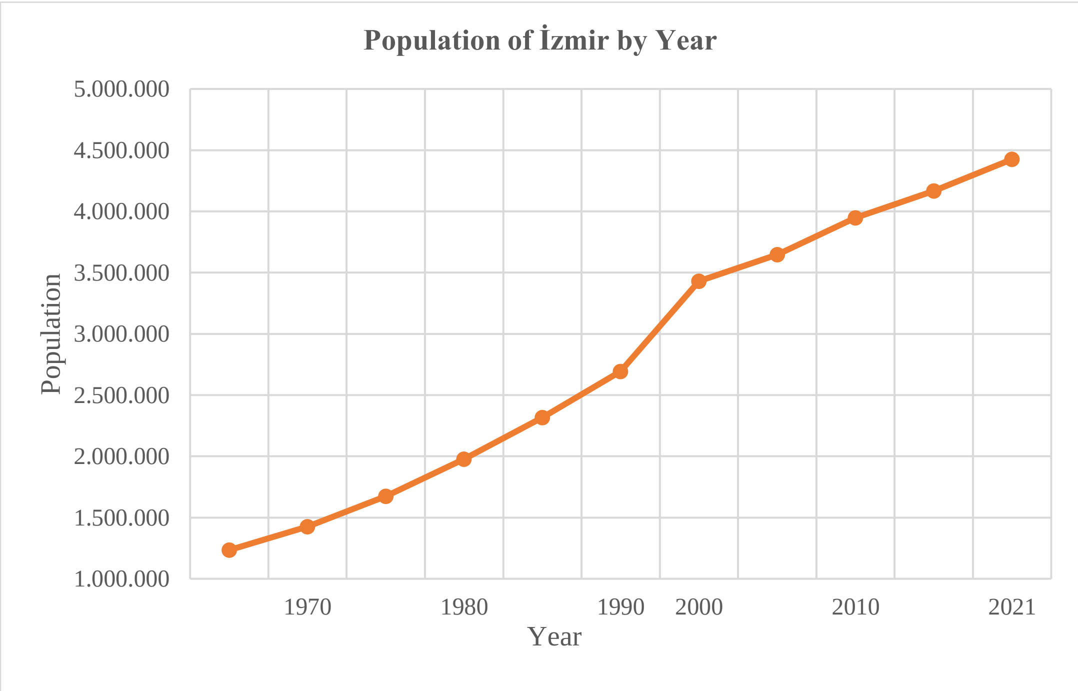
3.1. Demographic Features of the Study Area

İzmir is the third-largest city in Turkey in terms of population size, with 4 425 789 people according to the 2021 census. İzmir province consists of 30 districts and 1297 neighborhoods in total. 5.23% of Turkey's population lives in İzmir province. İzmir's annual population growth rate is ‰ 7,1, and its population density is 369 (Table 3.1).

Table 3.1 Compare the Population of Turkey and İzmir (2021)

(Source: TURKSTAT)

	Population	**Annual population growth rate (‰)**	**Population Density**
Turkey	84.680.273	12,7	110
İzmir	4.425.789	7,1	369

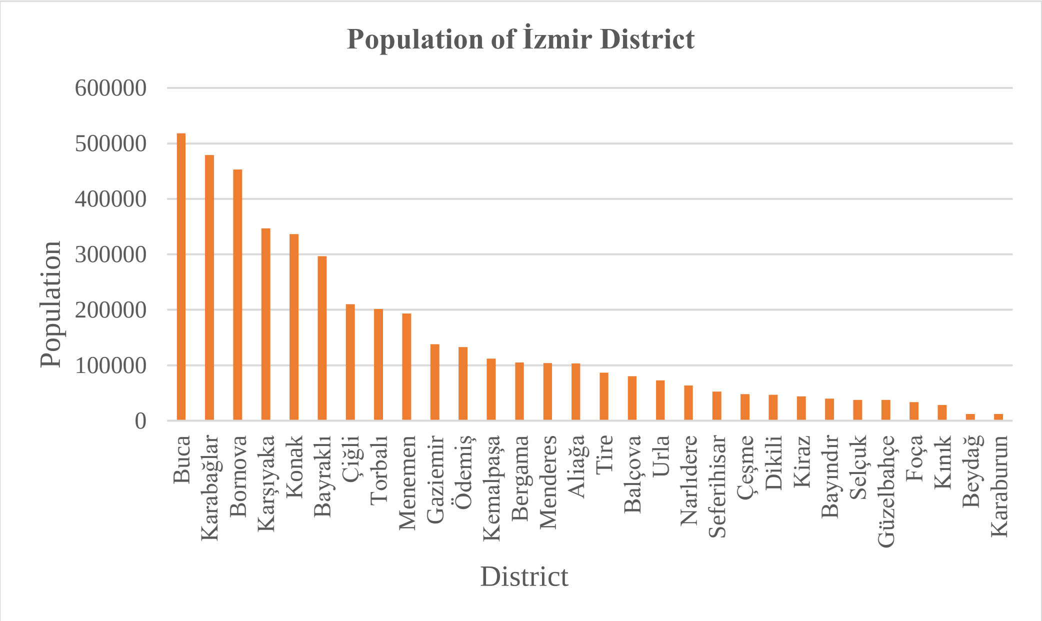


Graph 3.1 Population of İzmir by Year

(Source: TURKSTAT)

According to the population structure of İzmir province, the population density is significantly higher than the average in Turkey. İzmir is one of Turkey's provinces receiving the highest number of immigrants (IDA, 2013).

According to TURKSTAT, the population of İzmir was 1,234,667 in the general population census conducted in 1965. The population growth continued over the years, and the population of İzmir is 4,425,789, according to the data for 2021 (Graph 3.1). TURKSTAT calculated projection populations in 2017. Calculations were handled by considering different fertility rates and migration assumptions, and 2025 population estimates were made for all provinces. According to these population projections, the population of İzmir in 2025 was determined as 4,672,976.

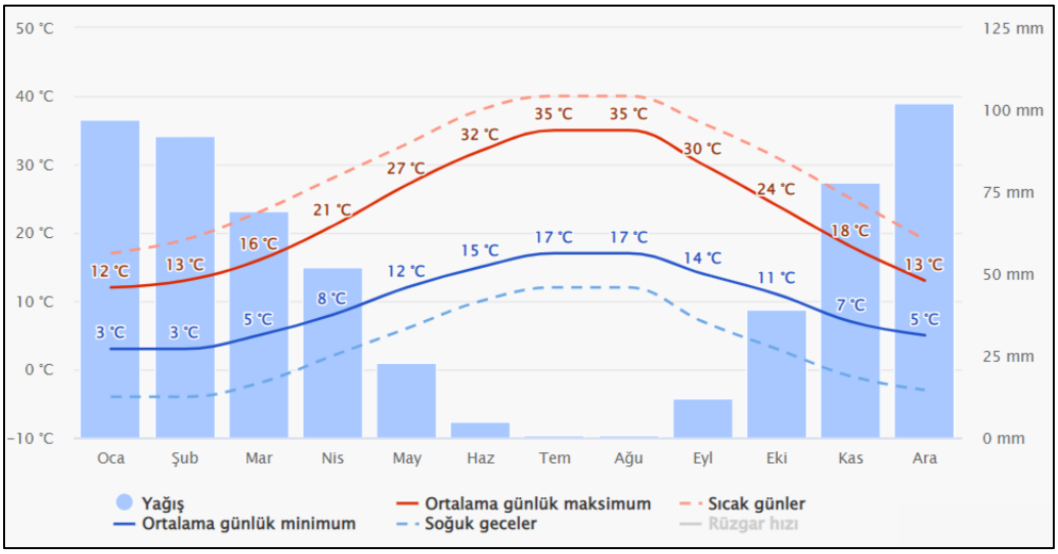


Graph 3.2 Population of İzmir District (2021)
(Source: TURKSTAT)

According to TURKSTAT data for the population size of districts of İzmir (2021), the district with the highest population size in İzmir is Buca (517 963), while the district with the lowest population size is Karaburun (11 927).

3.2. Climate of Study Area

The İzmir province is located in the Mediterranean climate zone. Summers are hot and dry, and winters are warm and rainy. The fact that the mountains lie perpendicular to the sea in İzmir allows the marine influences to spread to the inner parts. The annual average temperature in İzmir varies between 16ºC (Bergama) and 17ºC (Bayindir). While the maximum temperature in İzmir is 45.1ºC (Torbalı), the minimum temperature is -13ºC (Ödemiş) (Izmir Governorship, 2022).



Graph 3.3 Average Temperature and Precipitation

(Source: meteoblue)

The amount of precipitation in İzmir is the climate element that varies the most. The average amount of precipitation in the province is measured as 700 mm. In some years, it is observed that this amount of rain eases up to 1000 mm. In some years, it is seen that it decreases up to 300 mm. Considering the annual precipitation, an increase in precipitation is observed starting from the second half of October, and the precipitation continues until May. December, January, and February are the months with the highest precipitation (Izmir Governorship, 2022).

3.3. Agricultural Areas of Study Area

While giving general information about the study area, it is mentioned that there are three basins in the area. These are the Gediz, Bakırçay and Küçük Menderes basins. Agricultural areas in the study area are generally located in these basin areas.

Figure 3.2 Basin Areas in Study Area
(Saygılı, 2017)

Table 3.2 Agricultural Lands According to CORINE Data
(Source: Copernicus Land Monitoring Service, 2022)

Agricultural Areas		2012 Area (Ha)	2018 Area (Ha)
Arable Land	Non-Irrigated Arable Lands	20480.09	20295.66
	Permanently Irrigated Areas	148261.64	148311.14
	Rice Fields	-	-
Permanent Crops	Vineyards	6673.44	6673.44
	Fruit Trees and Berry Plantations	15624.24	15593.45
	Olive Groves	15624.24	75786.10
Pastures	Pastures	6788.87	6565.00
Heterogeneous Agricultural Areas	Annual Crops Associated with Permanent Crops	-	-
	Complex Cultivation Patterns	182006.64	180875.03
	Land Principally Occupied by Agriculture, with Significant Areas of Natural Vegetation	134663.01	134855.98
	Agro-Forestry Areas	-	-

According to CORINE data, there is a decrease in agricultural areas in the study area between 2012 and 2018. At the same time, a decrease is observed in forest areas and semi-natural areas. (Copernicus Land Monitoring Service, 2022).

Table 3.3 Land Cover According to CORINE Data
(Source: Copernicus Land Monitoring Service, 2022)

	2012 Area (Ha)	**2018 Area (Ha)**
Artificial Areas	65640.62	68573.57
Agricultural Areas	590240.39	588955.81
Forest and Semi Natural Areas	731368.54	728160.27
Water Bodies	29155723.31	29133884.72
Wetlands	6685.02	6685.02

3.4. Land Use Capability Class of Study Area

The lands are divided into eight classes according to their ability to use. These eight classes are; The lands that can be cultivated in the best, easiest, and most economical way are among the first-class and the eighth classes, which are not suitable for any agriculture and cannot even be used as meadow or forestry (USDA, 2008). General definitions of these classes are below.

I. Slight one or two restraints, perfect for agricultural production
II. Very good for agricultural production, limiting factors involved
III. Moderate productivity with limiting factors
IV. Low or moderate productivity and many limiting factors require careful handling when processed
V. It is possible to make a profit with forestry or meadow improvement, agricultural production cannot be done; there are limiting factors, includes rocky soils
VI. Agricultural production cannot be done; it can be used for meadow, pasture, or forest
VII. The possibilities of using it as a meadow or pasture are very low; tree planting can be done to protect the land.
VIII. Highly eroded terrain, beaches, bare cliffs, etc. Unsuitable for plant cultivation, it can be used as a resting place for wildlife, (Land Classification Report for İzmir, 2013).

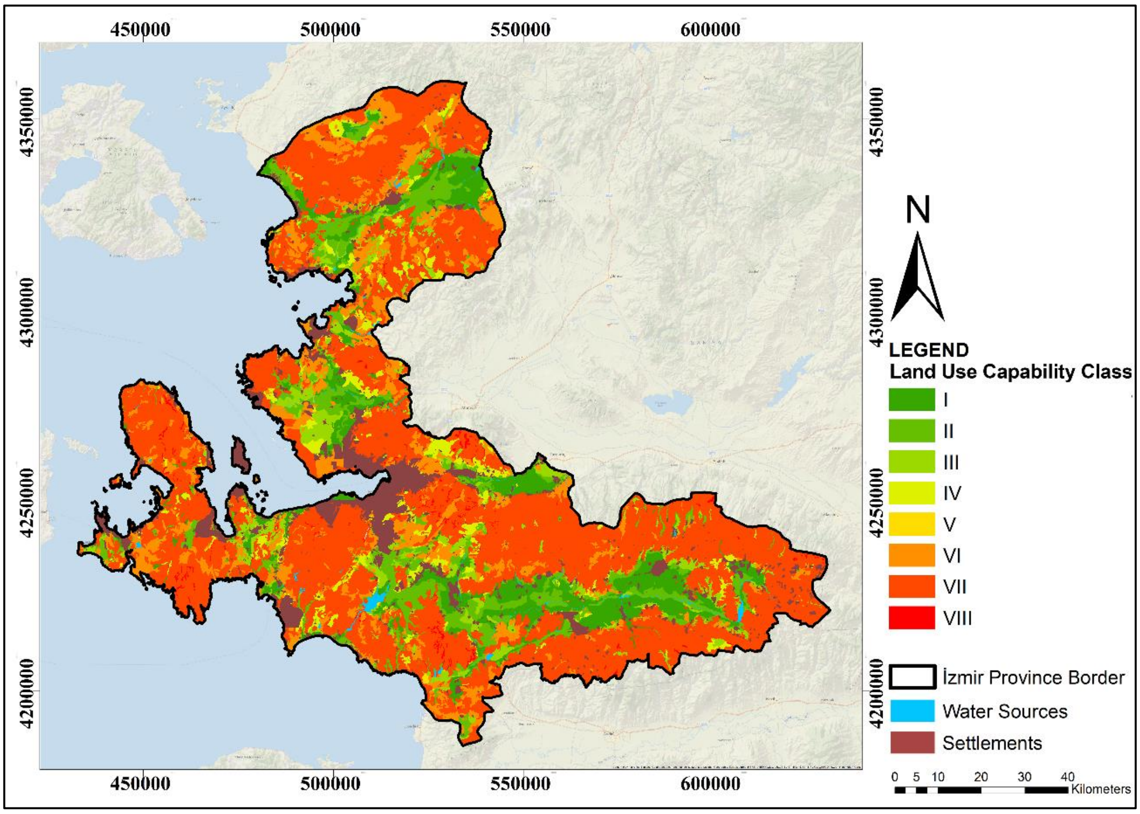


Figure 3.3 Land Use Capability Class Analysis

(Source: Land Classification Report for İzmir, 2013)

Considering the distribution of land use capability classes, the class with the highest surface area is placed in VII with a rate of 53.48%. I and II class agricultural lands constitute 19.34% of the area.

Table 3.4 Land Use Capability Class of the İzmir

(Source: Land Classification Report for İzmir, 2013)

Land Use Capability Class	Area (ha)	Area (%)
I	108,712	9.05
II	111,588	9.29
III	63,010	5.24
IV	47,155	3.92
V	510	0.04
VI	156,45	12.99
VII	684,519	53.48
VIII	11,542	0.96
Lake	4,288.56	0.36
Residential	56,106.90	4.67
	1,201,477.55	100

3.5. Planning Regulations for Agricultural Areas

While examining the legal regulations for agricultural areas, the soil protection and land use law No. 5403, the great lowland protection areas within the scope of the study area and the plans for the study area were examined in detail.

3.5.1. Soil Conservation and Land Use Law No. 5403

There is a regular population increase in Turkey. This situation brings rapid urbanization and an increase in building stock. City centers are developing towards the periphery and occupying agricultural lands. Also, settlements and industrialization put pressure on agricultural areas. The necessity of protecting agricultural areas is a phenomenon mentioned in the plans made for İzmir. Each plan includes decisions on its scale for the protection of agricultural lands. The "Soil Conservation and Land Use Law No. 5403" comes to the fore to protect the soil and determine agricultural land use.

When the laws on protecting agricultural lands are examined, Law No. 5403 comes to the fore. The purpose of the Soil Conservation and Land Use Law No. 5403 can be summarized as the classification of agricultural lands and soil protection and development. This law covers the principles for preparing agricultural land use plans and the prevention of misuse of agricultural areas. According to Law No. 5403, agricultural areas include planted areas, special crop areas, marginal agricultural lands, and absolute agricultural lands.

a) Absolute Agricultural Lands: No limiting features, no topographical limitations, suitable for agricultural production
b) Special Crop Areas: There are soil and topographic limitations, adapted to the region, and special crops can be grown
c) Marginal Agricultural Lands: There are soil and topographical limitations, only land with traditional tillage farming
d) Lands Planted Areas: Plants in the form of trees and shrubs suitable for the local ecology can be cultivated

According to law no 5403, the areas mentioned above are included in the scope of agricultural areas. Agricultural areas cannot be used for purposes other than agricultural production unless deemed appropriate by the ministry or governorship in special cases (defense, natural disasters, oil and natural gas exploration, mining for public benefit, etc.).

Considering the distribution of agricultural areas, the agricultural area with the highest surface area is marginal agricultural lands with 50.08%. Absolute agricultural areas, which have the highest potential for agricultural production, cover 23.98% of İzmir. When the areal distribution of agricultural areas is examined, we see that agricultural areas are concentrated in the north and south of the city.

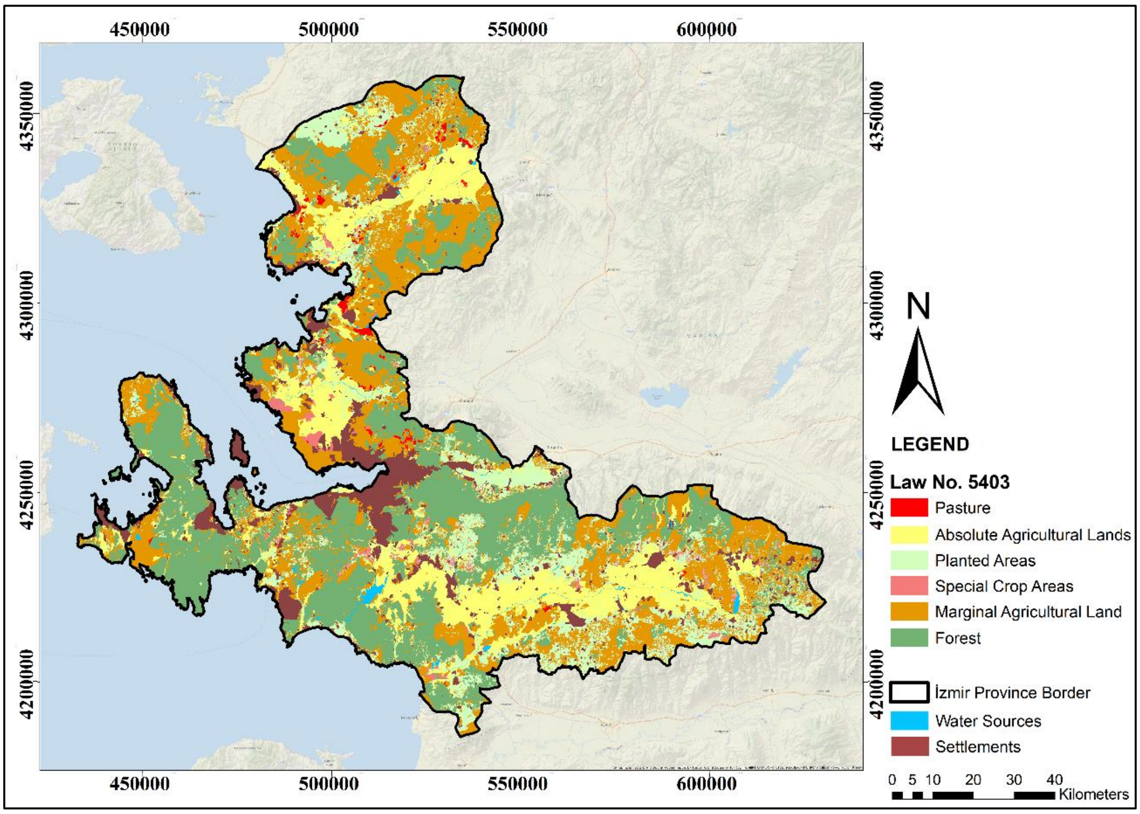


Figure 3.4 Agricultural Lands According to Law No. 5403

(Source: Land Classification Report for İzmir, 2013)

Table 3.5 Agricultural Lands According to Law No. 5403
(Source: Land Classification Report for İzmir, 2013)

Land Use Type	Total (Ha)	Area (%)
Absolute Agricultural Lands	174,712.27	23.98
Special Crop Areas	14,940.19	2.08
Marginal Agricultural Land	365,686.33	50.80
Planted Areas	164,557.23	22.86
	719,896.05	

3.5.2. Great Lowland Protection Areas

These are areas with high agricultural production potential. In these areas, soil loss and land degradation are rapidly developing due to erosion, pollution, or misuse. There are ten great lowland protection areas in İzmir. These lowlands are as follows from north to south (T.C. Resmi Gazete 21.01.2017/29955; 31.03.2018/20377; 07.05.2021/ 31478).

1. Bakırçay
2. Aliağa
3. Menemen (Gediz)
4. Kemalpaşa
5. Menderes
6. Oğlananası
7. Ödemiş (Küçük Menderes)
8. Kiraz
9. Selçuk
10. Selçuk / Çamlık

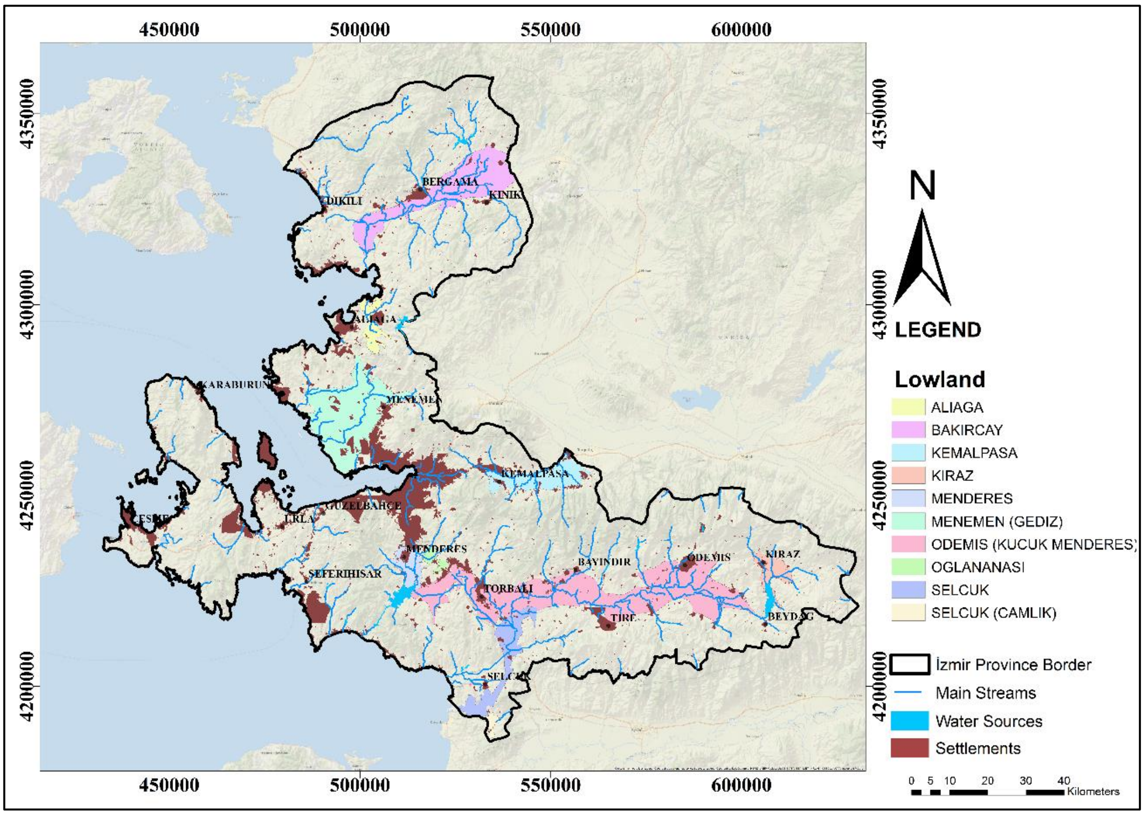


Figure 3.5 Great Lowland Protection Areas
(T.C. Resmi Gazete, 2017, 2018 and 2021)

3.5.3. Plans That Cover Study Area

There are similar decisions regarding agricultural areas in the plans covering the province of İzmir. According to the Izmir Metropolitan Municipality 2020-2024 Strategic Plan; Under the aim of "making İzmir an exemplary city of life in harmony with nature", the target for agricultural areas is "Agricultural areas will be developed in a way that protects the ecosystem; the loss of natural areas and biodiversity will be stopped" (İzmir Metropolitan Municipality, 2020).

According to the İzmir Regional Plan, industrial areas and urban settlements are developing towards agricultural areas in İzmir, and the necessity of protecting agricultural areas is mentioned in the plan. According to the plan, absolute agricultural, special crops and planted agricultural lands are the priority protection areas. In addition, marginal agricultural lands are among the secondary priority protection areas. (IDA, 2010)

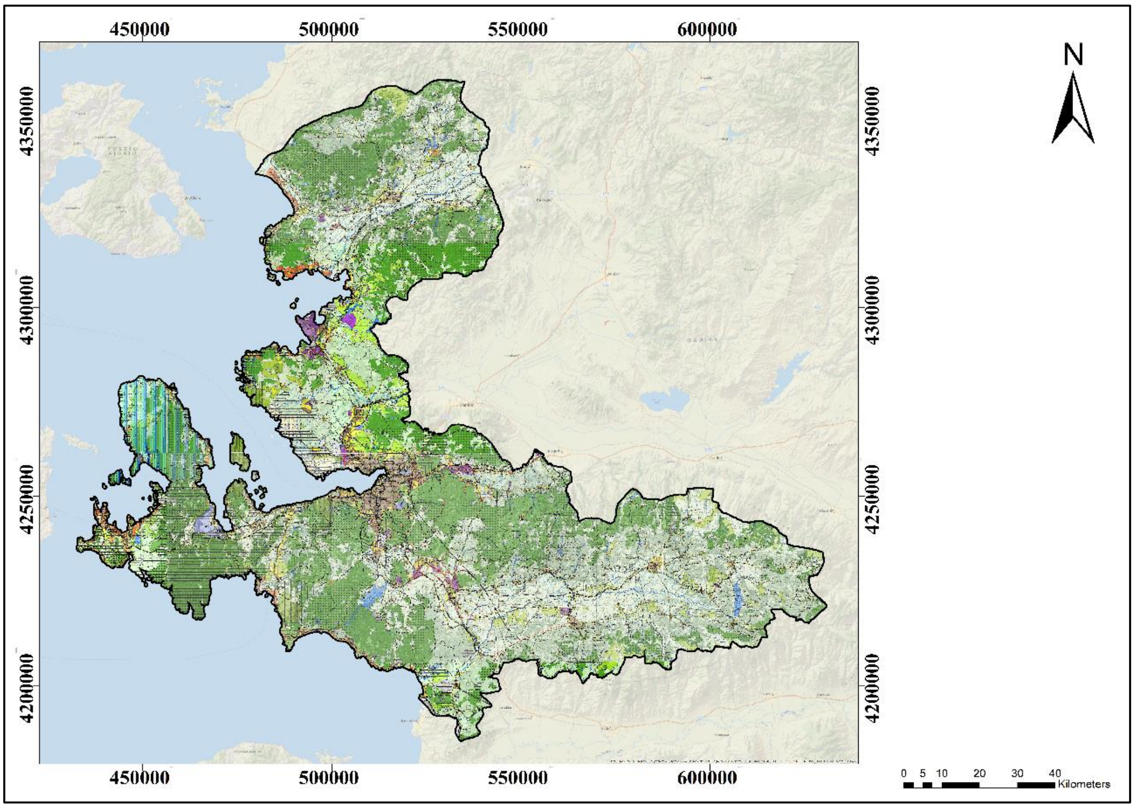


Figure 3.6 1/100 000 Scaled Environmental Plan of İzmir (Legend in Appendix C)
(Ministry of Environment, Urbanization and Climate Change, 2014)

According to the 1/100 000 scaled Environmental Plan, agricultural lands are determined as absolute agricultural lands, planted agricultural lands, special croplands, and marginal agricultural lands. The agricultural lands in the planning area were evaluated within the scope of the Soil Conservation and Land Use Law No. 5403 and gathered under a single display as agricultural land. Marginal agricultural areas are also among the areas where agricultural quality will be preserved (Ministry of Environment, Urbanization and Climate Change, 2014).

It is emphasized in the 1/25.000 scaled Izmir Master Development Plan, in which that a green belt will be created that surrounds the central city and limits its uncontrolled spread. It is among the plan decisions to create a green belt that combines with the Küçük Menderes basin extending from west to east, including the Gediz, Emiralem, Nif, and Tahtalı basins. It was decided to create a second green belt connecting the Bakırçay basin located in the north of Aliağa and the Küçük Menderes basin located in the south of Selçuk. In this way, controlling the growth of the central city and the peripheral settlements is one of the decisions included in the plan report (Ministry of Environment, Urbanization and Climate Change, 2013).

CHAPTER 4

DATA, APPLICATIONS AND ANALYSES

There are main factors affecting agricultural areas. These factors can be shown as soil properties, environmental factors, and legal regulations. Agricultural production has an important place worldwide and in our country. This situation creates the need to determine the agricultural production areas that need to be protected. A large-scale literature review was conducted for agricultural land suitability analysis. In a suitability analysis to be made for a particular agricultural product, the criterias and the classifications to be determined for each criterion will differ. However, in this study, a suitability analysis will be carried out for agricultural areas rather than a specific product. In the light of the literature review, criteria were determined, and suitability analyzes were carried out for agricultural areas. The determining criteria are as follows.

1. **Great Soil Groups**
2. **Soil Depth**
3. **Slope**
4. **Land Use Capability Sub-Class**
5. **Aspect**
6. **Elevation**
7. **Precipitation**
8. **Temperature**
9. **Distance Irrigation Dams, and Lakes**
10. **Distance to Main Streams**
11. **Distance to Settlements**
12. **Distance to Main Road**

The spatial analysis will be obtained with the data. A digital elevation model (DEM) will be used for distance to streams, slope, aspect, and elevation. Annual average temperature and annual average precipitation analyses will be obtained with station-based data ed from the General Directorate of Meteorology. Great soil groups, soil depth, distance to settlements and land use capability sub-class analyses will be carried out with the data obtained from the İzmir Directorate of Agriculture and Forestry. Distance to irrigation dams, and lakes data obtained from General Directorate of State Water Works. The suitability analysis will be obtained from the twelve criteria; the first suitability map for the agricultural areas will be obtained by performing the overlay analysis. The second suitability map will be obtained with the weighted overlay method using the analytic hierarchy process (AHP). These two maps will be a visual result of suitable areas for agricultural areas.

The first step in the study is to determine the criteria for finding suitable areas for agricultural areas. Completion of this step will take place with a literature review. It will be obtained by giving the necessary information and will be reviewed before starting the analysis process and converted into the formats to be used in the analysis phase. While some of the data were obtained from the relevant institutions, the digital elevation model data were obtained from the United States of Geological Survey (USGS) platform.

Before analyzing each criterion, certain studies must be carried out to bring all analyses to the same format. Reaching the result bar is possible by creating a certain model that will cover all analyses. To create this model, reclassify, extraction, intersect, Inverse distance weighted (IDW) interpolation, slope, aspect, hydrology, buffer, etc. tool commands can be used. All analyzes can be performed by different methods.

Data are collected in the same format after the criteria are set and, the analysis is completed. Then the methodology flow chart is followed. First of all, the first map is obtained by overlay analysis. Then, using the AHP method, weights are determined for all criteria, and the second fitness map is obtained with the weighted overlay method.

The weight values of the criteria in the suitability analyzes for a particular agricultural product will differ according to this study. In this study, the most suitable areas for agriculture were determined. The criteria, classification and weighting of the criteria are discussed in order to determine the most suitable areas for agricultural areas.

4.1. Raw Data Processing

The purpose of the thesis is to determine the suitable agricultural areas of the region. Figure 4.1 shows how the analyzes are made and how the data sources are used to achieve this goal. 5 suitability classes are; not suitable, less suitable, moderately suitable, suitable, and particularly suitable. The criteria prepared grid format and projection is WGS_1984_UTM_Zone_35N. The resolution is 30m-30m.

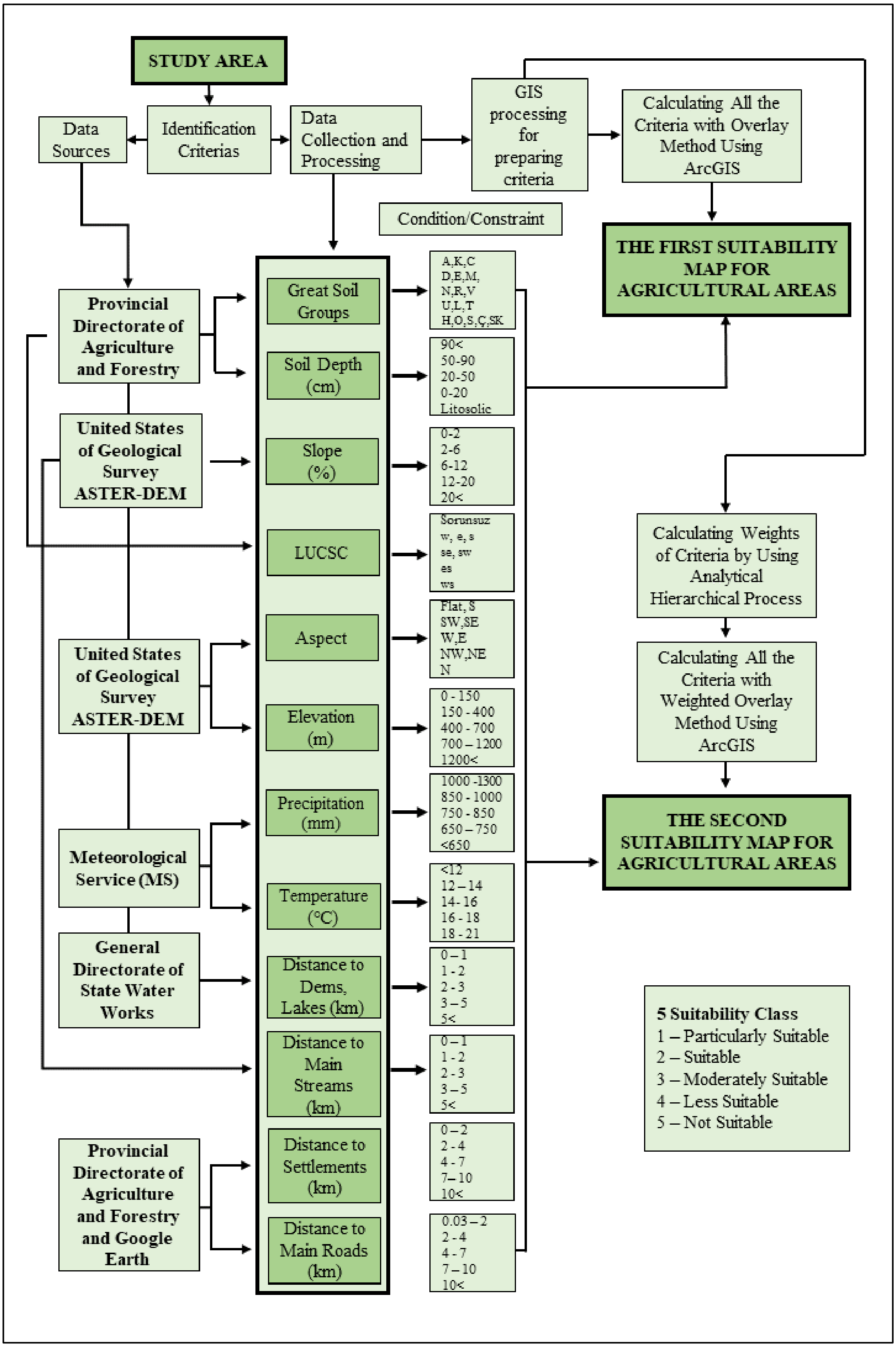


Figure 4.1 Data Processing of the Study

4.2. Data and Suitability Analysis

The selection of criteria has an important place in the evaluation of suitable areas for agricultural areas. With the proper criteria selection, the current situation will be understood more clearly.

4.2.1. Great Soil Groups

Systematic classification of the great soil groups has been established to determine the state and behavior of soil conditions. Soil behaviors help predict soil performance in terms of agricultural production. For this reason, it is necessary to know the great soil groups while performing the agricultural land suitability analysis (Akıncı et al., 2013).

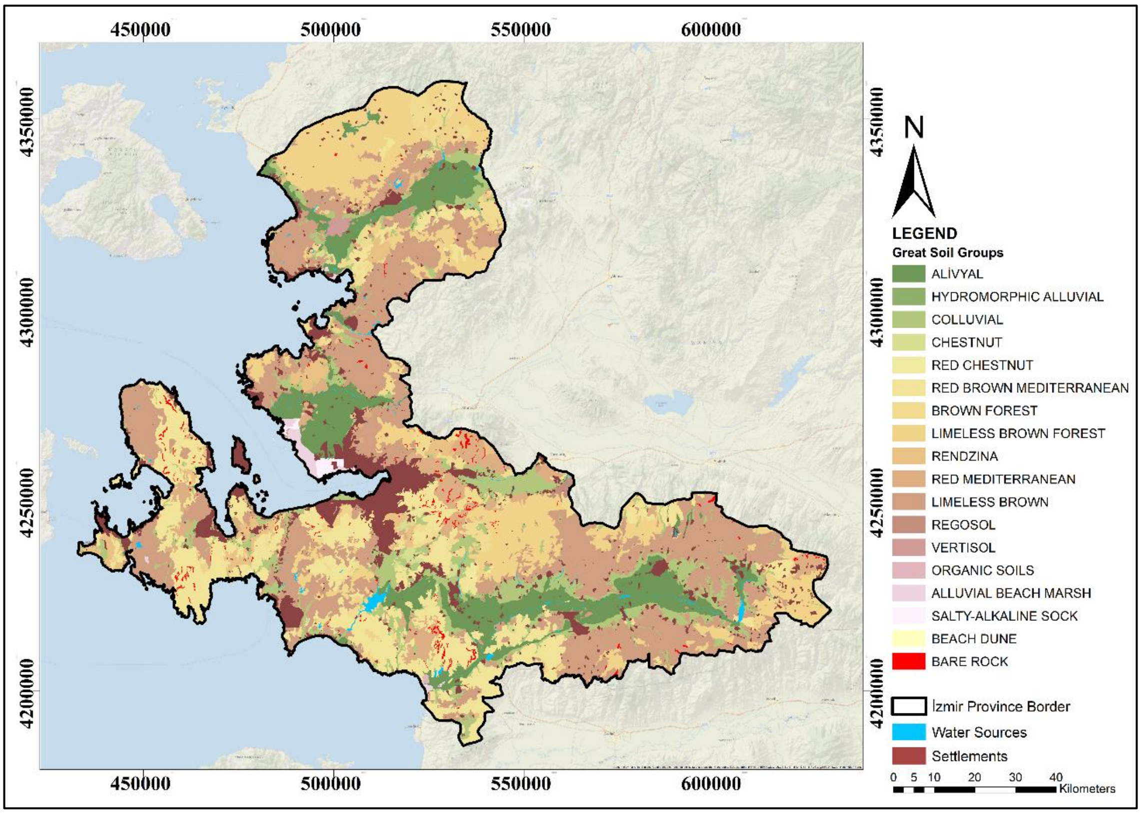


Figure 4.2 Great Soil Groups Analysis

(Source: Land Classification Report for İzmir, 2013)

When we look at the study area, it is seen that the dominant soil group in the area is non-calcic brown soils (29.49 %). The red-brown mediterranean (15.73 %) is in the second place, and alluvial soils (11.3 %) are in the third place. Alluvial soils are the most fertile soil group in the area. Great soil groups, symbols, total areas, and percentage of these soil groups in İzmir are indicated in table 4.1.

Table 4.1 Great Soil Groups

(Source: Land Classification Report for İzmir, 2013)

Great Soil Groups	Total (Ha)	Area %
(A) **Alivyal**	133,683.98	11.3
(H) Hydromorphic Alluvial	128.33	0.01
(K) Colluvial	118,413.74	9.86
(C) Chestnut	4,995.04	0.42
(D) Red Chestnut	1,145.52	0.10
(E) Red Brown Mediterranean	189,034.14	15.73
(M) Brown Forest	45,346.90	3.77
(N) Non-Calcic Brown Forest	189,804.00	15.8
(R) Rendzina	34,791.62	2.90
(T) Red Mediterranean	42,647.43	3.55
(U) Non-Calcic Brown	354,287.42	29.49
(L) Regosol	1,809.32	0.15
(V) Vertisol	2,297.33	0.19
(O) Organic Soils	382.08	0.03
(S) Alluvial Beach Marsh	7,526.39	0.63
(Ç) Salty-Alkaline Sock	3,246.79	0.27
(SK) Beach Dune	174.64	0.01
Riverbed	3,407.29	0.28
Bare Rock	7,960.13	0.66
Lake	4,288.56	0.36
Residential	56,106.90	4.67
	1,201,477.55	100

Great Soil Groups are grouped for suitability analysis purposes. While making this grouping, the information obtained from the literature review, expert opinion and the provincial directorate of agriculture were compared. Five degrees of conformity have been determined. In Table 4.2, the suitability degrees and the values of the soil groups in these suitability degrees are given. In Figure 4.3, the spatial distribution of the suitability analysis can be observed. It can be said that the most integrated areas in terms of great soil groups are in the north and south of the city.

Table 4.2 Great Soil Groups Suitability

Suitability	GSG
Particularly Suitable	A, K, C
Suitable	D, E, M
Moderately Suitable	N, R, V
Less Suitable	U, L, T
Not Suitable	H, O, S, Ç, SK

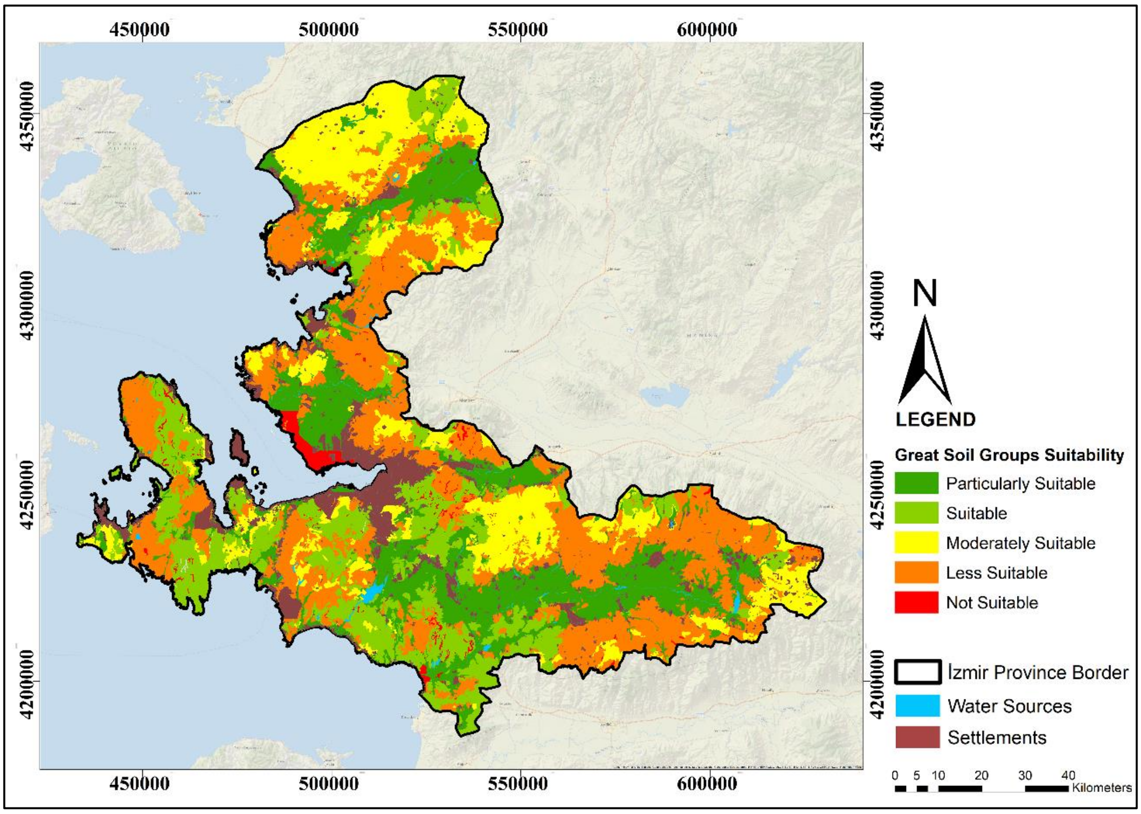


Figure 4.3 Great Soil Groups Suitability Map

4.2.2. Soil Depth

Soil depth is an important factor in terms of agricultural production. It gives information about how deep the soil goes. In agricultural production, the depth reached by the plant roots is important in getting the plant's nutrients and water (Fu et al., 2011). Plant roots' healthy growth is important for plants' reach the necessary nutrients. (Everest et al., 2021).

Soil depth is highly related to the topographic features of an area (Gessler et al., 2000). From of the physical properties of the soil, soil depth is an important physical criterion. Deep soils play an important role in root growth, while shallow and lithosolic soils limit root growth (Bandyopadhyay et al., 2009).

In Law No. 5403, soil depth is mentioned as one of the parameters used to determine the agricultural lands that need to be protected. At the same time, this criterion is among the important criteria when determining land use capability classes. This criterion is among the important criteria when performing suitability analysis for agricultural areas. The spatial distribution of the soil depth analysis of the study area is shown in Figure 4.4.

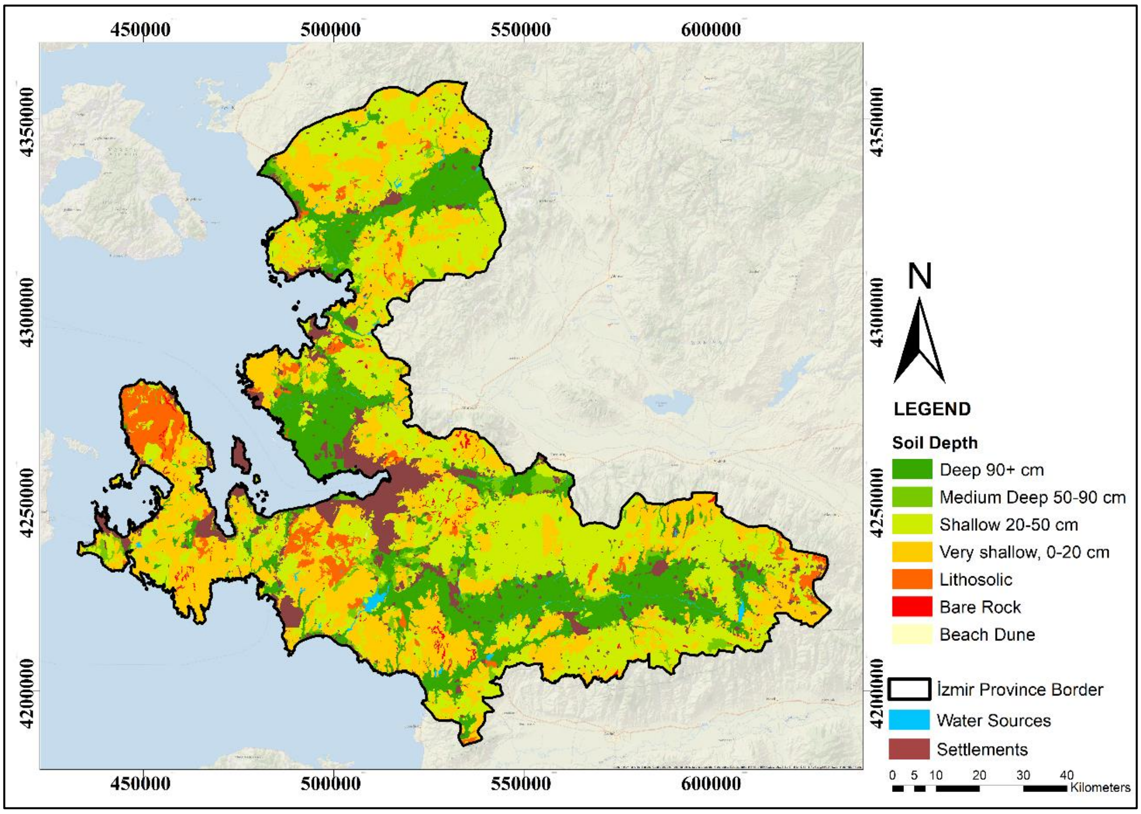


Figure 4.4 Soil Depth Analysis
(Source: Land Classification Report for İzmir, 2013)

Considering soil depth distribution, the largest surface area has a shallow (20-50 cm) soil depth with 35.47%. The areas with more than 90 cm soil depth cover 20.13% of the study area.

Table 4.3 Soil Depth
(Source: Land Classification Report for İzmir, 2013)

Soil Depth	Area (ha)	Area (%)
A (Deep 90+ cm)	241,826.94	20.13
B (Medium Deep 50-90 cm)	37,079.99	3.09
C (Shallow 20-50 cm)	426,213.43	35.47
D (Very shallow, 0-20 cm)	370,551.98	30.84
E (Lithosolic)	53,867.69	4.48
Beach Dune	174.64	0.02
Riverbed	3,407.29	0.28
Bare Rock	7,960.13	0.66
Lake	4,288.56	0.36
Residential	56,106.90	4.67
	1,201,477.55	100

While examining the soil depth in terms of suitability analysis, the law numbered 5403, Land Classification Report for İzmir (2013), and the literature review were used.

Areas that have 90+cm soil depth were determined as particularly suitable. Areas with 50-90 cm soil depth as suitable; 20-50 cm soil depth as moderately suitable; 0-20 cm soil depth as less suitable and lithosolic soils determined as not suitable. In Figure 4.5, the spatial distribution of the suitability analysis for soil depth can be observed.

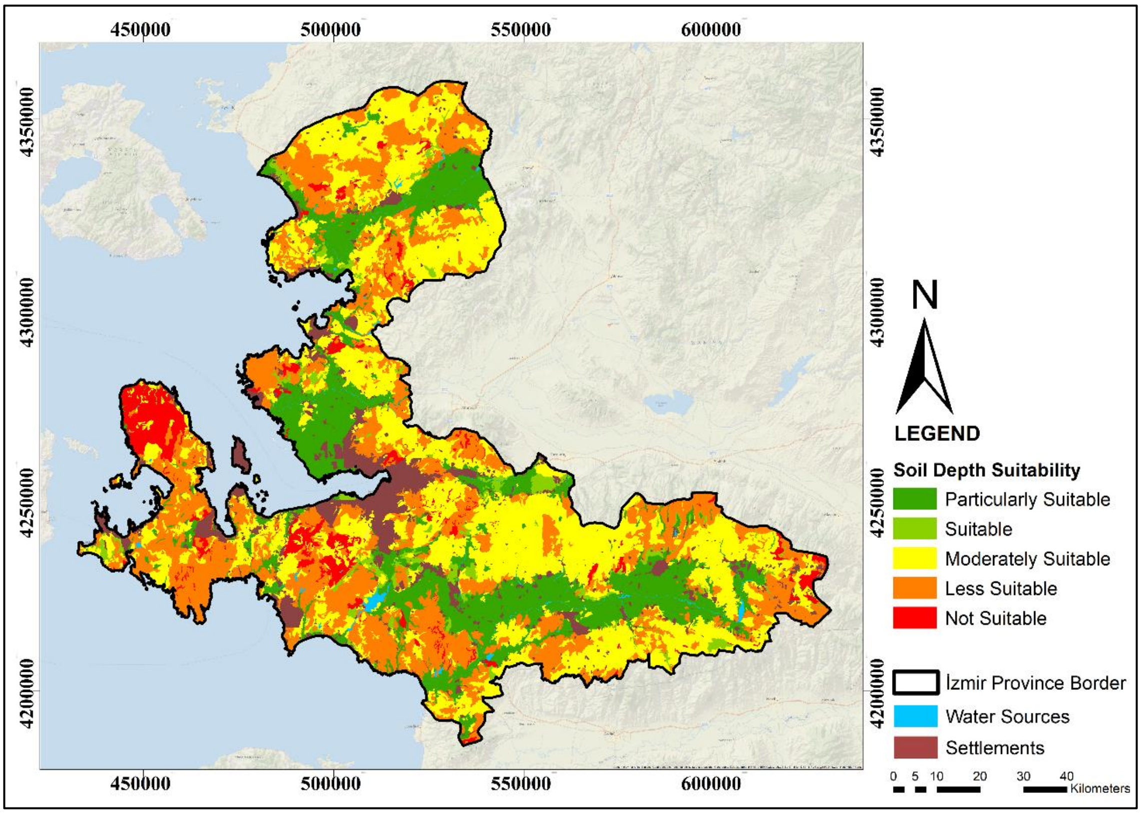


Figure 4.5 Soil Depth Suitability Map

4.2.3. Slope

Geomorphological features such as soil depth and erosion are directly related to the topography of the area. Soil depth decreases as the slope increases and increases as the slope decreases. The main factor determining the degree of erosion is again the degree of slope. Soil loss due to erosion also causes a decrease in soil depth and productivity. (Akıncı et al., 2013).

Slope is a prominent criterion in agricultural areas. The slope criterion has a significant impact on many factors that are important to agriculture. The slope analysis showing the distribution of slope percentages within the study area is shown in the Figure 4.6.

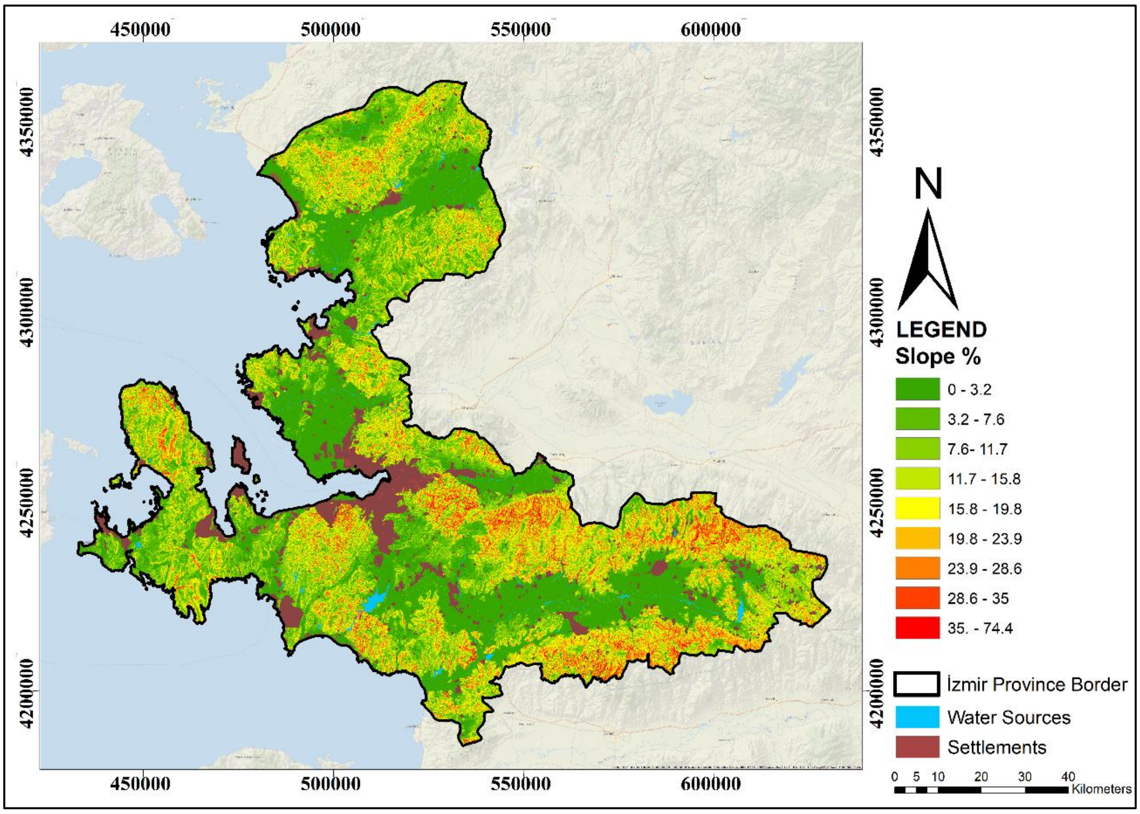


Figure 4.6 Slope Analysis

(Source: USGS, 2022)

For slope analysis, the digital elevation model (DEM) was obtained from the USGS, and the slope analysis was performed in the ArcGIS interface. The spatial distribution of İzmir province in terms of slope percentage is shown in Table 4.4.

Table 4.4 Slope Analysis

(Source: Land Classification Report for İzmir, 2013)

Slope	Area (ha)	Area (%)
1 (Flat, nearly flat 0-2%)	201,037.69	16.73
2 (Mild, 2-6%)	66,791.72	5.56
3 (Medium, 6-12%)	100,575.04	8.37
4 (Vertical, 12-20%)	227,042.41	18.90
5 (Very steep, 20-30%)	308,578.84	25.68
6 (30%+)	225,514.33	18.77
Beach Dune	174.64	0.01
Riverbed	3,407.29	0.28
Bare Rock	7,960.13	0.66
Lake	4,288.56	0.36
Residential	56,106.90	4.67
	1,201,477.55	100

The soil depth increases in the valley floors and on the slightly sloping lands on the foothills of the mountains. The areas where the soil depth is shallow are located on steeper slopes. The amount of minerals and nutrients in the soil varies according to the soil depth. The productivity in agricultural production, varies with the soil depth and therefore the slope, as well as the local differences (Zoleker and Bhagat, 2015). As a result of the literature review, it is seen that the slope criterion is included in all studies while performing the agricultural land suitability analysis.

The slope criterion is one of the criteria used for the determination of agricultural areas in the Law No. 5403. This criterion is one of the criteria used when determining land use capacity classes. Slope is one of the important factors in agricultural production.

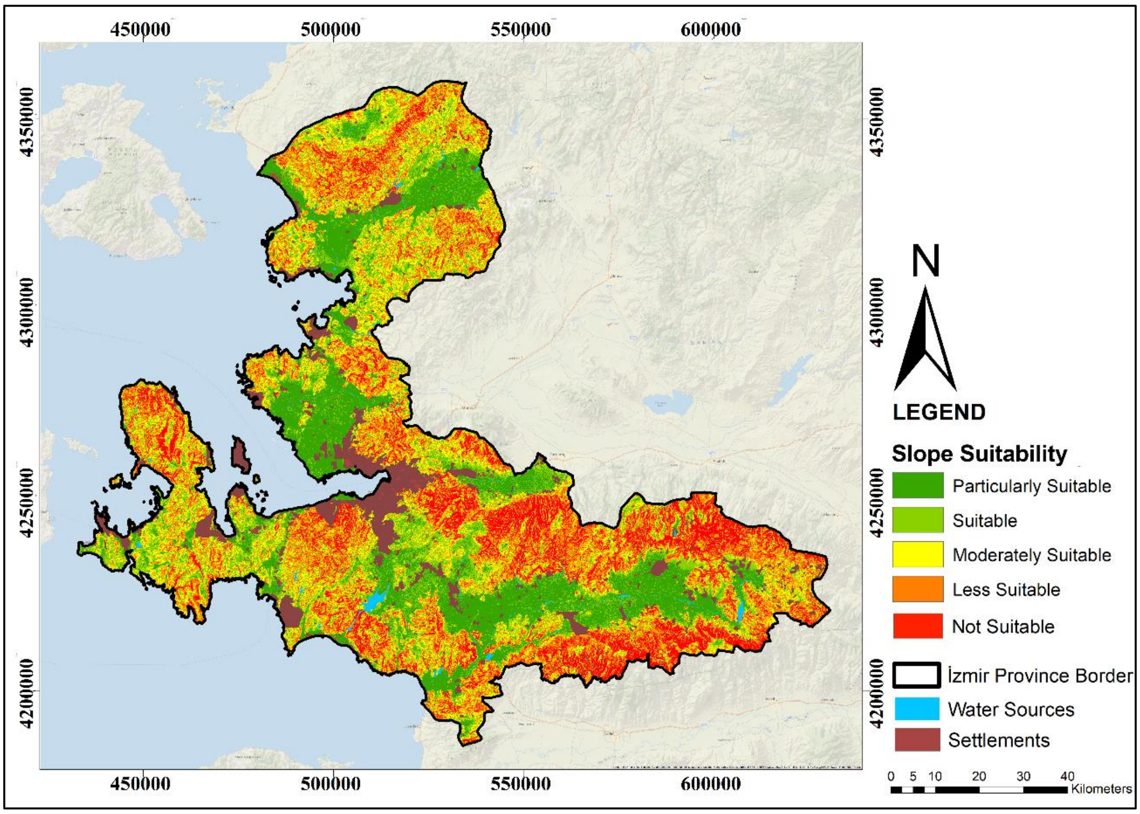


Figure 4.7 Slope Suitability Map

Considering the literature review and expert opinion, areas with slope between 0-2% are particularly suitable, areas between 2-6 % are suitable, areas between 6-12 % are moderately suitable, areas between 12-20 % are less suitable and areas with more than 20% are determined as not suitable. The suitability analysis prepared for the slope criterion is shown in Figure 4.7.

4.2.4. Land Use Capability Sub-Class

While making land capability classification, sub-capability classification is also made by considering the limiting factors. If a problem dominates the area, it is indicated with a symbol next to the land capability class. These classes are:

(e) erosion or susceptibility to erosion

(w) poor drainage, age problem, high groundwater, flooding

(s) root zone limitations (soil shallowness, stoniness, salinity, alkalinity, low moisture-holding capacity, inefficiency etc.)

(c) climatic limitations (insufficient temperature, humidity, frost etc.)

If these limitations are together, LUSCC is expressed with symbols such as ws, es, se, ce etc. (Ministry of Agriculture and Forestry, 2012). The distribution of the areas that cause problems for agricultural areas is one of the important criteria when performing the suitability analysis.

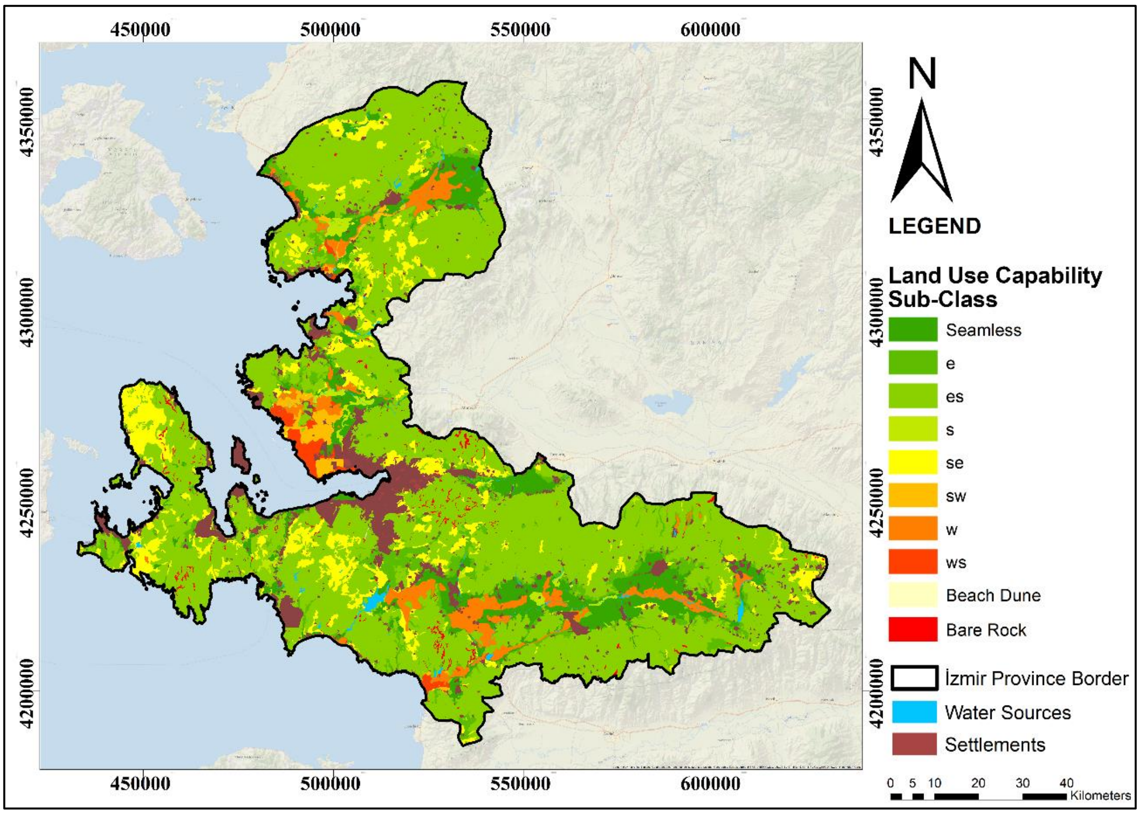


Figure 4.8 Land Use Capability Sub-Class Analysis

(Source: Land Classification Report for İzmir, 2013)

Considering the distribution of land use capability sub-classes, the class with the largest surface area is (es) with 62.14%. Agricultural lands that do not have problems constitute 9.05% of the area.

Table 4.5 Land Use Capability Sub-Class
(Source: Land Classification Report for İzmir, 2013)

Land Use Capability Sub-Class	Area (ha)	Area (%)
Seemless	108,712.42	9.05
e	68,617.36	5.71
es	746,571.55	62.14
s	9,953.26	0.83
se	113,313.43	9.43
sw	14,486.28	1.21
w	53,842.44	4.48
ws	14,043.29	1.17
Beach Dune	174.64	0.02
Riverbed	3,407.29	0.28
Bare Rock	7,960.13	0.66
Lake	4,288.56	0.36
Residential	56,106.90	4.67
	1,201,477.55	100

Although not used under the LUCSC title, in many articles, the problems in describing the classes were considered as criteria. In the literature review, it was observed that the problems above were evaluated as criteria for other soil properties, soil texture or directly as separate criteria (the criteria list can be seen in Table 2.4).

Akıncı et. al. (2013) have mentioned the LUCSC as a title. Areas have problems as “es” (slope and erosion damage, soil inadequacy) and “se” (soil inadequacy, slope and erosion damage) were mentioned as least suitable, and “w” (wetness, inadequate drainage or flood losses) was mentioned as most suitable in the study.

In the literature review and Land Classification Report for İzmir (2013); agricultural lands with no problems were determined to be particularly suitable. While making classifications for problematic areas, literature review was used.

Areas that do not have any problems are classified as particularly suitable. Problem areas based on only one problem were evaluated as suitable within the scope of the study. Agricultural lands that have problems like; “w”, “e”, and “s” suitable; “se”, and “sw” moderately suitable; “es” as less suitable and “ws” not suitable.

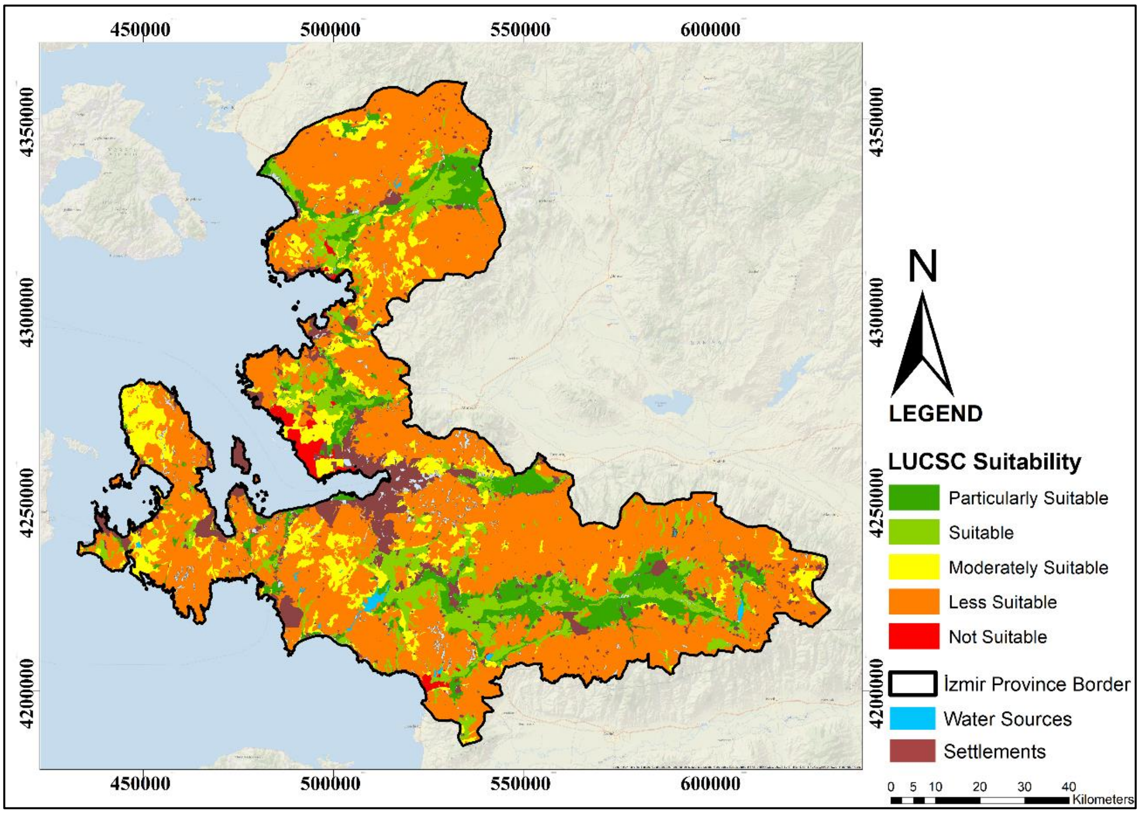


Figure 4.9 Land Use Capability Sub-Class Suitability Map

4.2.5. Aspect

Aspect is one of the main elements for agricultural production. Aspect plays an important role in ecosystem change. Factors such as plant diversity, crop yield, distribution of plant species in the area are related to aspect. (Bale, et al., 1998)

Plants need sunlight at certain times of the day to maintain their life necessities. How much sunlight the plant will need depends on the type of plant. Sunlight is seen mostly in the south and west directions during the day. The optimum growth efficiency of plants is observed in these areas where sunlight is the most. Considering all these reasons, aspect should be considered as an important criterion in the selection of agricultural areas. (Akinci et al., 2013).

Based on the literature review, areas with a flat and south-facing aspect are particularly suitable, areas with a southwest and southeast aspect are suitable, areas with a west and east aspect are moderately suitable, areas with a northwest and northeast aspect are less suitable, and areas with a north aspect are determined as not suitable.

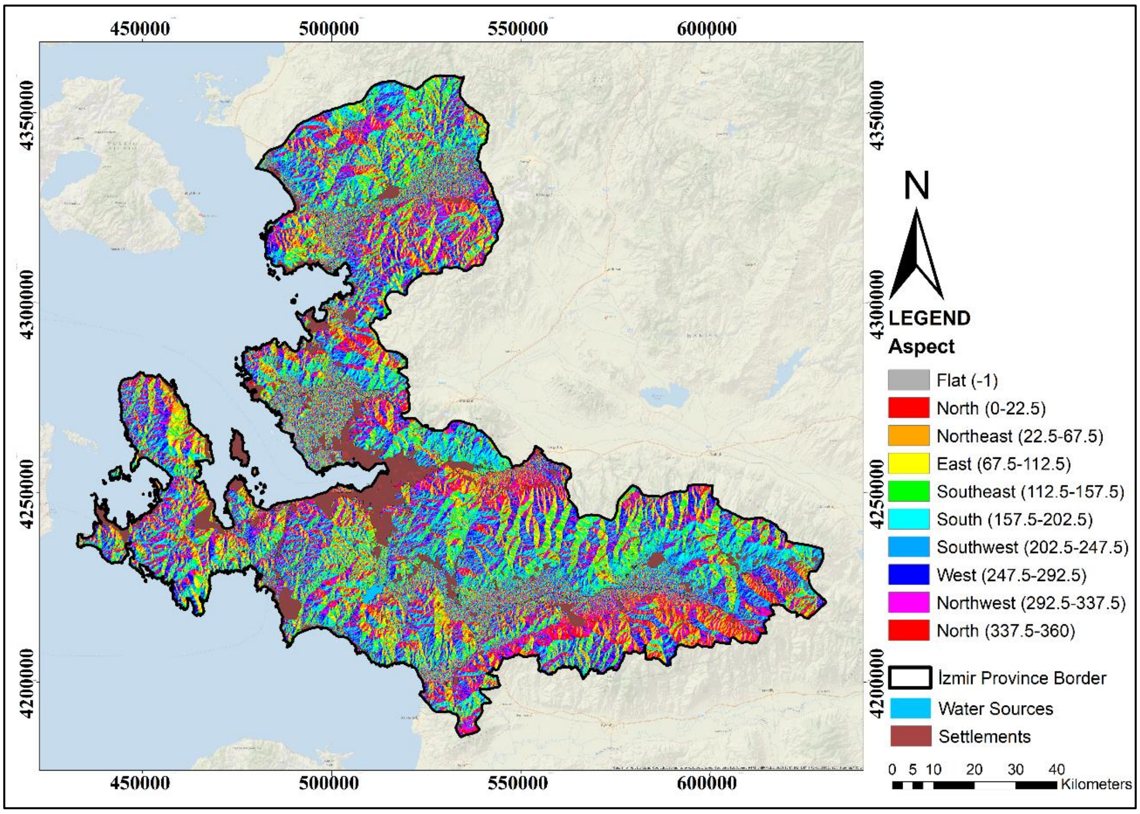


Figure 4.10 Aspect Analysis

(Source: USGS, 2022)

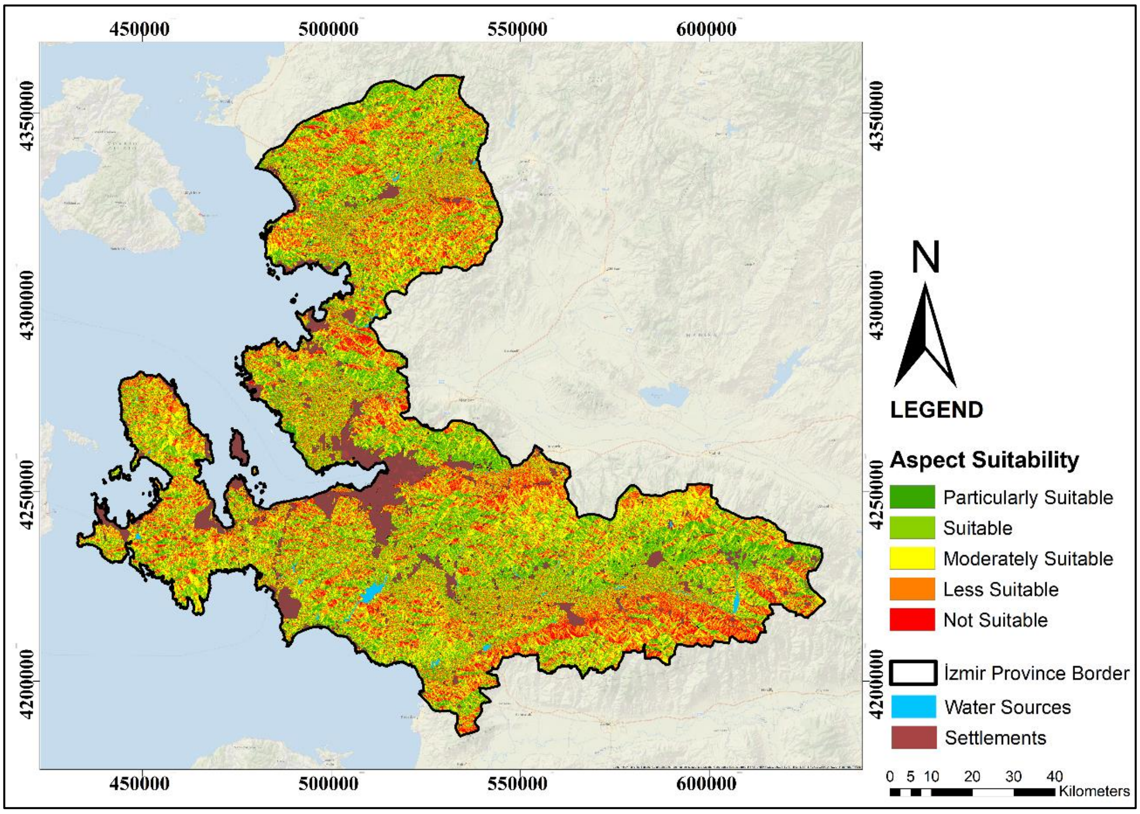


Figure 4.11 Aspect Suitability Map

4.2.6. Elevation

Elevation plays a very important role in plant diversity. There is an inversely proportional relationship between the change in elevation and temperature. The temperature drops 0.5°C for every 100 m increase in elevation. In relation to this situation, there is a delay of 4 to 6 days in the flowering periods of plants for every 100 m increase in height (Atalay, 2006). It is seen in the literature review that the elevation criterion is frequently used when performing suitability analysis for agricultural areas.

For elevation analysis, the digital elevation model (DEM) was obtained from the USGS, ArcGIS interface was used. The lowest elevation in the study area is 0 m, and the highest elevation is 2124 m.

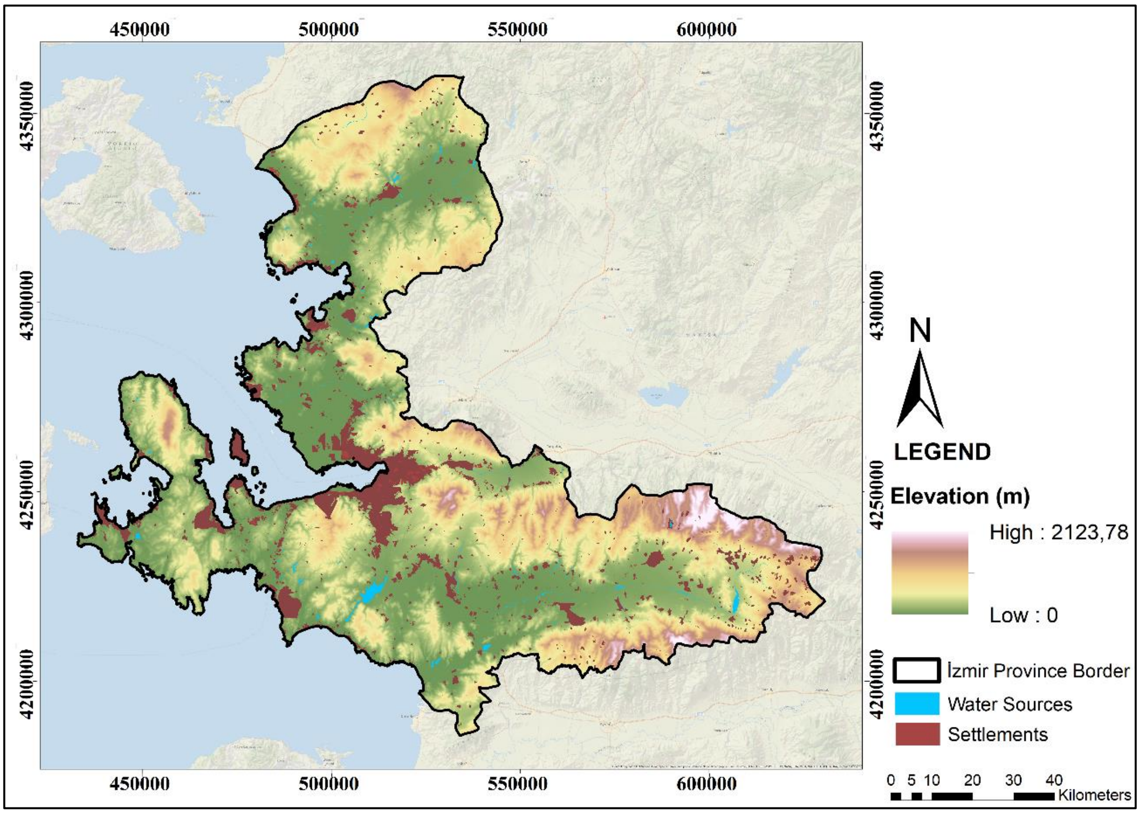


Figure 4.12 Elevation Analysis
(Source: USGS, 2022)

Areas with 0 -150 m elevation are particularly suitable, areas with a 150 – 400 m elevation are suitable, areas with 400 – 700 m elevation are moderately suitable, areas with 700 – 1200 m elevation are less suitable, and areas with more than 1200 m elevation are determined as not suitable. The elevation suitability analysis of the study area can be seen in Figure 4.19.

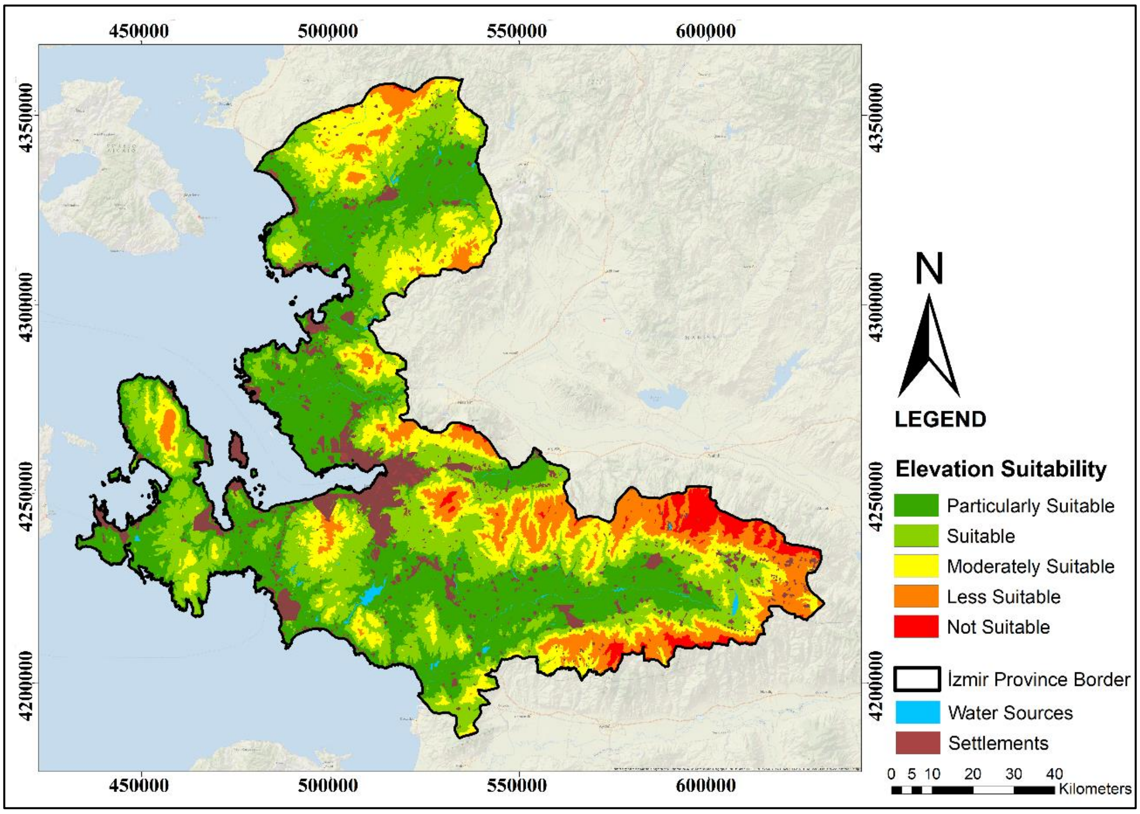


Figure 4.13 Elevation Suitability Map

4.2.7. Precipitation

In terms of agricultural production, precipitation is considered as one of the most basic factors. Annual average precipitation of 400 mm is considered suitable for agricultural production (Jafari and Zaredar 2010).

While preparing the precipitation map of İzmir province, the annual precipitation average data for forty-five stations were obtained from the General Directorate of Meteorology, and the coordinates of each station were recorded on the ArcGIS as points. Inverse distance weighted (IDW) interpolation analysis was used in the ArcGIS interface for annual average precipitation analysis.

The annual average precipitation map obtained as a result of the IDW analysis is shown in Figure 4.14.

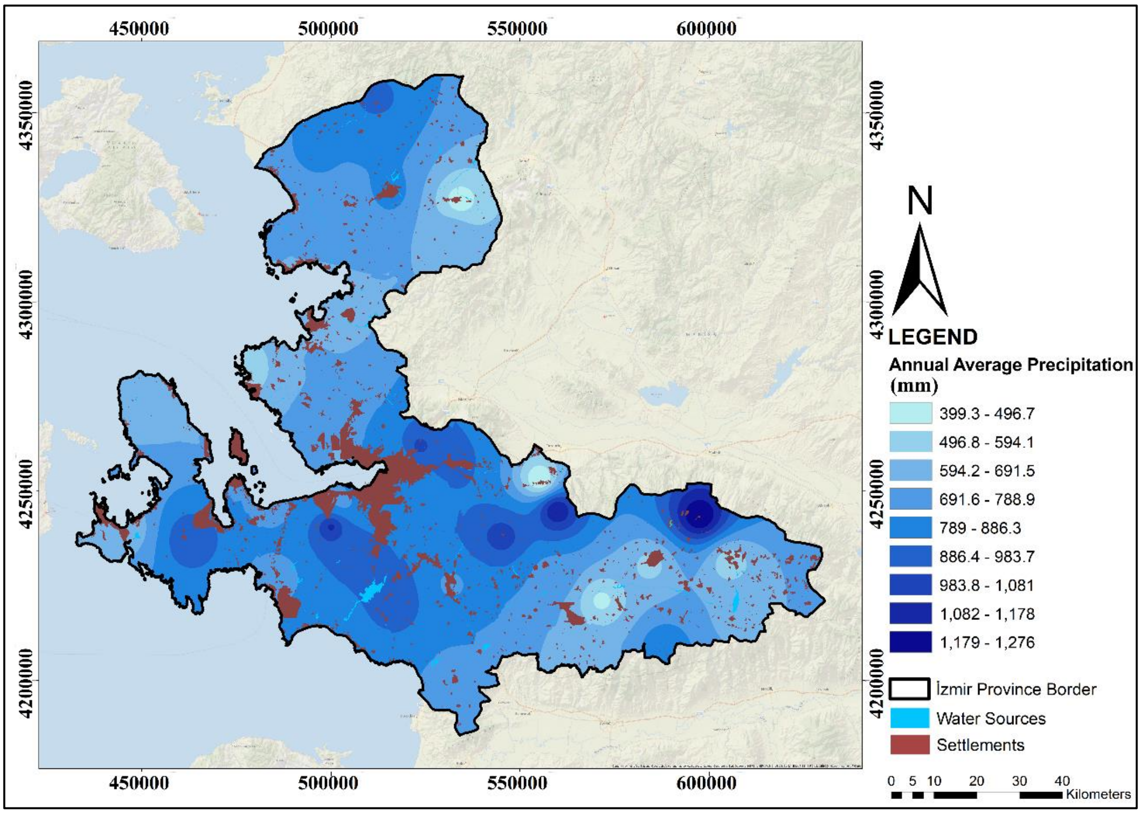


Figure 4.14 Annual Average Precipitation Analysis
(Source: General Directorate of Meteorology, 2021)

The station that recorded the highest annual precipitation value was Bozdağ Ski Resort (1277.2 mm), and the station that recorded the lowest annual precipitation value was Kemalpaşa/Bağyurdu Village (397.7 mm). Perennial precipitation average of İzmir is 713.8 mm (General Directorate of Meteorology, 2021).

Table 4.6 Annual Average Precipitation by Stations
(Source: General Directorate of Meteorology, 2021)

Station Name	Annual Precipitation (mm)
Kemalpaşa/Bağyurdu Village	397.7
Kınık	445.8
Tire	471
Foça Soil Water	527.4
Kiraz	531.1
Ödemiş	559.6
Aliağa	593.8
Karaburun	600.3
Tire/Somak Village	611.9
Çeşme	614.1

(cont. on the next page)

Table 4.6. (cont.)

Kınık/Köseler Village	650
Karşıyaka	654.8
Beydağ	660.1
Dikili	689.4
Bergama/Çamköy	692.2
Aliağa/Bozköy Forest Area	706.6
Menemen	710.6
Seferihisar	728.2
Urla	733.4
Balcova	735.4
Selçuk	738.8
Bayındır	748.9
Bornova/Olive Res. (Tagem)	766.6
Narlıdere	767
Torbalı	770.7
Güzelbahçe	799
Menderes/Gümüldür	806.4
Dikili/Çukuralan Village	818.9
Konak	823
Bergama/İncecikler Forest Area	846.7
Bayraklı	850.8
Bergama	855.6
Buca	855.6
İzmir Region	866.7
Ödemiş/Demirdere Village	874.3
Bergama/Çamavlu Village	921.9
Kemalpaşa	923.8
Menderes Forest Area	953.6
Menderes/Çileme Village	955.1
Urla/Uzunkuyu Forest Area	971.2
Bornova Forest Area	1011
Bayındır / Çınardibi Village	1032.7
İzmir Çatalkaya Radar Field	1097.3
Kemalpaşa/Ovacık Village	1165.4
Bozdağ Ski Resort	1277.2

Analysis shows that the lowest precipitation in İzmir is 399.03 mm. In this case, it is observed that the entire study area is suitable for agricultural production. However, precipitation data were grouped for suitability analysis to determine the most suitable areas for agriculture. Considering the literature review, areas with average annual precipitation between 1000 – 1300 mm are particularly suitable, areas between 850 – 1000 mm are suitable, areas between 750 – 850 mm are moderately suitable, areas between 650 – 750 mm are less suitable and areas with less than 650 mm are determined as not suitable.

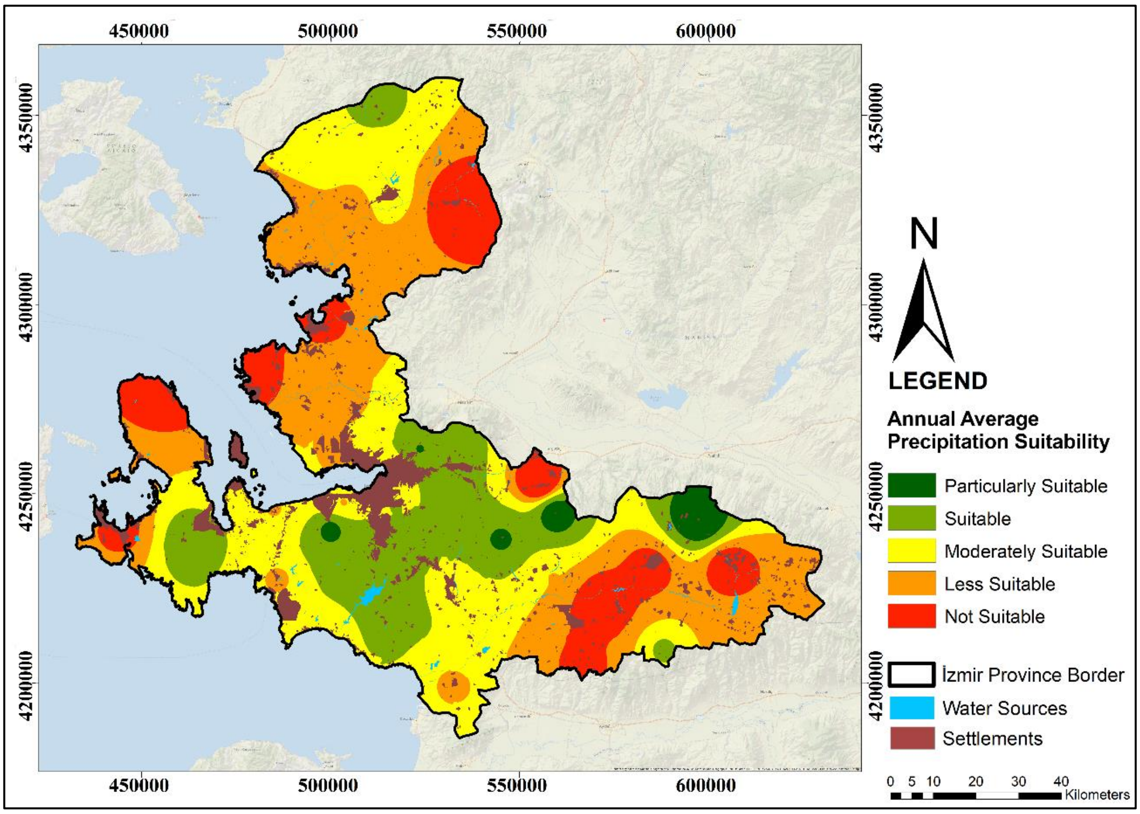


Figure 4.15 Annual Average Precipitation Suitability Map

4.2.8. Temperature

For the suitability analysis of agricultural lands, climatic characteristics such as temperature and precipitation should also be included in the evaluation (Wang, 1994). Plants can generally continue their vital activities between 5 °C - 54 °C. The most suitable growth temperature in terms of agricultural production is between 15 °C - 30 °C (Cengiz, 2003). In the GIS-based study to determine bioclimatic comfort conditions in İzmir, it is seen that comfort decreases in areas where residential areas are dense. It has been concluded that comfort increases in areas where the density of residential areas decreases (Kestane and Ülgen, 2013).

The annual temperature average data for sixty stations were obtained from the General Directorate of Meteorology, and the coordinates of each station were recorded on ArcGIS as points. Inverse distance weighted (IDW) interpolation analysis was used in the ArcGIS interface for annual average temperature analysis.

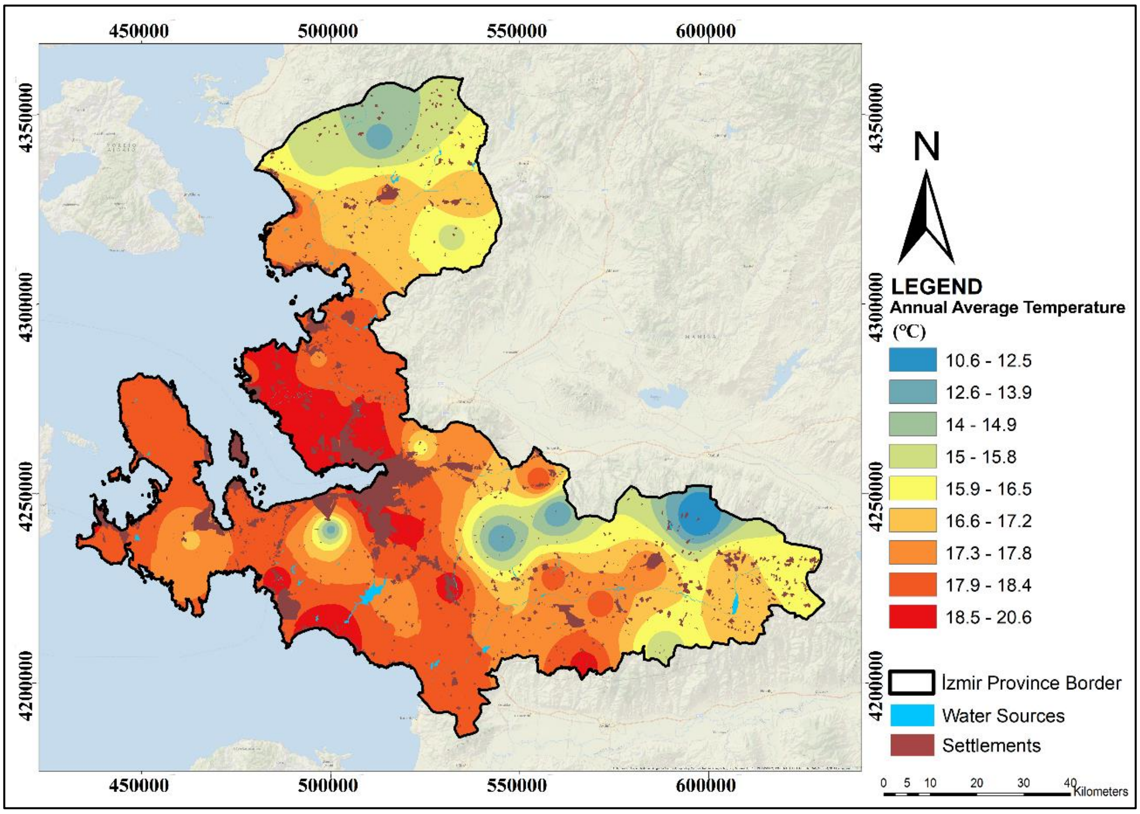


Figure 4.16 Annual Average Temperature Analysis
(Source: General Directorate of Meteorology,2021)

The station that recorded the highest annual temperature value was İzmir Kaklıç Airport (20.6 °C), and the station that recorded the lowest annual temperature value was Bozdağ Ski Resort (10.6 °C). Perennial temperature average of İzmir is 17.9 °C (General Directorate of Meteorology, 2021).

Table 4.7 Annual Average Temperature by Stations
(Source: General Directorate of Meteorology, 2021)

Station Name	Average Temperature (°C)
Bozdağ Ski Resort	10.6
Kemalpaşa/Ovacık Village	12.9
Bayındır / Çınardibi Village	12.9
Bergama/İncecikler Forest Area	13.3
İzmir Çatalkaya Radar Field	13.4
Bergama/Çamavlu Village	14
Dikili/Çukuralan Village	15.1
Ödemiş/Demirdere Village	15.3
Kınık/Köseler Village	15.5
Bornova Forest Area	16.1

(cont. on the next page)

Table 4.7. (cont.)

Beydağ	17
Urla/Uzunkuyu Forest Area	17.1
Kınık	17.1
Bergama/Çamköy	17.1
Kiraz	17.2
Bergama	17.4
Konak	17.4
Menderes/Çileme Village	17.4
Kemalpaşa	17.5
Aliağa Traffic Surveillance Kegm	17.6
Menderes Forest Area	17.6
Aliağa/Bozköy Forest Area	17.6
İzmir Adnan Menderes Airport	17.7
Ödemiş	17.8
Narlıdere	17.8
Balcova	17.8
Dikili	17.9
Buca	17.9
Çiğli Airport	18
Çeşme	18
Güzelbahçe Lighthouse	18
Tire	18
Urla Balıkçı Barınağı Jetty Lighthouse	18.1
Karaburun/Mordoğan Main Jetty (North) Lighthouse	18.1
Foça Soil Water	18.1
Selçuk	18.1
Bayındır	18.1
Aliağa	18.2
Karaburun	18.2
Güzelbahçe	18.2
Narlıdere/ İzmir Bay Point A Light Buoy	18.3
Menemen	18.3
Urla	18.3
Kemalpaşa/Bağyurdu Village	18.3
Çeşme/Kale Yeri Sığ. (Döküntütaşı) Lighthouse	18.5
Foça/Azaplar (Venedik) Kayalığı Lighthouse	18.6
Konak/İzmir Pasaport Jetty Lighthouse	18.6
Seferihisar	18.6
Karşıyaka	18.6
Tİre/Somak Village	18.6
Konak/Alsancak Harbor Lighthouse	18.7
Torbalı	18.7
Bayraklı	18.7
Bornova/Olive Res. (Tagem)	19.1

(cont. on the next page)

Table 4.7. (cont.)

Menderes/Gümüldür	19.2
İzmir Region	19.9
Foça Traffic Surveillance Kegm	19.9
İzmir Gaziemir Airport	20.4
İzmir Kaklıç Airport	20.6

Considering the literature review, areas with average annual temperature areas with less than 12 °C are particularly suitable, areas between 12 – 14 °C are suitable, areas between 14 –16 °C are moderately suitable, areas between 16 – 18 °C are less suitable and 18 – 21 °C are determined as not suitable.

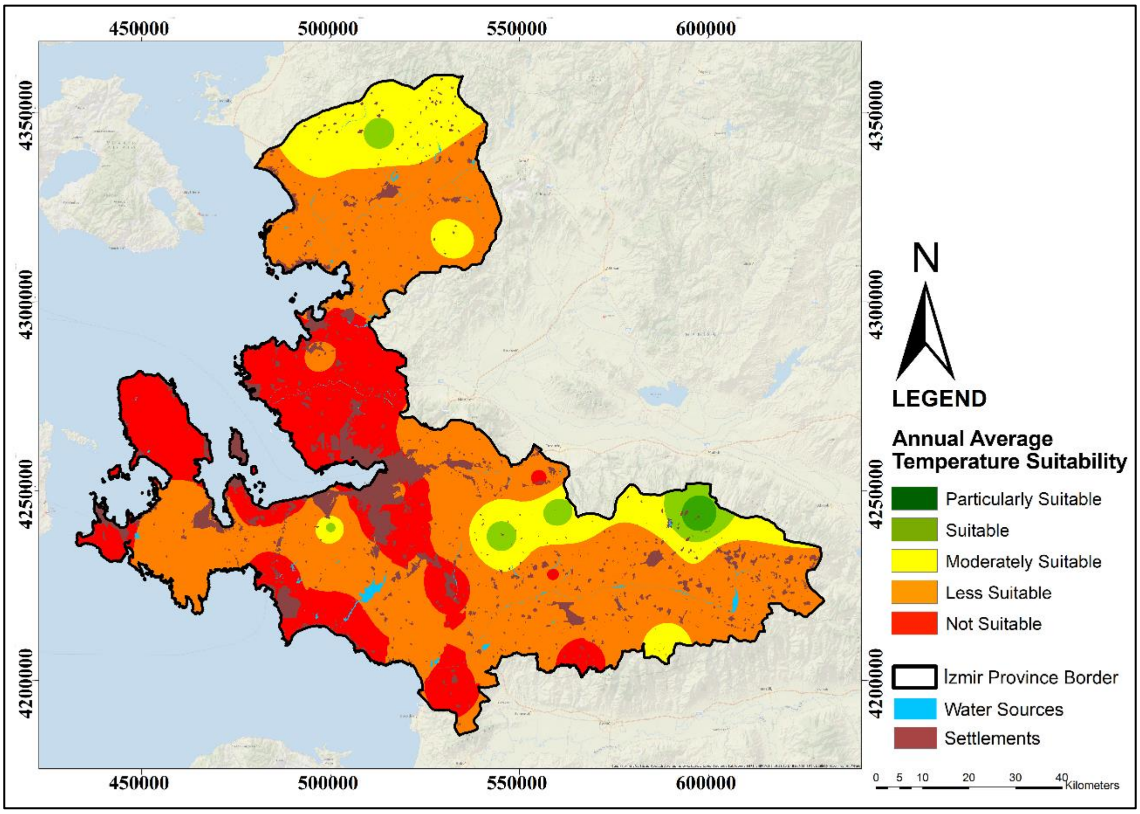


Figure 4.17 Annual Average Temperature Suitability Map

4.2.9. Distance to Irrigation Dams and Lakes

Irrigation conditions are a factor that affects the physiology of plants and the properties of the soil. Supply and management of irrigation water is an important factor for agricultural areas. It is very important to provide sufficient irrigation water in periods when climatic conditions are insufficient. Areas close to water resources are among the most suitable areas for agricultural production (Özşahin et al., 2022). It is important to meet the need for water during periods of insufficient rainfall. In the Aegean region, where the Mediterranean climate is dominant, the precipitation either stops or becomes insufficient after April. This drought usually lasts until mid-October, and in some cases until November (Orhan, 2021).

The distance between agricultural areas and irrigation dams and lakes is a criterion that should be taken into account when performing suitability analysis for agricultural areas. During the study, dams and lakes data were obtained from the State Hydraulic Works. Irrigation dams and lakes were taken into consideration among the data, and proximity was arranged in kilometers with buffer analysis.

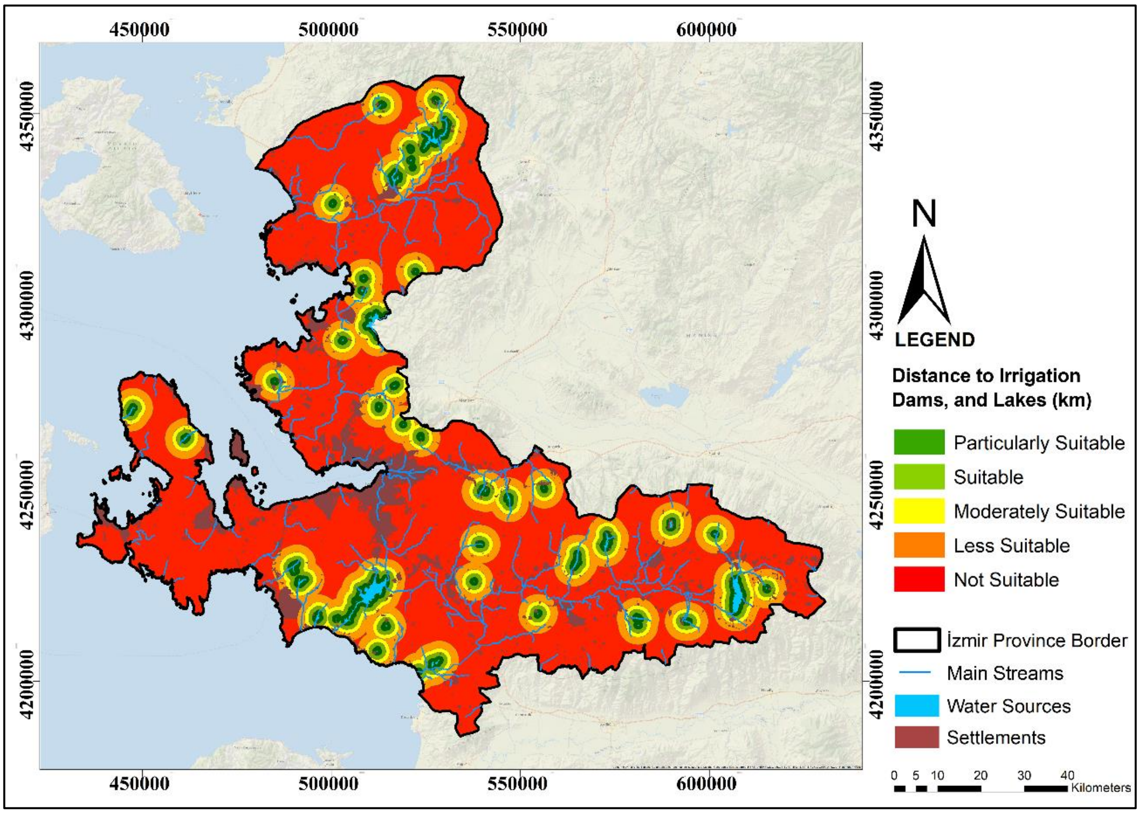


Figure 4.18 Distance to Irrigation Dams, and Lakes Suitability (km)

Considering the literature review and expert opinion, it is decided that areas with distance to dams and lakes between 0 – 1 km are particularly suitable, areas between 1 – 2 km are suitable, areas between 2 – 3 km are moderately suitable, areas between 3 – 5 km are less suitable and areas with more than 5 km are determined as not suitable.

4.2.10. Distance to Main Streams

The deltas of the rivers are the ones with high potential in terms of agricultural production. There are alluvial lands in the areas where the streams flow into the sea, in the flood and accumulation areas of the streams, in the flood areas where the waters are calm and in the old stream beds. Alluvial soils are in the most valuable soil group in terms of agricultural production (Atalay, 2006).

The streams data were obtained by performing hydrology analyzes in the ArcGIS interface with the brew data obtained from the USGS. By making buffer analysis, the areas closest to the rivers were determined as the most suitable areas for agriculture.

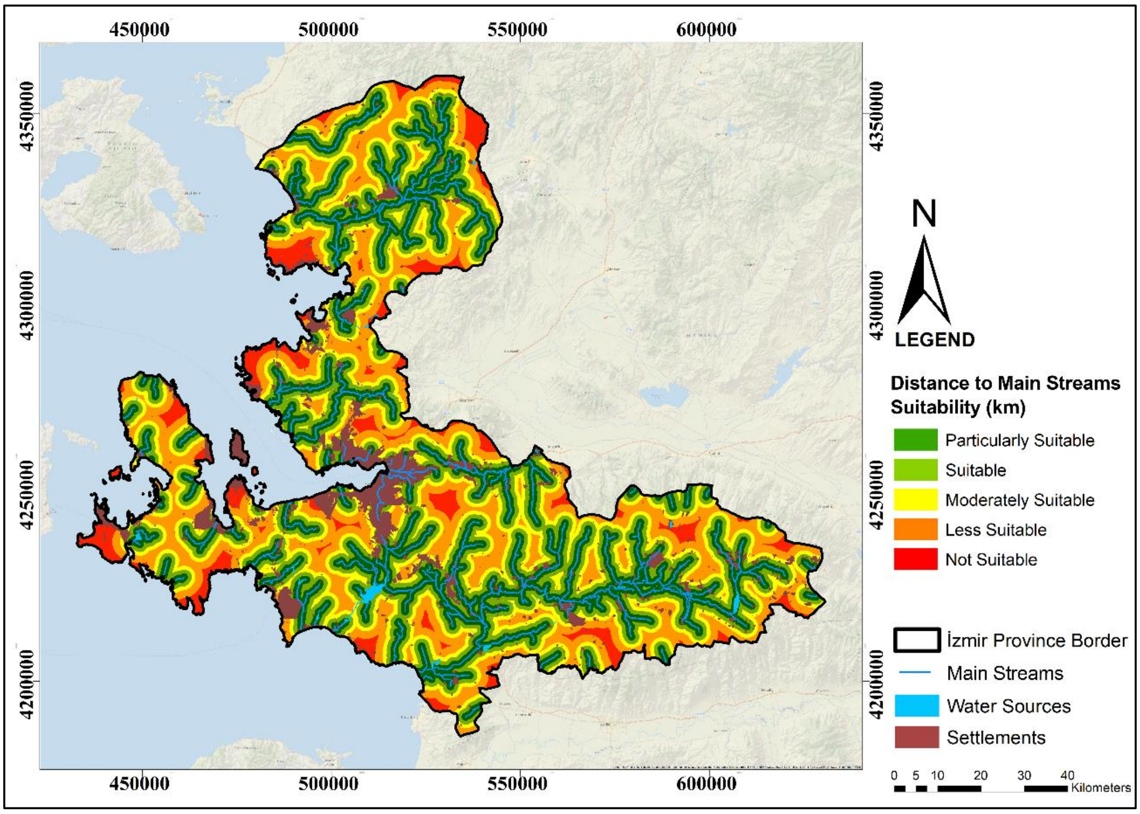


Figure 4.19 Distance to Main Streams Suitability (km)

Considering the literature review and expert opinion, it is decided that areas with distance to main streams between 0 – 1 km are particularly suitable, areas between 1 – 2 km are suitable, areas between 2 – 3 km are moderately suitable, areas between 3 – 5 km are less suitable and areas with more than 5 km are determined as not suitable.

4.2.11. Distance to Settlements

Settlements are potential market areas. Proximity to urban and rural settlements is an economically important factor. The proximity of agricultural areas to market areas plays a role in reducing costs Orhan, 2021). Proximity to settlement areas has been considered as an economic factor in terms of determining agricultural areas. In terms of reducing economic output, the areas closest to the settlement area are considered as the most suitable areas for agricultural areas. The distance to residential areas was determined by applying buffer analysis.

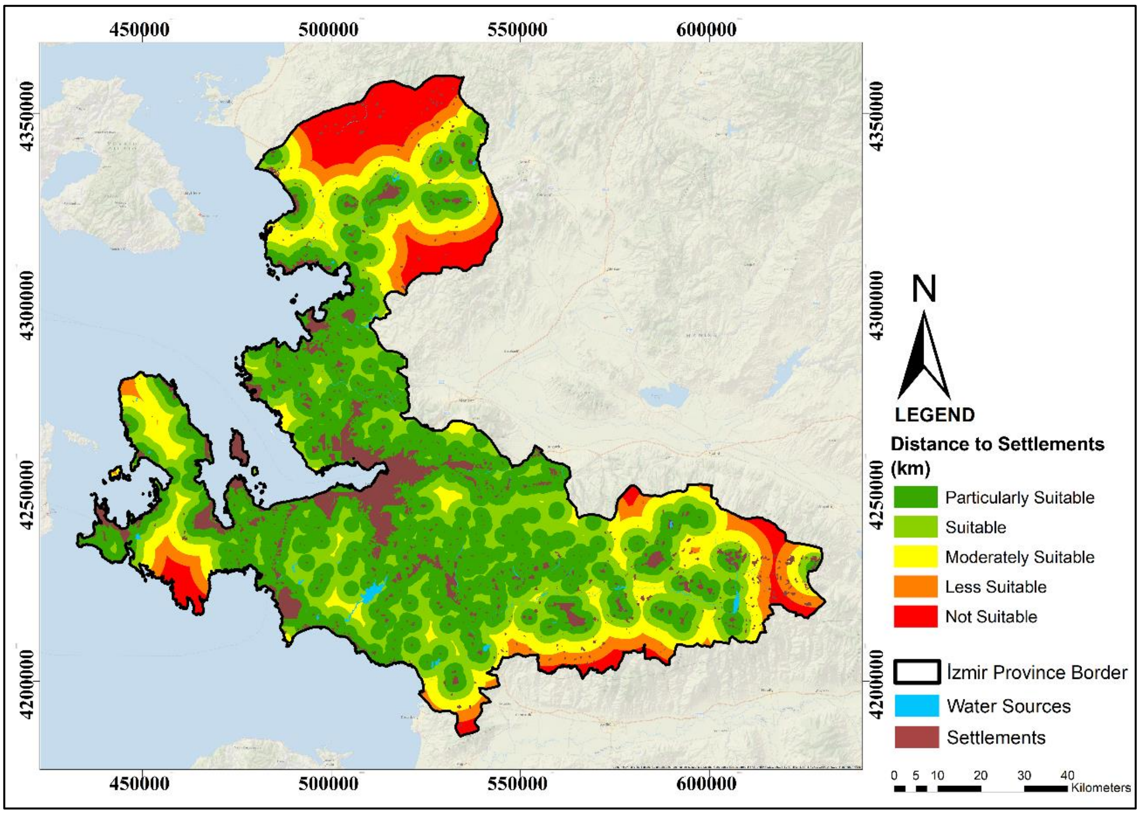


Figure 4.20 Distance to Settlements Suitability (km)

Considering the literature review, it is decided that areas with distance settlements between 0 – 2 km are particularly suitable, areas between 2 – 4 km are suitable, areas between 4 – 7 km are moderately suitable, areas between 7 – 10 km are less suitable and areas with more than 10 km are determined as not suitable.

4.2.12. Distance to Main Roads

The proximity of agricultural areas to main roads is an economically important criterion. Proximity to the road comes to the fore in terms of minimizing production, transportation, maintenance, etc. costs. There should also be a buffer zone between the road and the agricultural fields. This buffer zone is necessary to minimize negative environmental impacts (Tercan and Dereli, 2020).

During the study, the minimum value for buffer analysis was determined as 30 m. Distance to highways is considered as an economic factor. The areas closest to the main roads, that is, the areas where transportation costs will be low, have been determined as the areas with the highest value for agricultural areas.

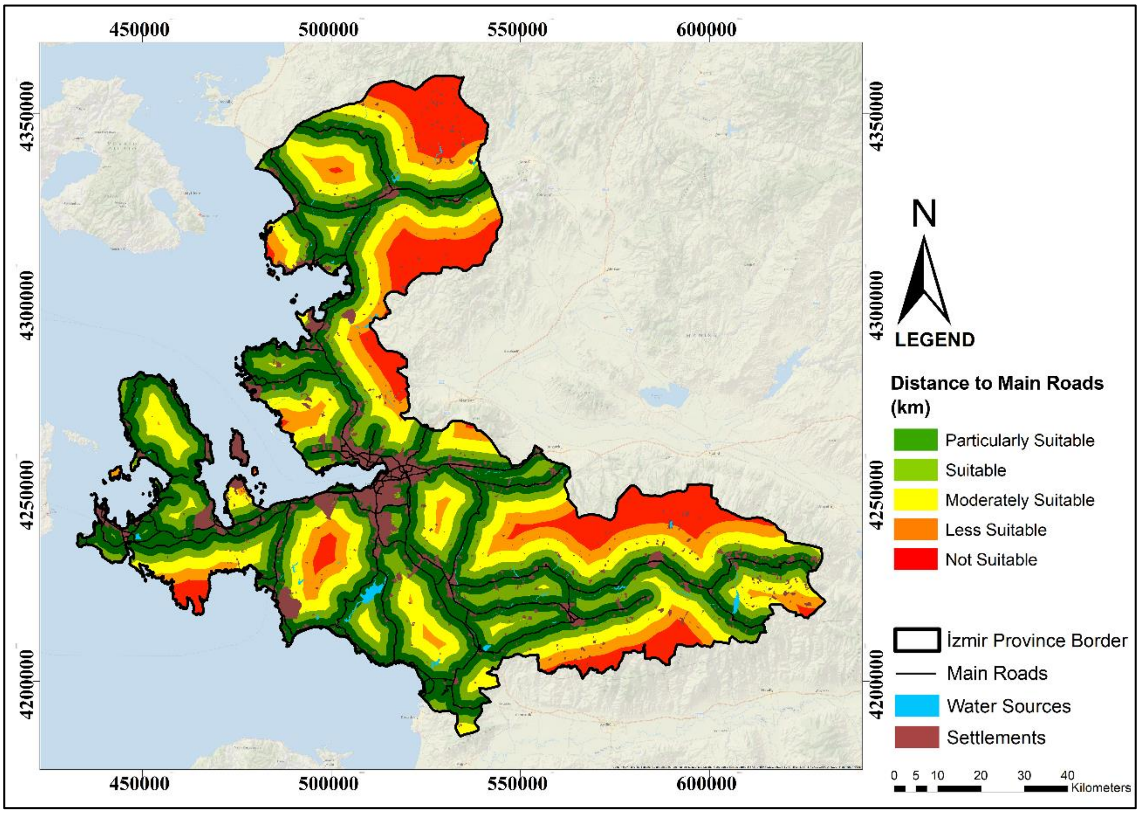


Figure 4.21 Distance to Main Roads Suitability (km)

Considering the literature review, it is decided that areas with distance main roads between 0.03 – 2 km are particularly suitable, areas between 2 – 4 km are suitable, areas between 4 – 7 km are moderately suitable, areas between 7 – 10 km are less suitable and areas with more than 10 km are determined as not suitable.

4.3. Criteria Weights

After completing the suitability analyzes for each criterion, the data obtained will be analyzed in the GIS environment and suitability maps for agricultural areas will be obtained. The first suitability memory will be created by the overlay method, while the second suitability map will be obtained using the weighted overlay method. The literature review shows that the issue of determining the weights in the suitability analysis for agricultural areas is mostly done with the AHP method. In this study, the AHP method will be used to determine the weights. There is more than one method to compare the criteria with the AHP method. In this study, Saaty's relative importance scale between the two alternatives will be used (table 2.2).

First, a pairwise comparison matrix was created for each criterion. In the table, the comparison of each criterion with other criteria and their values and relative importance according to this comparison were determined by considering the literature review.

The criterias are as follows.

1. Great Soil Groups
2. Soil Depth
3. Slope
4. Land Use Capability Sub-Class
5. Aspect
6. Elevation
7. Precipitation
8. Temperature
9. Distance to Irrigation Dams, and Lakes
10. Distance to Main Streams
11. Distance to Settlements
12. Distance to Main Roads

Table 4.8 Comparison Matrix (Assuming Criterion 1 is superior to Criterion 2)

	Criteria 1	**Criteria 2**
Criteria 1	1	Numerical Rating
Criteria 2	1/Numerical Rating	1

The matrix of the pairwise comparison table was prepared according to the criteria determined for the study. The criteria in the headings in the rows were compared with the criteria in the headings in the columns.

Table 4.9 Developed matrix of the pairwise comparison of the criteria

Criteria	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00	3.00	4.00	5.00	5.00	6.00	6.00	6.00	6.00	6.00	8.00	9.00
2	0.33	1.00	2.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	7.00	8.00
3	0.25	0.50	1.00	3.00	3.00	4.00	5.00	6.00	5.00	5.00	7.00	9.00
4	0.20	0.33	0.33	1.00	2.00	3.00	4.00	5.00	4.00	5.00	6.00	8.00
5	0.20	0.25	0.33	0.50	1.00	2.00	4.00	5.00	3.00	4.00	6.00	8.00
6	0.17	0.25	0.25	0.33	0.50	1.00	3.00	3.00	3.00	4.00	5.00	7.00
7	0.17	0.20	0.20	0.25	0.25	0.33	1.00	2.00	2.00	2.00	5.00	6.00
8	0.17	0.20	0.17	0.20	0.20	0.33	0.50	1.00	2.00	2.00	5.00	6.00
9	0.17	0.17	0.20	0.25	0.33	0.33	0.50	0.50	1.00	1.00	4.00	4.00
10	0.17	0.17	0.20	0.20	0.25	0.25	0.50	0.50	1.00	1.00	4.00	4.00
11	0.13	0.14	0.14	0.17	0.17	0.20	0.20	0.20	0.25	0.25	1.00	2.00
12	0.11	0.13	0.11	0.13	0.13	0.14	0.17	0.17	0.25	0.25	0.50	1.00
Total	3.05	6.33	8.94	14.03	16.83	21.59	29.87	34.37	33.50	36.50	58.50	72.00

Comparisons were made in pairs for each criterion. As a result of these comparisons, values between 1 and 9 points were given to the criteria. A score of 1 means equally important, while a score of 9 means extremely important.

The resulting table is normalized. For this normalization, the sum of the column values of the pair-wise matrix is divided by the sum of the row values. Thus, a normalized pair-wise matrix table is obtained. The sums of this normalized matrix column are divided by the number of criteria.

Table 4.10 Standardization/normalization, average/weights

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	Total	Average
1	0.33	0.47	0.45	0.36	0.30	0.28	0.20	0.17	0.18	0.16	0.14	0.13	3.16	26.34%
2	0.11	0.16	0.22	0.21	0.24	0.19	0.17	0.15	0.18	0.16	0.12	0.11	2.01	16.79%
3	0.08	0.08	0.11	0.21	0.18	0.19	0.17	0.17	0.15	0.14	0.12	0.13	1.72	14.36%
4	0.07	0.05	0.04	0.07	0.12	0.14	0.13	0.15	0.12	0.14	0.10	0.11	1.23	10.28%
5	0.07	0.04	0.04	0.04	0.06	0.09	0.13	0.15	0.09	0.11	0.10	0.11	1.02	8.52%
6	0.05	0.04	0.03	0.02	0.03	0.05	0.10	0.09	0.09	0.11	0.09	0.10	0.79	6.60%
7	0.05	0.03	0.02	0.02	0.01	0.02	0.03	0.06	0.06	0.05	0.09	0.08	0.53	4.43%
8	0.05	0.03	0.02	0.01	0.01	0.02	0.02	0.03	0.06	0.05	0.09	0.08	0.48	3.96%
9	0.05	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.03	0.03	0.07	0.06	0.37	3.07%
10	0.05	0.03	0.02	0.01	0.01	0.01	0.02	0.01	0.03	0.03	0.07	0.06	0.36	2.97%
11	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.18	1.52%
12	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.14	1.16%
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		

(cont. on the next page)

Table 4.10 (cont.)

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0.26	0.50	0.57	0.51	0.43	0.40	0.27	0.24	0.18	0.18	0.12	0.10	3.77
2	0.09	0.17	0.29	0.31	0.34	0.26	0.22	0.20	0.18	0.18	0.11	0.09	2.44
3	0.07	0.08	0.14	0.31	0.26	0.26	0.22	0.24	0.15	0.15	0.11	0.10	2.09
4	0.05	0.06	0.05	0.10	0.17	0.20	0.18	0.20	0.12	0.15	0.09	0.09	1.46
5	0.05	0.04	0.05	0.05	0.09	0.13	0.18	0.20	0.09	0.12	0.09	0.09	1.18
6	0.04	0.04	0.04	0.03	0.04	0.07	0.13	0.12	0.09	0.12	0.08	0.08	0.88
7	0.04	0.03	0.03	0.03	0.02	0.02	0.04	0.08	0.06	0.06	0.08	0.07	0.56
8	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.04	0.06	0.06	0.08	0.07	0.49
9	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.06	0.05	0.39
10	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.06	0.05	0.37
11	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.19
12	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.15

To test the reliability of the AHP analysis, the calculation of the consistency ratio is performed.

Table 4.11 Weighted of Total and Average Values

Criteria	Weighted of Total Values	Weighted of Criterias (Average)	Total / Average
1	3.77	0.26	14.31
2	2.44	0.17	14.51
3	2.09	0.14	14.58
4	1.46	0.10	14.18
5	1.18	0.09	13.86
6	0.88	0.07	13.41
7	0.56	0.04	12.75
8	0.49	0.04	12.34
9	0.39	0.03	12.56
10	0.37	0.03	12.40
11	0.19	0.02	12.65
12	0.15	0.01	12.75

Table 4.12 Random Consistency Index (RCI) (Saaty, 1987)

n	3	4	5	6	7	8	9	10	11	12	13	14	15
RCI	0.58	0.89	1.12	1.24	1.33	1.40	1.45	1.49	1.511	1.54	1.56	1.57	1.59

Table 4.13 CI, RI and CR Values for Main Criteria

CI=(λmax-n)/(n-1)	RI=This is a table value (for n = 1.536)	CR=CI/RI

Consistency Index	Random Consistency Index	Consistency Ratio
CI	RCI	CI/RI
0.123513702	1.536	0.080
CR should be smaller than 0.10		<0.10

AHP method was applied for the criteria and the consistency ratio was obtained as 0.08. According to Saaty (1978), when applying the AHP method, 0.1 is considered appropriate for the consistency ratio (CR).

As a result of the pairwise comparisons, the CR was calculated as 0.080. Since the CR value obtained is less than 0.1, it can be said that the results are reliable. The weights obtained in the results will be applied in the weighted overlay analysis to be performed in the GIS environment.

Table 4.14 Weight of Criteria

Criteria		**Weight (%)**
1	Great Soil Groups	26.34%
2	Soil Depth	16.79%
3	Slope	14.36%
4	Land Use Capability Sub-Class	10.28%
5	Aspect	8.52%
6	Elevation	6.60%
7	Precipitation	4.43%
8	Temperature	3.96%
9	Distance to Irrigation Dams, and Lakes	3.07%
10	Distance to Main Streams	2.97%
11	Distance to Settlements	1.52%
12	Distance to Main Roads	1.16%

The first suitability analysis will be obtained by using the overlay method, while the second suitability analysis will be obtained with the weighted overlay method using the weights obtained using the AHP method.

CHAPTER 5

RESULTS AND DISCUSSIONS

Suitability analyzes were completed by considering the literature review, data from the provincial directorate of agriculture, data from the general directorate of meteorology, state water works, and DEM data obtained from the USGS and the unique characteristics of the region. As a result of the studies, the determination of suitable areas for agricultural areas was carried out based on GIS. In the study process, the process of collecting, organizing, converting to raster data, weighting, and completing the suitability analyzes were carried out using ArcGIS 10.7.1 software.

5.1. Suitability Maps for Agricultural Areas

In the process of reaching the resultant maps, firstly an overlay analysis was applied, in which all criteria were equally weighted. All criteria were used at 30 x 30 m resolution. This result map shows the suitability analysis that can be obtained if all criteria were used with equal weight. During the study, settlement areas and water resources were not added to the overlay process.

The weight calculation process with the AHP method was carried out with the Microsoft Excel program. The criteria were discussed one by one with the pairwise comparison method. All suitability analyses obtained were arranged in the ArcGIS environment with 30 x 30 m spatial resolution. The weights obtained by the AHP method for each suitability analyses were transferred to the GIS environment through the weighted overlay analysis. In the weighted overlaying process, the weights were entered into the table one by one. The weighted overlay method gives reliable results because it considers each criterion according to the degree of importance. By processing the weights in the overlay tool, the final map of the most suitable areas for agricultural areas was obtained.

By processing the weights obtained using the AHP method in the registration process of the raster data, the final map of the most suitable areas for agricultural lands was obtained. Five categories were determined for the twelve criteria used in this study. The resulting maps were also evaluated over five categories.

5.1.1. The First Suitability Map

The first result map was created by running the twelve criteria with equal weights.

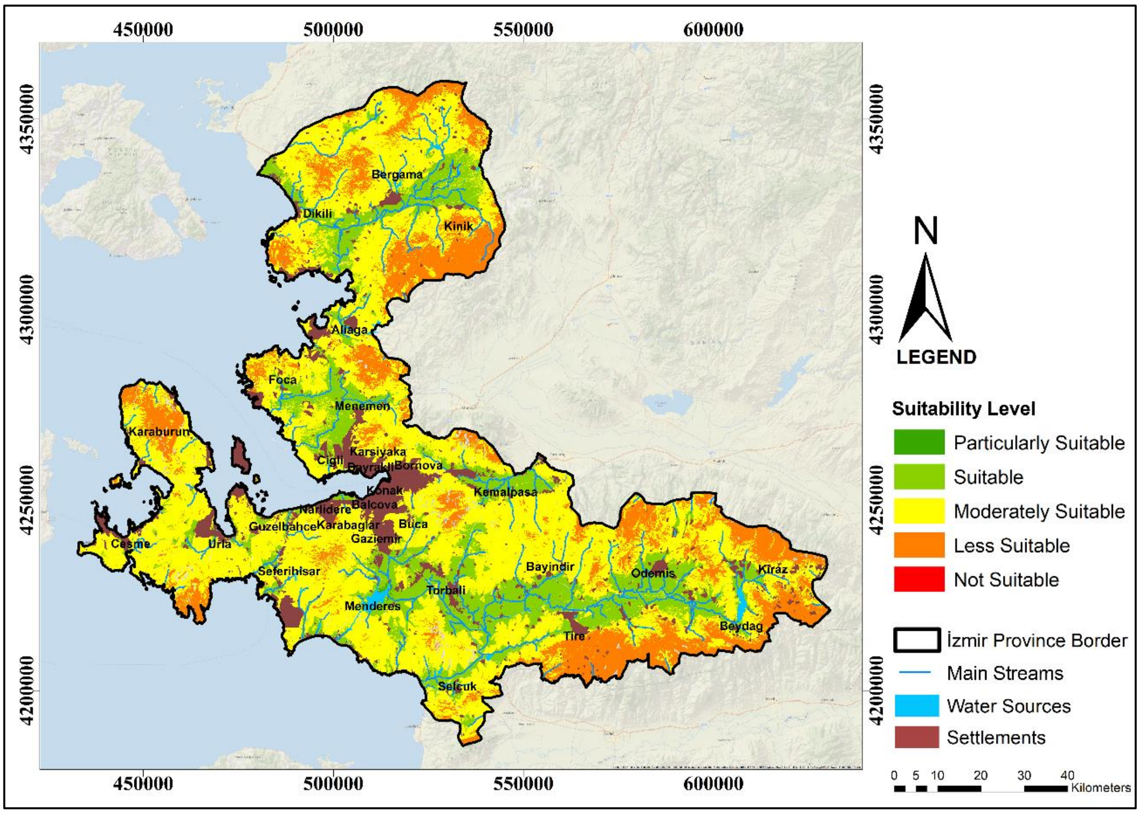


Figure 5.1 The First Suitability Map

Table 5.1 Areas of the First Suitability Map

	Suitability Class	Area (km²)	Area (%)	Area(ha)
1	Particularly Suitable	6.00	0.05	599.85
2	Suitable	2432.47	21.7	243247.05
3	Moderately Suitable	6627.30	59.2	662730.03
4	Less Suitable	2127.74	19.0	212773.5
5	Not Suitable	0.20	0.002	20.16
Total		11193.71		1119370.59

Table 5.2 Percentage of Suitability Classes for the First Suitability Map

Suitability Class	Area (%)
1st and 2nd class	21.78
3rd class	59.21
4th and 5th class	19.01

According to the first suitability map obtained, it is seen that 6 km² of the area are the most suitable areas for agricultural lands. Particularly suitable and suitable areas cover 21.7 % of the study area. 19.0% of the area was determined as less suitable and not suitable. 59.21% of the area is moderately suitable.

5.1.2. The Second Suitability Map

The second result map was created by running the criteria with weights obtained from the AHP analysis.

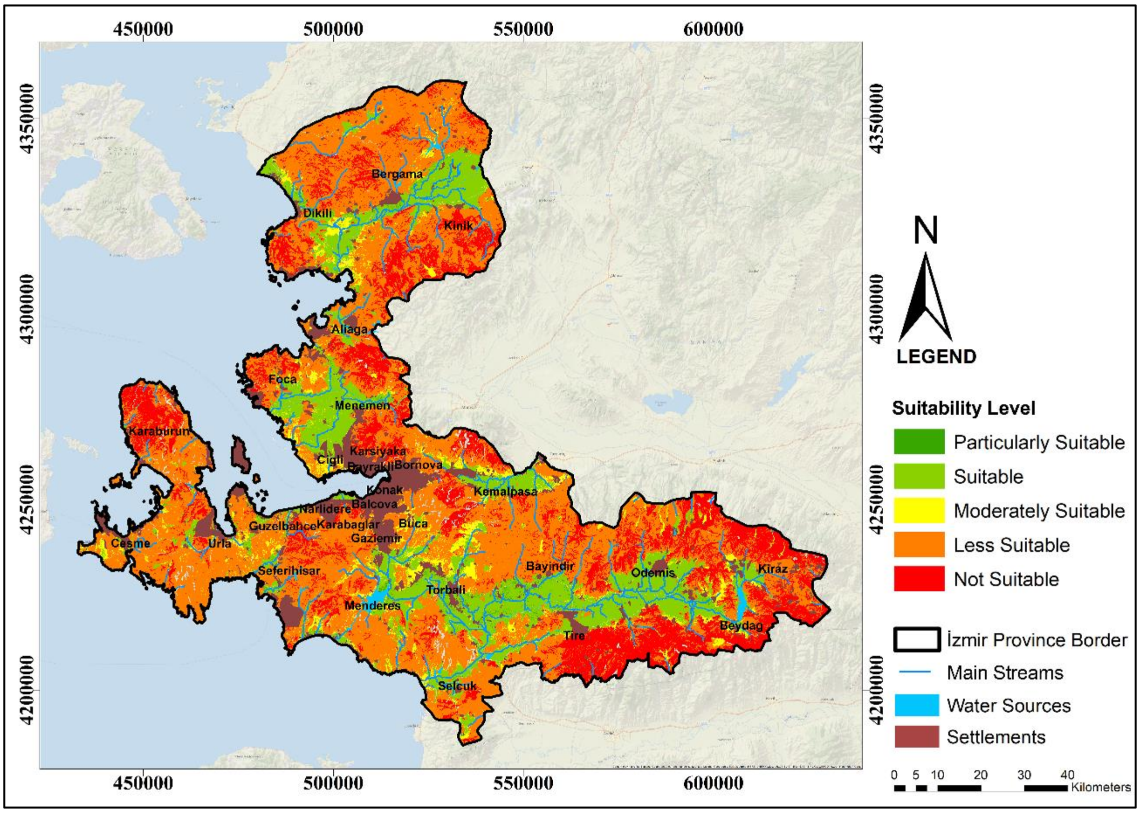


Figure 5.2 The Second Suitability Map

Table 5.3 Areas of Second the Suitability Map

Suitability Class		Area (km²)	Area (%)	Area(ha)
1	Particularly Suitable	47.55	0.42	4754.79
2	Suitable	2236.05	19.98	223604.55
3	Moderately Suitable	630.21	5.63	63020.52
4	Less Suitable	5945.47	53.11	594546.84
5	Not Suitable	2334.44	20.85	233443.89
Total		11194	100	1119370.59

Table 5.4 Percentage of Suitability Classes for the Second Suitability Map

Suitability Class	Area (%)
1st and 2nd class	20.4
3rd class	5.6
4th and 5th class	74.0

According to the first suitability map obtained, it is seen that 48 km² of the area are the most suitable areas for agricultural lands. The particularly suitable and the suitable areas cover 20.4% of the study area. 5.6% of the area was determined as less suitable and not suitable. 65.8% of the area is moderately suitable.

5.1.3. Comparison Between the Suitability Maps

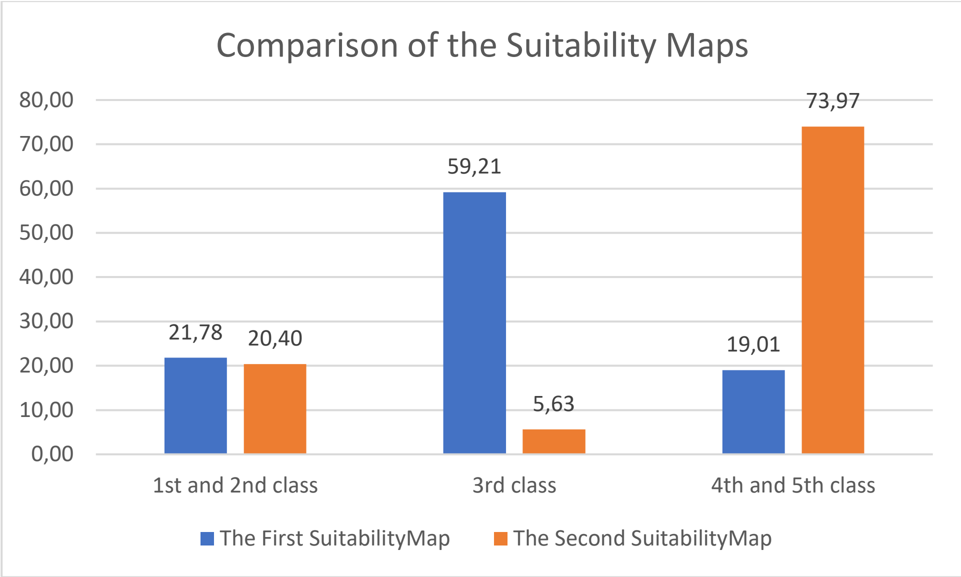
According to the suitability maps, the most suitable areas for agricultural production are in the north and east of the settlement area and in the north and south of the study area. In both result maps, the particularly suitable and the suitable areas for agriculture are similar to each other (Figure 5.3).

In the suitability analysis obtained by the weighted overlay method, 1st and 2nd degree suitable areas have a rate of 20.4%. In the suitability analysis obtained by using equal weights, 1st and 2nd degree suitable areas have a rate of 21.8%.

The percentage of areas determined as moderately suitable as a result of the first analysis is 59.21. The suitability map obtained as a result of the second analysis gives sharper results in terms of suitability degrees. Moderately suitable, less suitable and not suitable areas differ clearly between the two maps. The differences between the numerical values are clearly seen in the areal distribution.

When the first suitability map was examined in detail, it was observed that some areas that were not/less suitable in terms of soil properties resulted in moderately suitable in first suitability map. The same areas resulted as less/not suitable in the second suitability analysis. In line with the comparisons made between the two maps, and the suitability analysis it is concluded that the second suitability analysis is more reliable.

Base-map, settlement areas, water sources main, streams, main roads etc. was not used for clarity of the figures while making comparisons.



Graph 5.1 Comparison Between the Suitability Maps

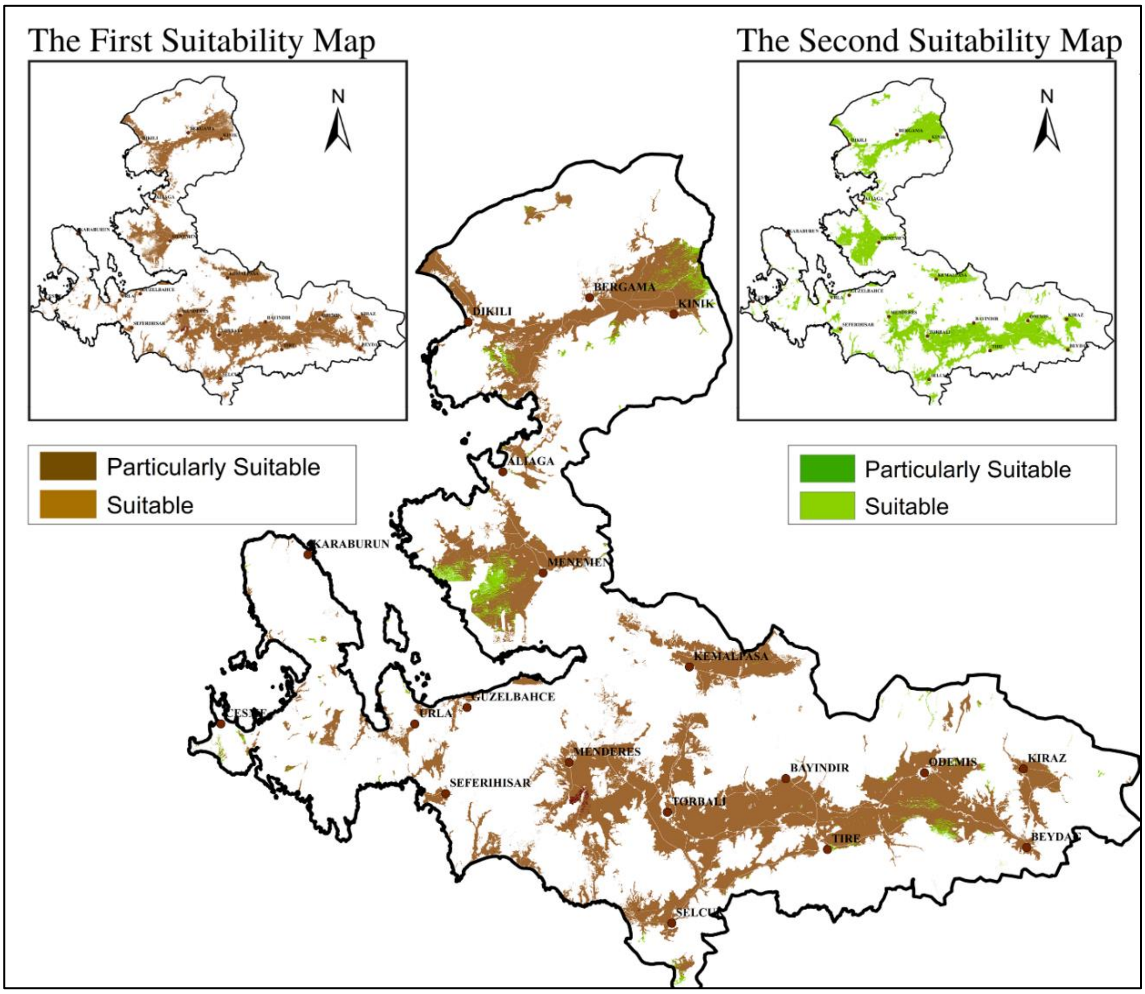


Figure 5.3 Comparison Between the Suitability Maps

When the suitability maps are compared, it is seen that the first- and second-degree suitable areas are concentrated in similar regions. When the area size was compared between the two maps, it was calculated that particularly suitable areas were 4155 hectares more in the second analysis.

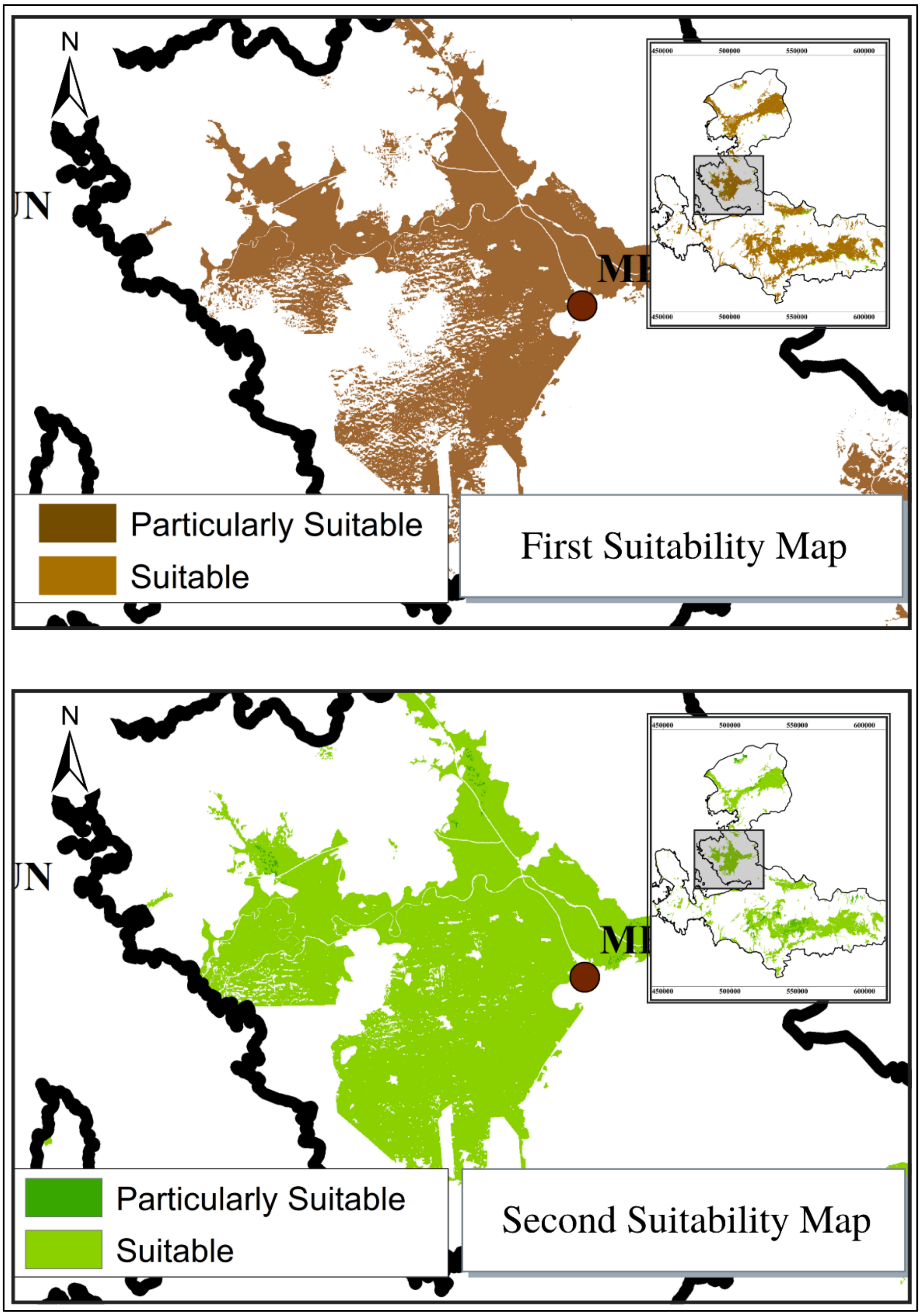


Figure 5.4 Comparison Between the Suitability Maps - Example Area (Gediz Basin)

According to the suitability map obtained by the weighted overlay method, it is seen at some areas the first- and second-degree suitable areas are more integrated. It is observed that when the weights are taken equally, more fragmented agricultural areas are obtained (Figure5.4). The results obtained without weighting according to the importance of the criteria can be misleading. This can have a negative impact on the management and protection of agricultural lands. Since the second suitability map is more reliable, the second suitability map is preferred for comparisons to be made.

5.2. Comparison Between the Suitability Map and Current Situation

While making the current situation and comparison process, with the second suitability analysis, the CORINE land cover classification, the 1/100000 scale environmental plan and the areas determined according to the technical instruction of the law no 5403 were compared. The densest areas among the areas suitable for agriculture were examined more closely. Areas examined more closely are shown in Figure 5.5. Base-map was not used for clarity while making comparisons.

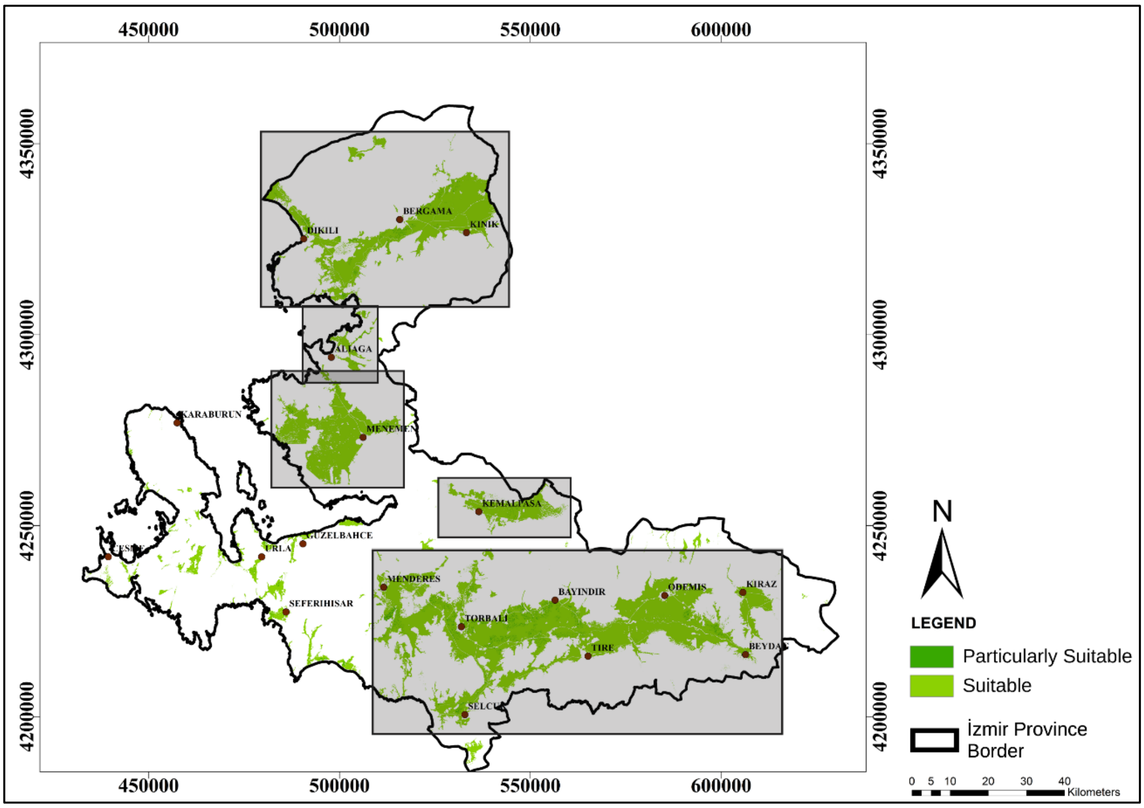


Figure 5.5 The most suitable areas for agriculture

5.2.1. Comparison Between the Suitability Map and the Environmental Plan of İzmir

The obtained suitability map was examined together with the environmental plan. Agricultural areas are based on the law no. 5403 in the 1/100000 scaled environmental plan. When the suitability analysis and the environmental plan are compared, it is observed that the most suitable areas for agriculture in the suitability map remain within the border of the agricultural areas in the environmental plan.

The most suitable areas for agriculture obtained in the suitability analysis were evaluated together with the industrial zones, residential areas, development residential areas in the 1/100000 Scaled Environmental Plan's decisions.

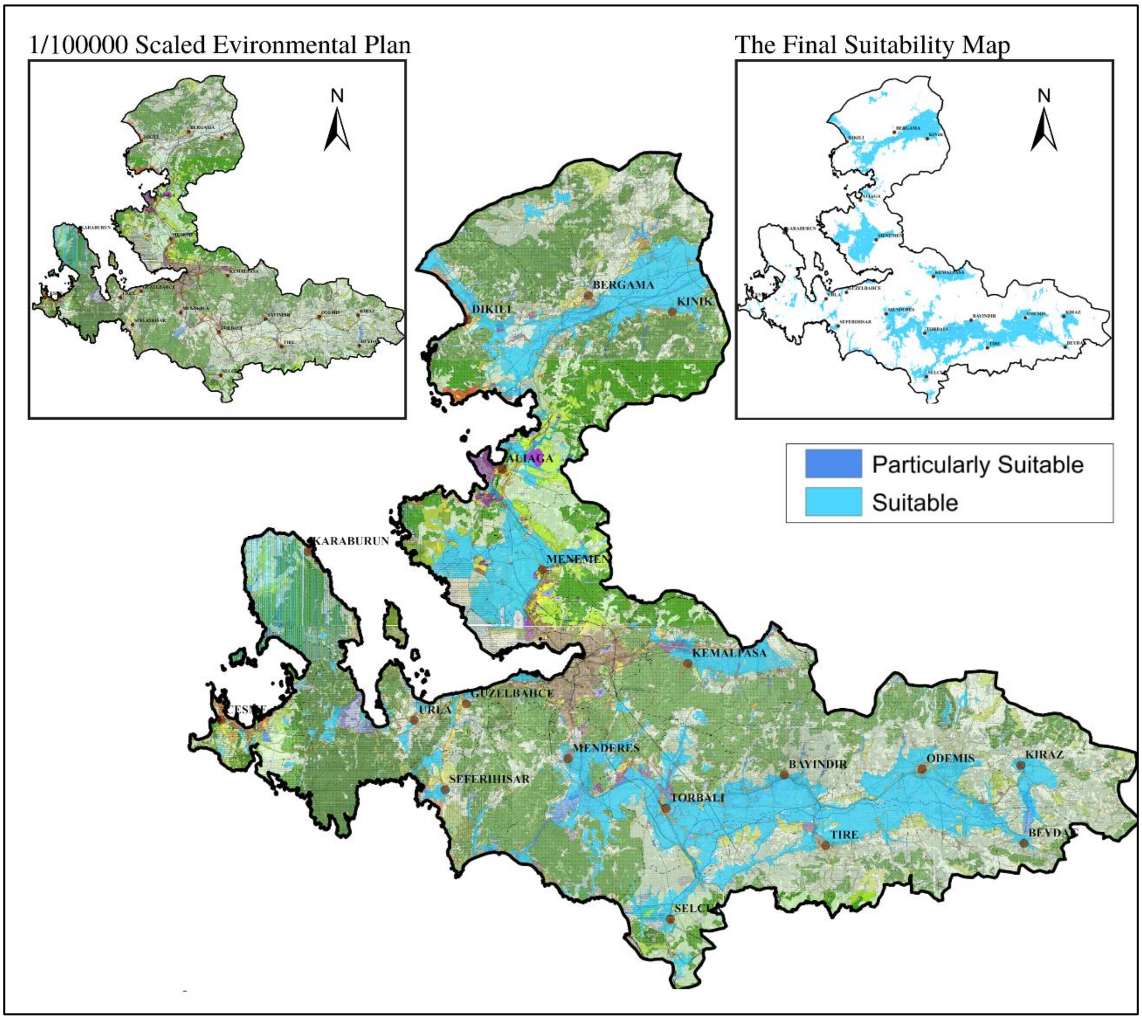


Figure 5.6 Comparison Between the Second Suitability Map and the 1/100000 Scaled Environmental Plan of İzmir

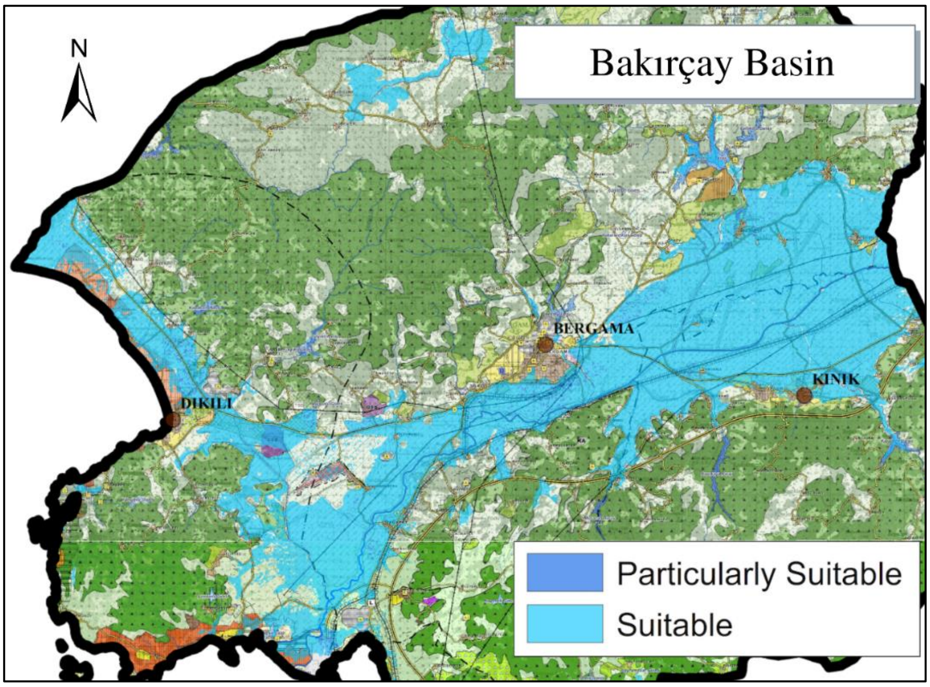


Figure 5.7 Comparison of the Bakırçay Basin with 1/100000 Scaled Environmental Plan

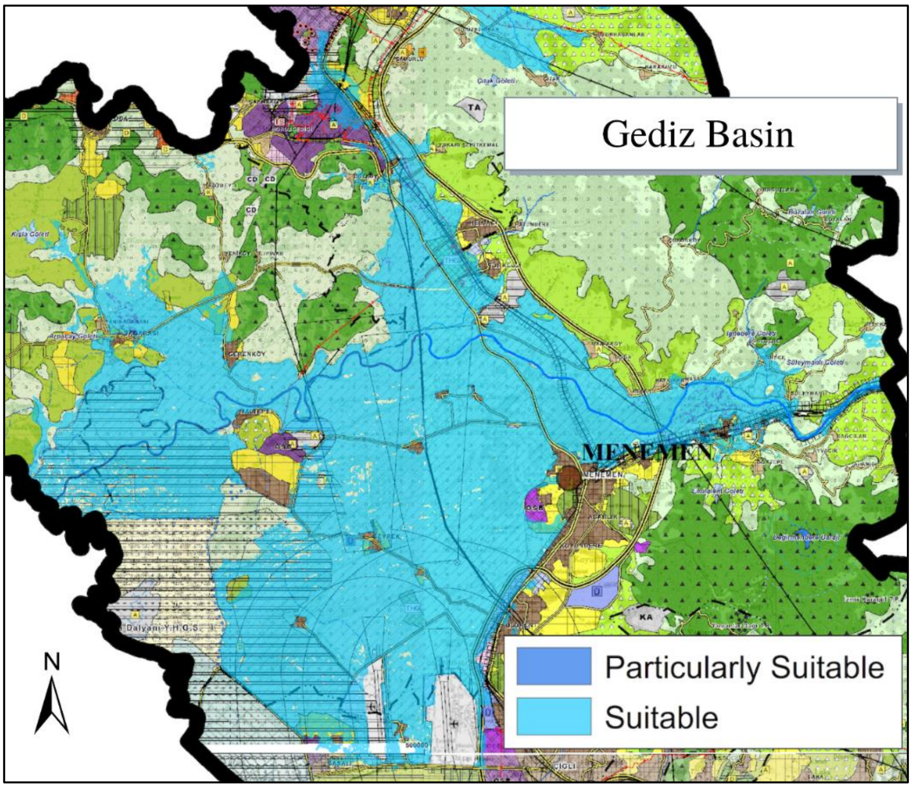


Figure 5.8 Comparison of the Gediz Basin with 1/100000 Scaled Environmental Plan

When the Bakırçay basin is examined in detail, it is observed that the urban development areas are in the direction of the areas determined as suitable for agricultural areas. In particular, the development residential areas of the Kınık district were determined for the most suitable areas for agriculture in the north. There are two OIZs between Bergama and Dikili districts. While one of these OIZs remains in the most suitable area for agriculture, the other OIZ is adjacent to agricultural areas.

The most suitable areas for agriculture obtained as a result of the analyzes in the Gediz basin are in the directions where the urban development areas are determined in the plans. There are two OIZs in the south of suitable agricultural areas and one OIZ in the middle of the most suitable agricultural areas in the west. The OIZ, which is between the wildlife development area and the agricultural areas, also includes urban development areas.

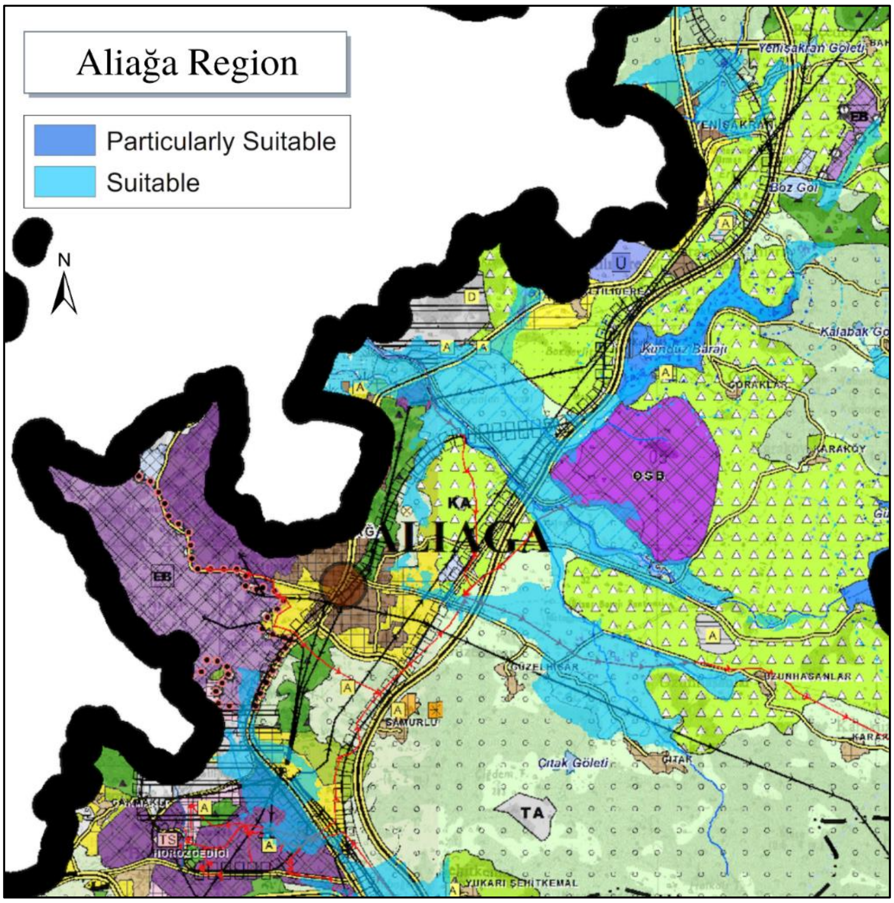


Figure 5.9 Comparison of the Aliağa Region with 1/100000 Scaled Environmental Plan

As can be seen in the comparison map, there is an OIZ right next to the most suitable areas for agriculture in Aliağa. The proximity of the OIZ to the water source is also noteworthy. Some urban development areas are spilling over into areas most suitable for agriculture.

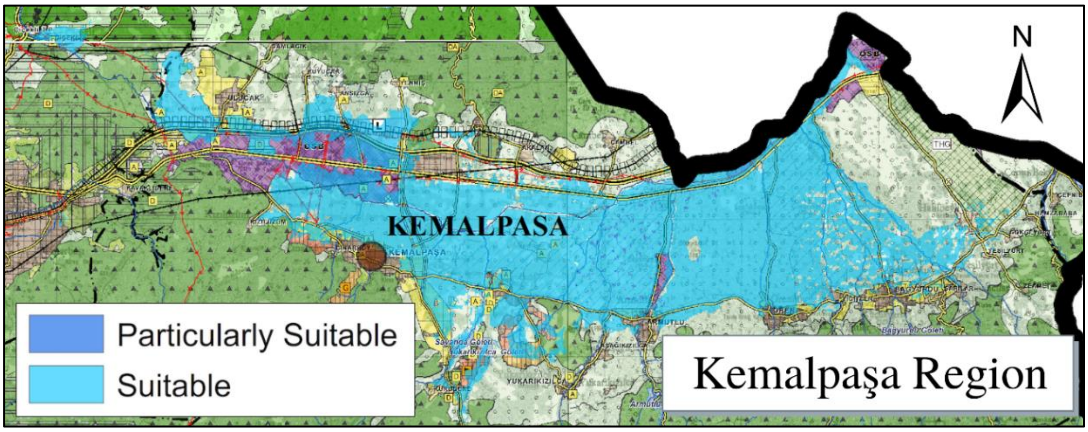


Figure 5.10 Comparison of the Kemalpaşa Region with 1/100000 Scaled Environmental Plan

When Kemalpaşa region is examined closely, it is observed that there are two OIZs on the eastern and western borders of the areas determined as suitable for agriculture. The OIZ, located in the west, is in the most suitable area for agriculture. In the center of Kemalpaşa district, urban development areas are determined in the direction of agricultural areas. The urban development areas in the neighborhoods such as Yiğitler, Bağyurdu, Sarılar, Ören, which are located in the southeast of the agricultural areas outside the district center, are towards the most suitable areas for agriculture. A similar situation is observed in the west of the area.

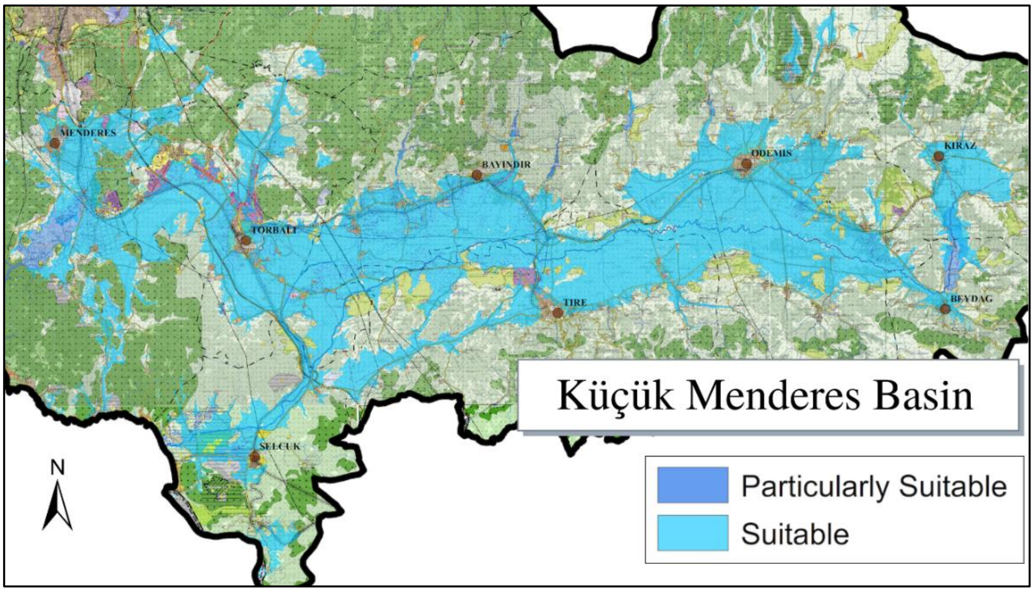


Figure 5.11 Comparison of the Küçük Menderes Basin 1/100000 Scaled Environmental Plan

There are a total of five OIZs around the Küçük Menderes basin. There are two OIZs in the west of the areas determined as the most suitable for agricultural areas. These

OIZs are located between Menderes and Torbalı districts, dividing suitable agricultural areas. There is one OIZ, which is the center of agricultural lands, between Tire and Bayındır district centers in the south. The urban development areas of all district centers in the area are indicated towards the most suitable areas for agriculture.

5.2.2. Comparison Between the Suitability Map and Law No: 5403

A comparison was made between the suitability map for agricultural lands and the absolute agricultural areas in the Law No. 5403. Absolute agricultural lands are the most productive lands in terms of agricultural production. Since the suitability map determines the most suitable areas for agricultural lands, it is compared with the areas that appear as absolute agricultural land in the legal sense. In the comparison of absolute agricultural areas and the most suitable areas for agriculture, it was observed that the areas obtained as a result of the suitability analysis had a more sprawled structure.

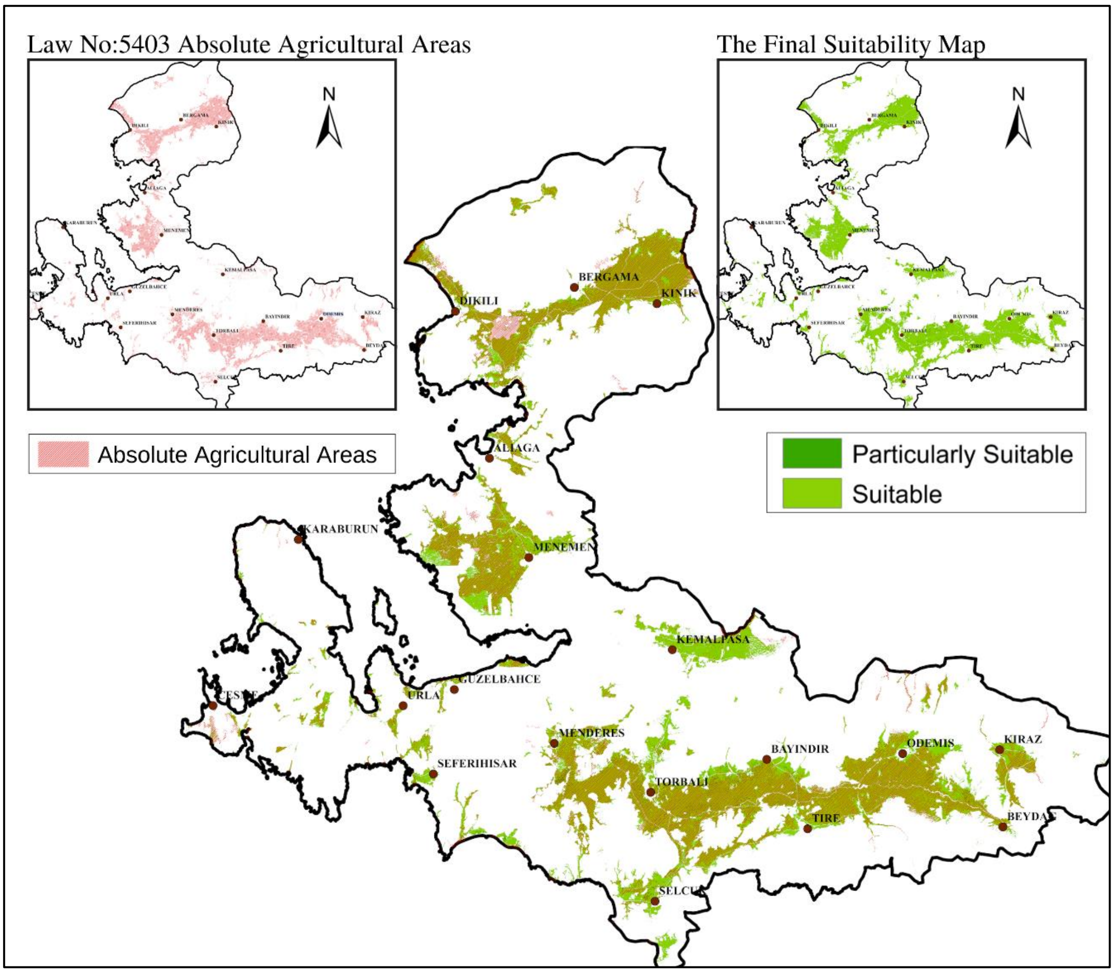


Figure 5.12 Comparison Between the Second Suitability Map and Law No:5403

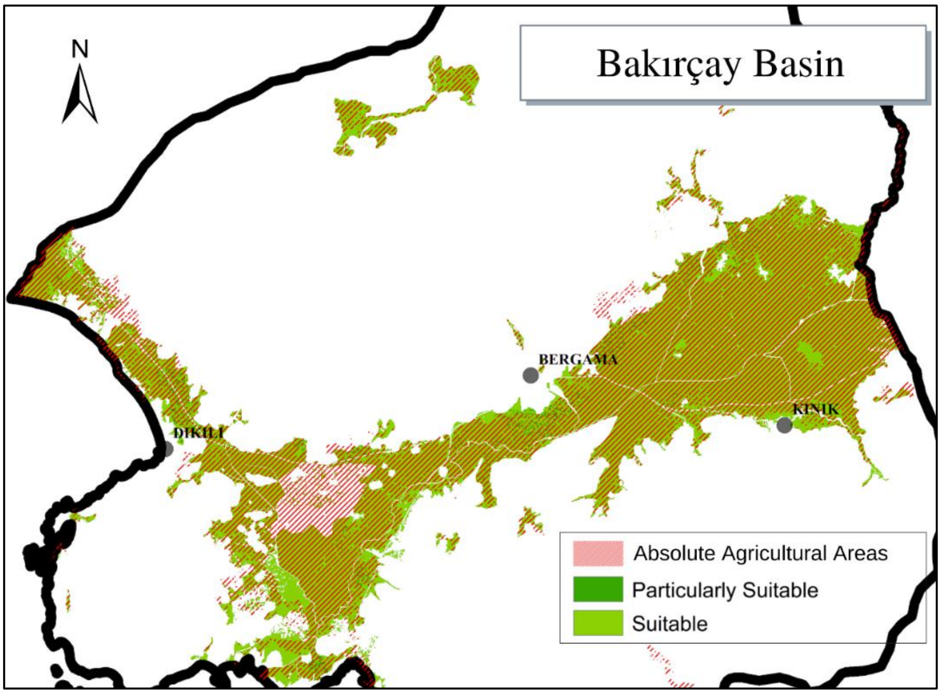


Figure 5.13 Comparison of the Bakırçay Basin with Law No:5403

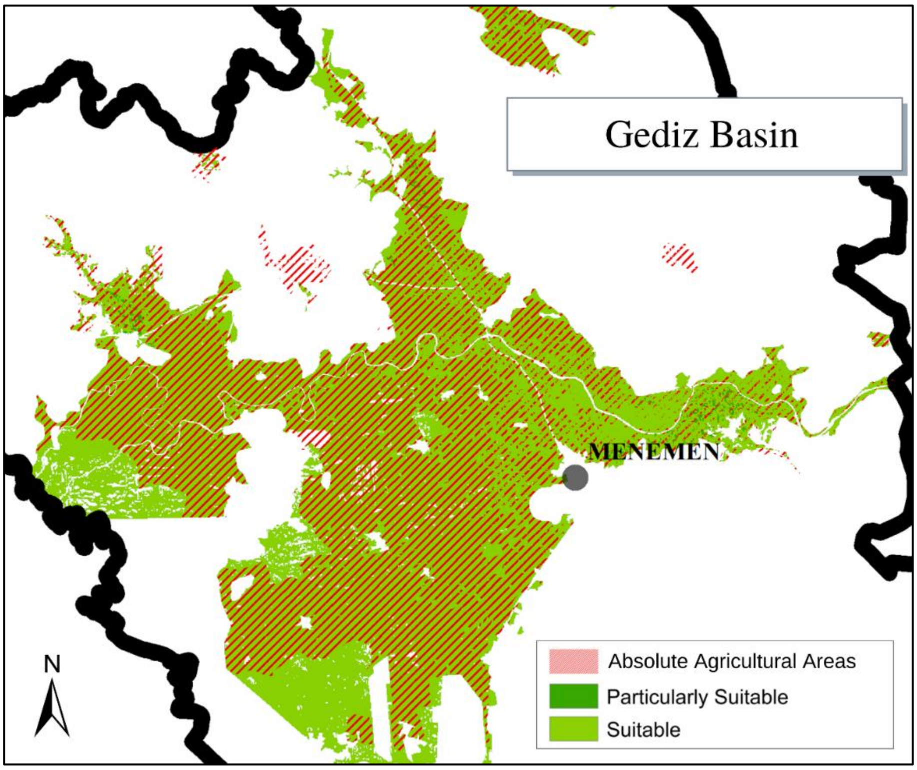


Figure 5.14 Comparison of the Gediz Basin with Law No:5403

It is observed that the areas obtained as a result of the conformity analysis in the Northeast and Southwest directions in the Bakırçay basin are more spread out. The areas to the south of Bergama district center and the areas to the north of Kınık district center are among the most suitable areas for agricultural lands. The same areas are not included in the absolute agricultural land class.

When the Gediz basin is examined more closely, the differences between the absolute agricultural lands and the areas obtained as a result of the suitability analysis are clearly noticed. The results of the conformity analysis were observed to be more holistic and spread over more areas. Compared to the absolute agricultural lands, it is observed that the most suitable areas for agriculture are seen more in the areas close to the sea border in the southwest. Appropriate agricultural lands located in the northeast of Menemen district center also have a more holistic structure compared to the current situation.

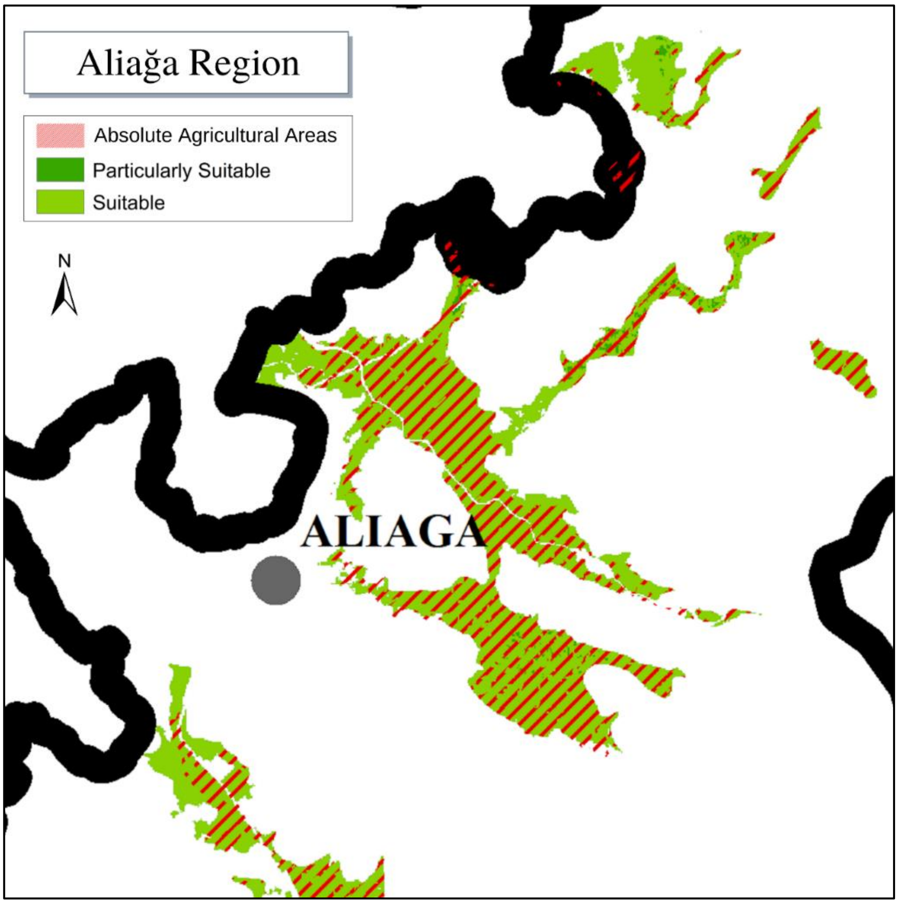


Figure 5.15 Comparison of the Aliağa Region with Law No:5403

There are differences in the northeast and southwest directions between the suitable agricultural lands obtained in the Aliağa region and the current situation.

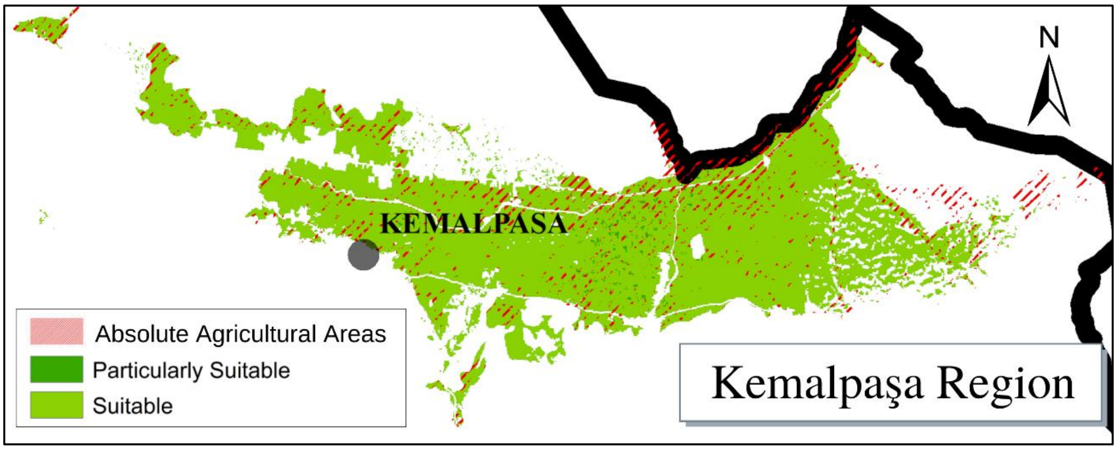


Figure 5.16 Comparison of the Kemalpaşa Region with Law No:5403

The most obvious difference between the most suitable areas for agriculture and the absolute agricultural areas is seen in the Kemalpaşa region. Kemalpaşa region is a region that has the most suitable features for agriculture in general.

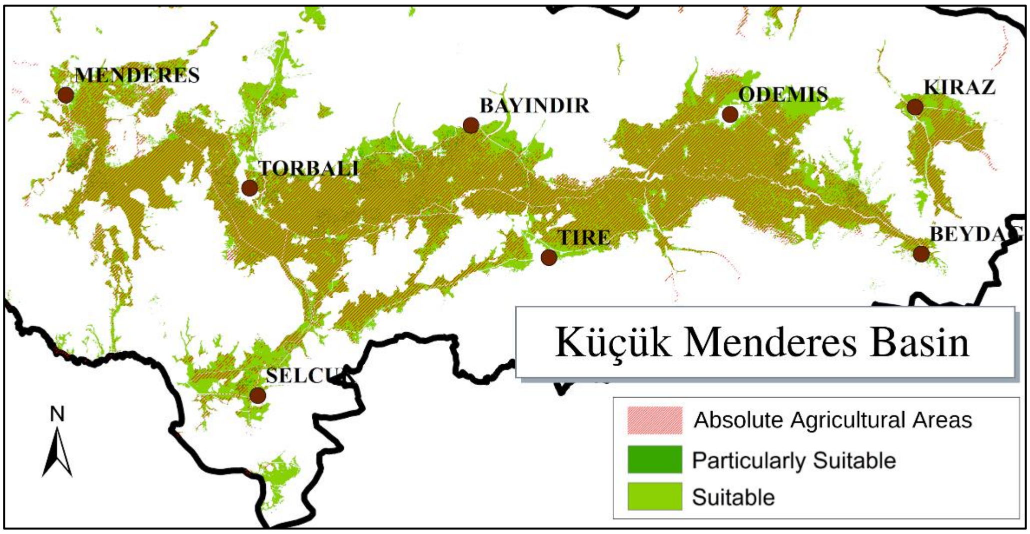


Figure 5.17 Comparison of the Küçük Menderes Basin with Law No:5403

In the comparisons made in the Küçük Menderes basin, it is observed that the most suitable agricultural areas are spread over larger areas than the absolute agricultural lands. It is observed that the areas obtained from the suitability analysis show more spread in the north and south directions. There are the most suitable areas for agriculture in the north of Torbalı town center, east and west of Bayındır and Tire centers, northeast of Ödemiş center and around the center of Kiraz. The surrounding of Selçuk district is seen among the most suitable areas for agriculture. These areas are differentiated by absolute agricultural lands.

5.2.3. Comparison Between the Suitability Map and the Great Lowland Protection Areas

The agricultural areas in the result suitability analysis were compared with the legally protected "The Great Lowland Protection Areas". The great lowland protection areas are agricultural areas that are determined as the most productive areas in terms of agricultural production and are taken under protection. These areas are areas where construction is not allowed legally. There are a total of ten great lowland protection areas within the borders of İzmir province.

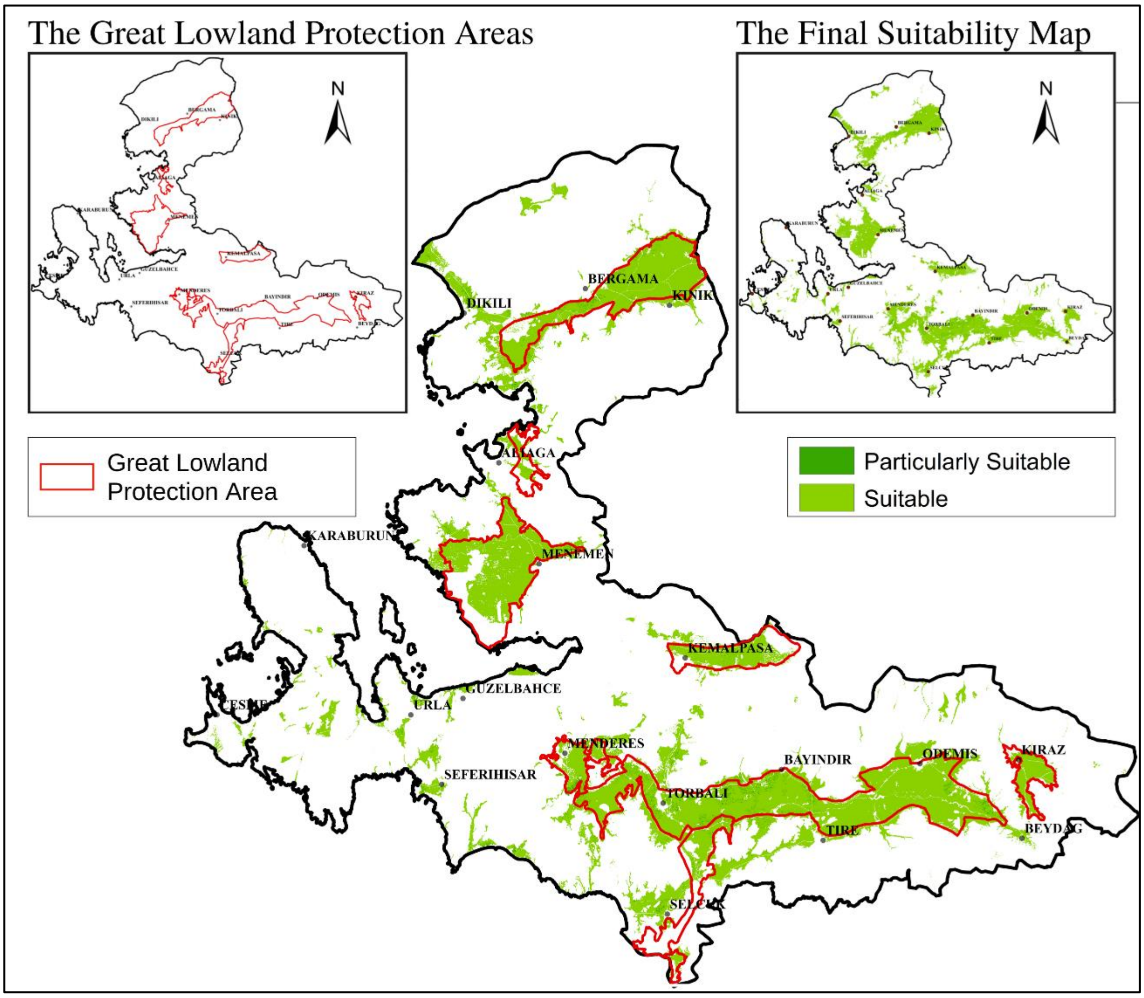


Figure 5.18 Comparison Between the Second Suitability Map Great Lowland Protection Areas

When the suitable agricultural areas in Bakırçay Lowland are compared with the large plain protection areas, it has been observed that suitable agricultural areas have a larger area than the lowland areas. Especially in the northwest, west and southwest directions, it is observed that agricultural areas are widespread outside the lowland borders.

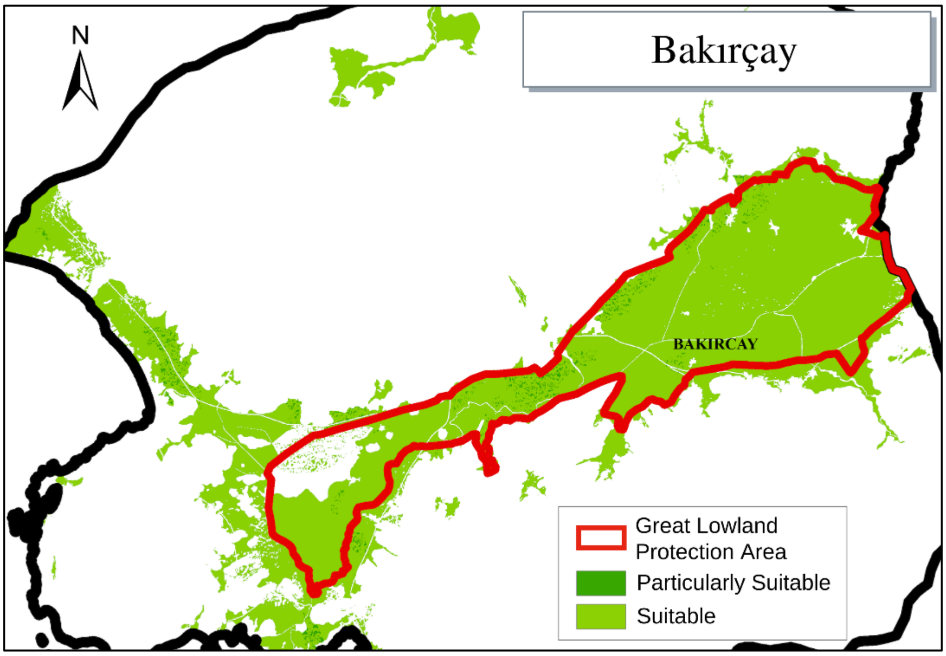


Figure 5.19 Comparison of the Bakırçay Great Lowland Protection Area

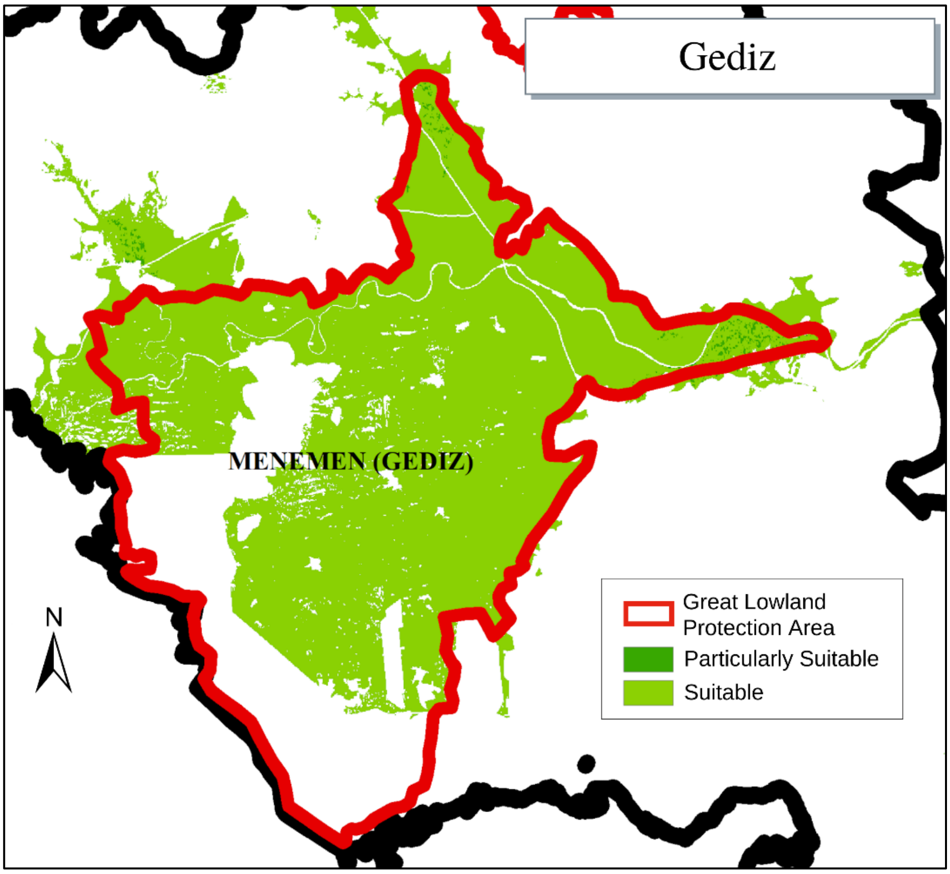


Figure 5.20 Comparison of the Menemen (Gediz) Great Lowland Protection Area

The lowland area of Menemen (Gediz) and the areas suitable for agriculture obtained as a result of the suitability analysis were compared. The areas within the lowland area, which are found to be unsuitable for agriculture as a result of the analysis, are the wildlife development area and the areas where the OIZ is located. These areas remain within the borders of the lowland, which is not declared as a protected area in the law. The agricultural areas obtained as a result of the analysis, spread beyond the borders of the lowland. It is seen that the most suitable agricultural areas are located especially in the northwest.

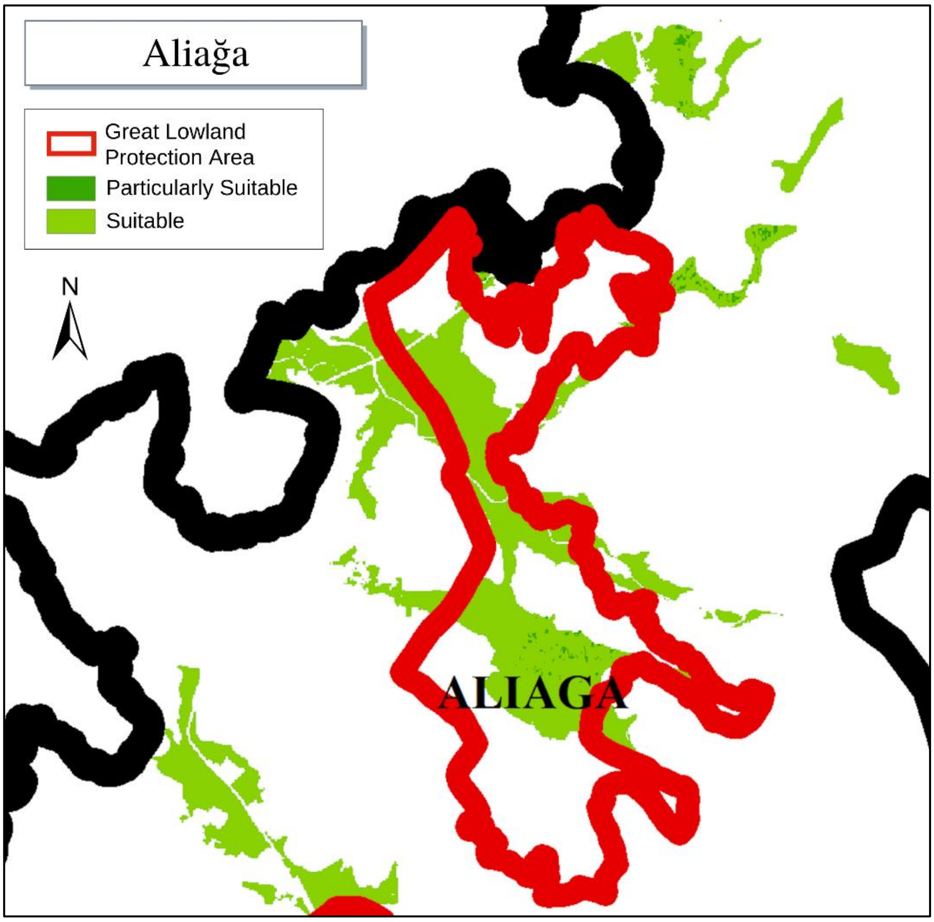


Figure 5.21 Comparison of the Aliağa Great Lowland Protection Area

There are suitable areas for agriculture in the west of Aliağa lowland. The areas within the borders of the lowland but determined to be suitable for agriculture as a result of the analyzes were determined as the areas to be afforested within the scope of the 1/100000 scale Environmental Plan.

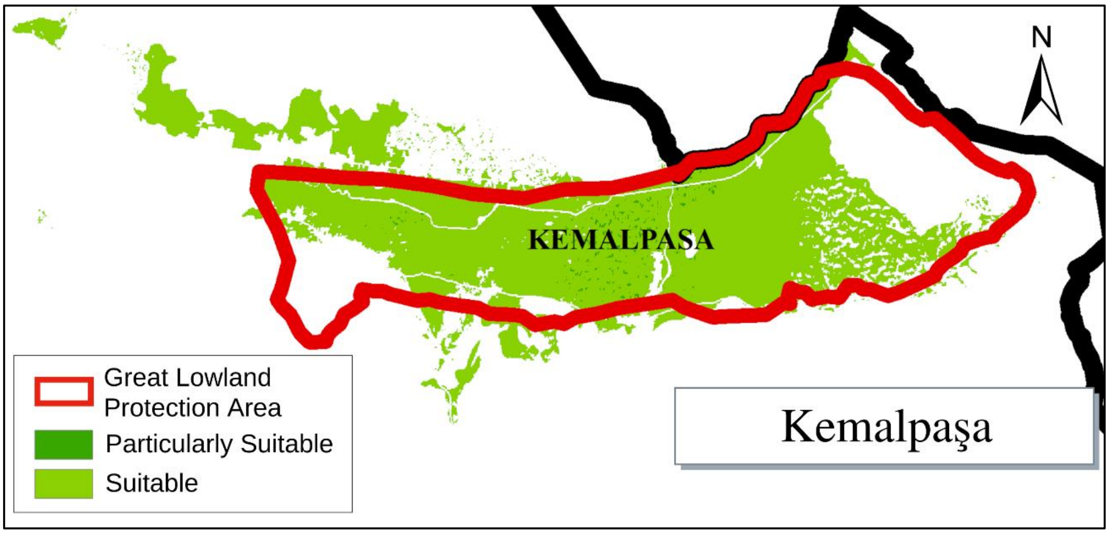


Figure 5.22 Comparison of the Kemalpaşa Great Lowland Protection Area

It is seen that the areas determined to be suitable for agriculture in the northeast and south of the Kemalpaşa lowland were determined as a result of the analysis.

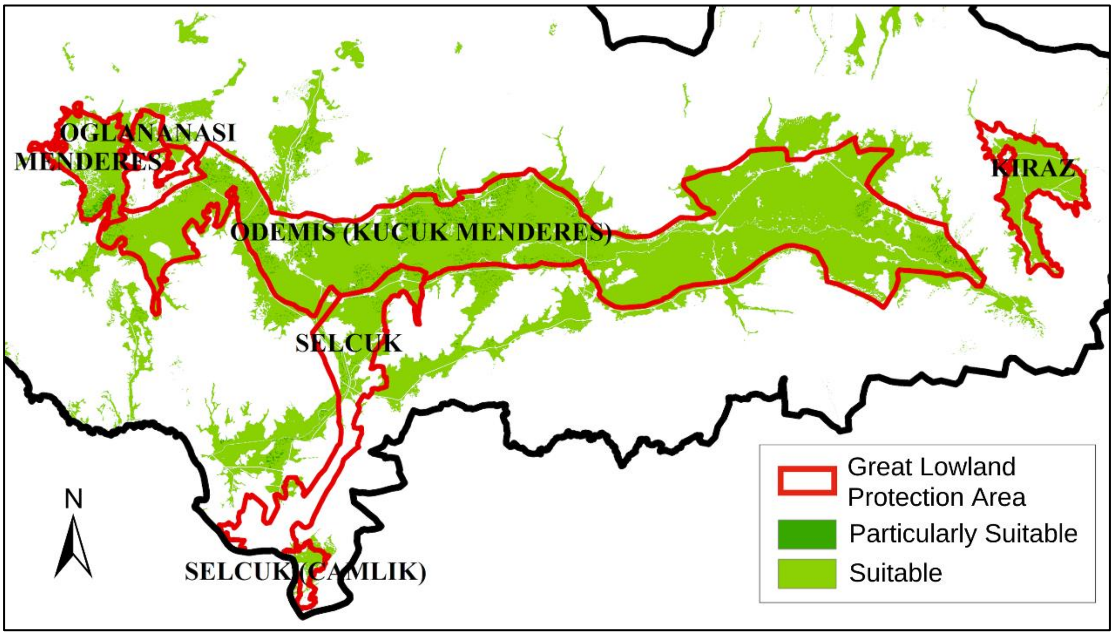


Figure 5.23 Comparison of the Menderes, Oğlananası, Ödemiş, Kiraz Selçuk and Selçuk/Çamlık Great Lowland Protection Areas

When the plains in the south of the study area are compared with suitable agricultural areas; It is observed that there are areas outside the borders of the plain whose suitability for agriculture has been determined by analysis.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Agriculture is the main source of life on earth. The protection of agricultural lands and the continuity of agricultural production are of great importance considering the population growth. The most appropriate use of agricultural lands, and the protection of fertile agricultural lands are important in terms of production. The fact that agriculture is the most basic source of life in human life and the development of settlements on a horizontal plane with the general population growth all over the world brings the efficient use of resources to the fore. The loss of agricultural lands is directly proportional to the foreign dependency of countries in terms of food production. This situation poses an economic problem. The sprawl of settlements on agricultural lands causes pollution and fragmentation in agricultural lands.

Each city has its own economic, environmental, and social activities. These activities of the city should be considered while planning. Policies should be shaped according to the unique characteristics of the cities. While urban planning is being done, the most suitable areas for agriculture should be specified in a clear framework. Policies should be clearly revealed to determine this framework. An absolute balance must be struck between urban and rural areas.

Correct management of agricultural lands is an important issue in terms of planning. The continuity of agriculture and the sustainability of the ecosystem are possible with the correct management of agricultural lands. Soil characteristics, climatic characteristics of the area and topography are of great importance when determining agricultural areas. Using the most suitable areas for non-agricultural purposes and not using them correctly is considered as a problem. For this reason, the most important areas for agriculture should be determined and these areas should be protected.

In this study, soil properties, climate and topography are discussed to determine the most suitable areas for agricultural areas. The relationship between the features was examined and a GIS-based multi-criteria approach was applied. The most suitable areas for agricultural areas were handled by evaluating different criteria, and a study was carried out for the whole of İzmir.

GIS is a good tool for classifying, analyzing and combining criteria appropriately. It has a powerful interface for making analytical studies in the decision-making process.

Studies show that the overlay method using weights obtained with AHP is a method that can be used at different scales. By using GIS and AHP together, the selection of the most suitable areas for agriculture can be carried out in the best way. With this method, environmental factors and soil properties can be evaluated and used for planning. When GIS and MCDA are integrated, fast and reliable results can be obtained for solving complex problems. According to the results obtained by scanning the literature, methods and criteria were determined and the method and criteria suitable for the study area were determined among these criteria. Afterwards, special analyzes were made for each layer and focused on the process of determining the most suitable areas for agriculture.

In order to determine the most suitable agricultural areas within the study area, 5 degrees of land suitability (particularly suitable, suitable, moderately suitable, less suitable and unsuitable) were determined. According to the suitability map obtained using the weighted overlay method; Particularly suitable areas of the study area, have a rate of 0.42%. Suitable areas constitute 19.98% of the study area. A portion of 5.63% of the study area was determined as moderately suitable. 53.11% of the study area was determined as less suitable. While these areas are places where trimming can be done by taking the necessary precautions, 20.85% of the area has been determined as unsuitable for agriculture. Maps made using the same criteria without determining any weight can give similar results in terms of location and percentages of most suitable agricultural areas. However, when this method is used, it is seen that the distribution of the areas is fragmentary in the resulted suitability analysis. At the same time, when compared with the criteria, it was observed that the areas not suitable for agriculture were moderately suitable as a result of this analysis.

The comparison of the results with the current situation was carried out with the 1/100000 scale environmental plan, the absolute agricultural lands determined by the law no. 5403 and the legally protected large lowland protection areas. The comparison of the maps was carried out one by one, and the regions where the most suitable areas for agriculture were concentrated were examined more closely. As a result of these comparisons, differences were determined. The areas obtained as a result of the analysis made to determine the most suitable areas for agriculture have a wider and fringed structure compared to the current situation. As a result of the comparisons made with the existing 1/100000 scale environmental plan, the existence of urban development areas towards the most suitable agricultural areas has been determined. At the same time, the existence of organized industrial zones has been observed within and within the borders of agricultural areas.

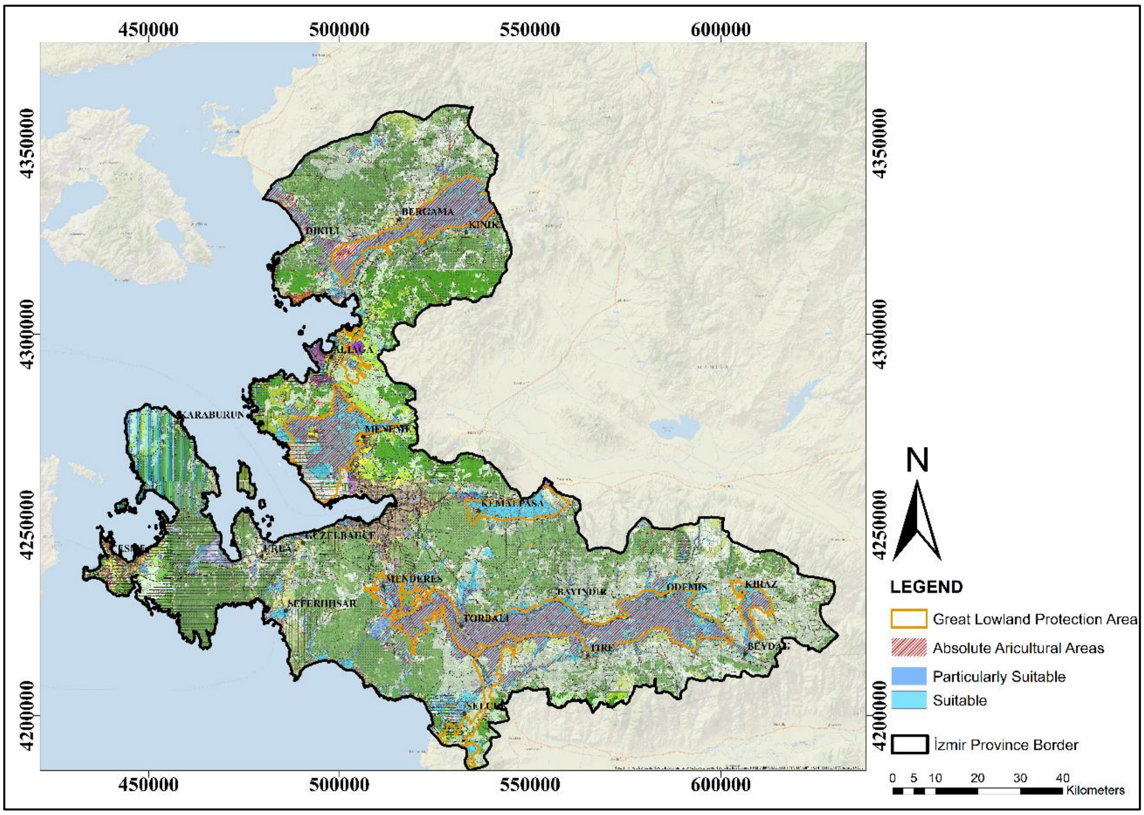


Figure 6.1 The Combination of All Comparison Maps

In summary, while performing suitability analysis for agricultural areas, important criteria in terms of agricultural production should be considered according to the degree of importance. In the studies carried out according to the legislation, the degree of importance is not mentioned. More clear and precise provisions can be obtained by emphasizing the importance of the criteria determined while making legal arrangements. The grading method may be preferred instead of determining a single value and determining the areas below or above this value as unsuitable or appropriate. In line with these clear and definite provisions, the spread of settlements and industrial areas can be kept away from the most suitable areas in terms of agriculture, according to the plan decisions. Environmental, economic, and climatic characteristics are important as well as soil characteristics in terms of agriculture. This study, which was carried out to determine the most suitable agricultural areas for İzmir, can be taken into account in the decisions and practices to be made during the planning process.

In the continuation of this study, basin areas can be examined at sub-scales and more detailed decisions can be made. Other criteria can be added to the studies to be carried out in the sub-scale with the change of the scale. These criteria can be listed as distance to road, distance to water source, hydrological characteristics. At the same time, in a study to be carried out at a lower scale, more comprehensive results can be obtained by examining the social characteristics of the area. With the surveys and interviews to be conducted to examine these social and economic characteristics, clear information can be revealed. Thus, the definition of sustainable agricultural areas can be made by including the human factor necessary for rural development and the sustainability of agriculture.

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APPENDICES

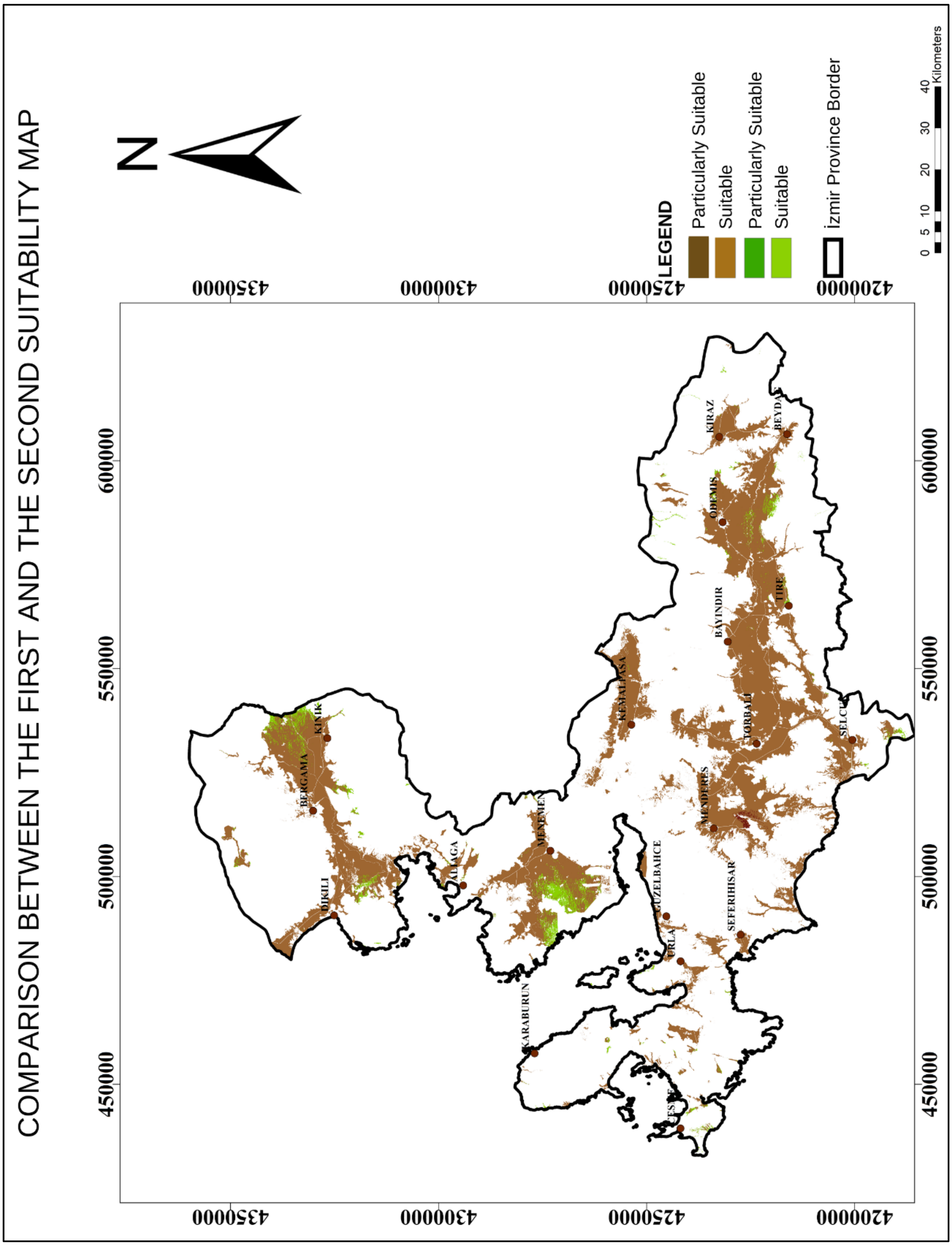
APPENDIX A

ALL CRITERIA CLASSES, WEIGHTS, AND PROCESSING

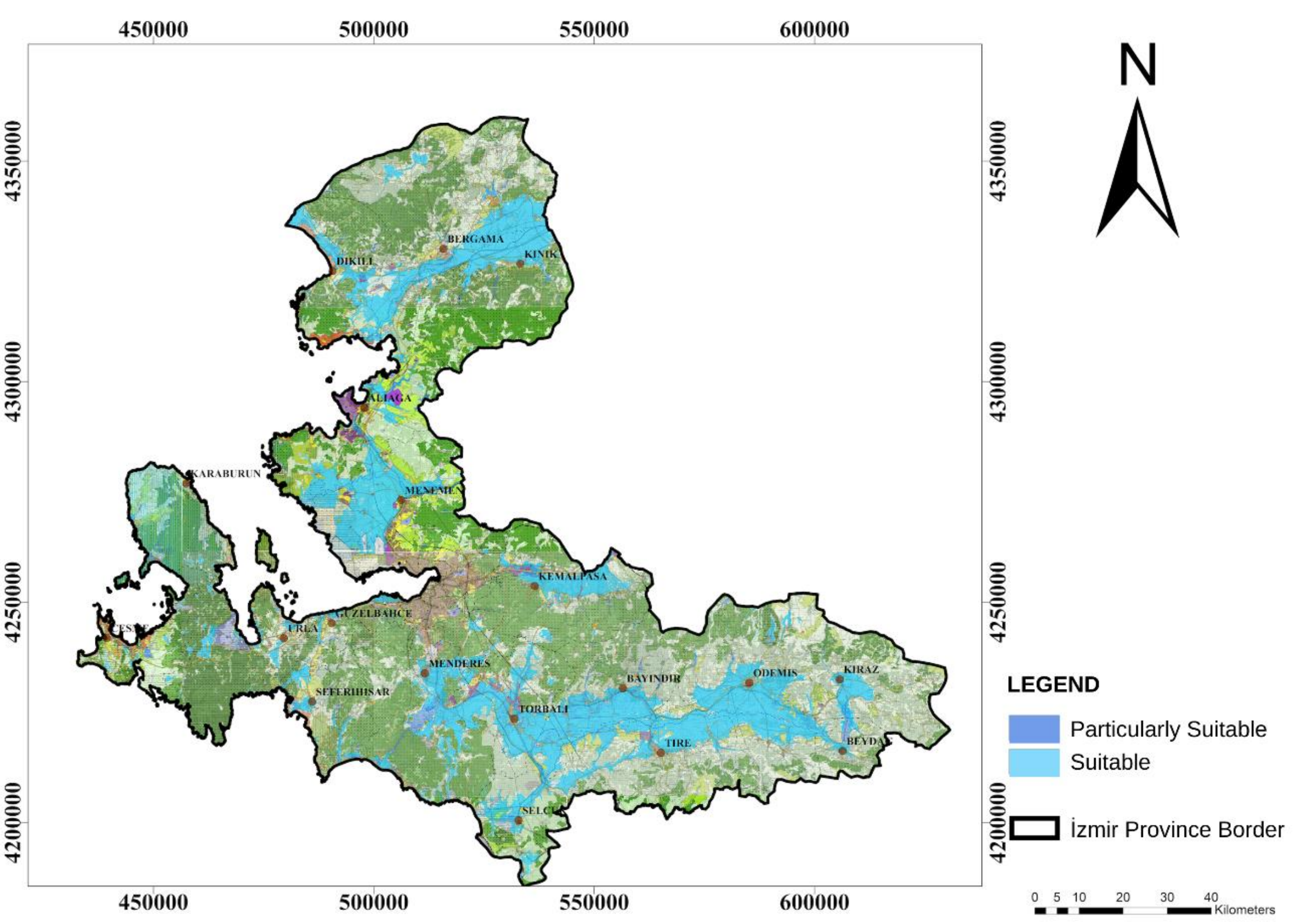
	Criteria	Unit	Intervals	Descriptive Class	Suitability Class	Weight	Data Processing Method
C1	Great Soil Groups		A,K,C	Particularly Suitable	1	26.3%	ArcGIS Software 10.7.1 Reclassification
			D,E,M	Suitable	2		
			N,R,V	Moderately Suitable	3		
			U,L,T	Less Suitable	4		
			H,O,S,Ç,SK	Not Suitable	5		
C2	Soil Depth	Centimeter (cm)	90<	Particularly Suitable	1	16.8%	ArcGIS Software 10.7.1 Reclassification
			50-90	Suitable	2		
			20-50	Moderately Suitable	3		
			0-20	Less Suitable	4		
			Litosolic	Not Suitable	5		
C3	Slope	Percentage (%)	0-2	Particularly Suitable	1	14.3%	ArcGIS Software 10.7.1 Slope Tool Slope Classification Reclassification
			2-6	Suitable	2		
			6-12	Moderately Suitable	3		
			12-20	Less Suitable	4		
			20<	Not Suitable	5		
C4	Land Use Capability Sub-Class		Seemless	Particularly Suitable	1	10.3%	ArcGIS Software 10.7.1 Reclassification
			w,e,s,	Suitable	2		
			se,sw	Moderately Suitable	3		
			es	Less Suitable	4		
			ws	Not Suitable	5		
C5	Aspect		Falt,S	Particularly Suitable	1	8.5%	ArcGIS Software 10.7.1 Aspect Tool Aspect Classification Reclassification
			SW,SE	Suitable	2		
			W,E	Moderately Suitable	3		
			NW,NE	Less Suitable	4		
			N	Not Suitable	5		
C6	Elevation	Meter (m)	0-150	Particularly Suitable	1	6.6%	ArcGIS Software 10.7.1 Hilshade Tool Elevation Classification Reclassification
			150-400	Suitable	2		
			400-700	Moderately Suitable	3		
			700-1200	Less Suitable	4		
			1200<	Not Suitable	5		
C7	Precipitation	Meter (m)	1000-1300	Particularly Suitable	1	4.4%	ArcGIS Software 10.7.1 Slope Tool Slope Classification Reclassification
			850-1000	Suitable	2		
			750-850	Moderately Suitable	3		
			650-750	Less Suitable	4		
			<650	Not Suitable	5		
C8	Temperature	Degrees Celsius (℃)	<12	Particularly Suitable	1	4.0%	ArcGIS Software 10.7.1 Inverse Distance Weighted (IDW) Interpolation Reclassification
			12-14	Suitable	2		
			14-16	Moderately Suitable	3		
			16-18	Less Suitable	4		
			18-21	Not Suitable	5		
C9	Distance to Irrıgation Dams and Lakes	Kilometer (km)	0-1	Particularly Suitable	1	3.1%	ArcGIS Software 10.7.1 Multiple Buffer Analysis Reclassification
			1-2	Suitable	2		
			2-3	Moderately Suitable	3		
			3-5	Less Suitable	4		
			5<	Not Suitable	5		
C10	Distance to Main Streams	Kilometer (km)	0-1	Particularly Suitable	1	3.0%	ArcGIS Software 10.7.1 Multiple Buffer Analysis Hydrology Tool Reclassification
			1-2	Suitable	2		
			2-3	Moderately Suitable	3		
			3-5	Less Suitable	4		
			5<	Not Suitable	5		
C11	Distance to Settlements	Kilometer (km)	0-2	Particularly Suitable	1	1.5%	ArcGIS Software 10.7.1 Multiple Buffer Analysis Reclassification
			2-4	Suitable	2		
			4-7	Moderately Suitable	3		
			7-10	Less Suitable	4		
			10<	Not Suitable	5		
C12	Distance to Main Roads	Kilometer (km)	0.03-2	Particularly Suitable	1	1.2%	ArcGIS Software 10.7.1 Multiple Buffer Analysis Reclassification
			2-4	Suitable	2		
			4-7	Moderately Suitable	3		
			7-10	Less Suitable	4		
			10<	Not Suitable	5		

APPENDIX B

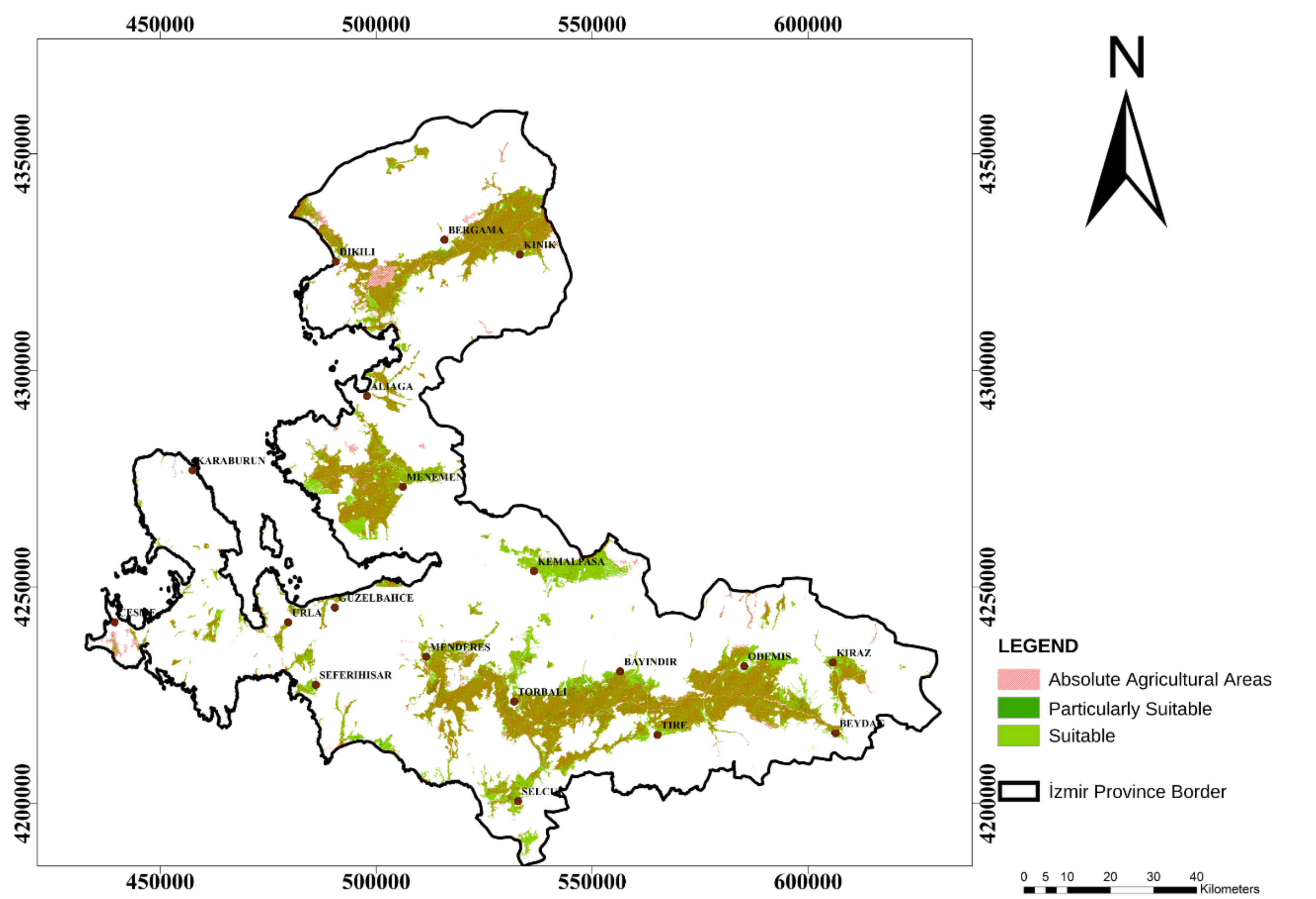
ALL COMPERISON MAPS



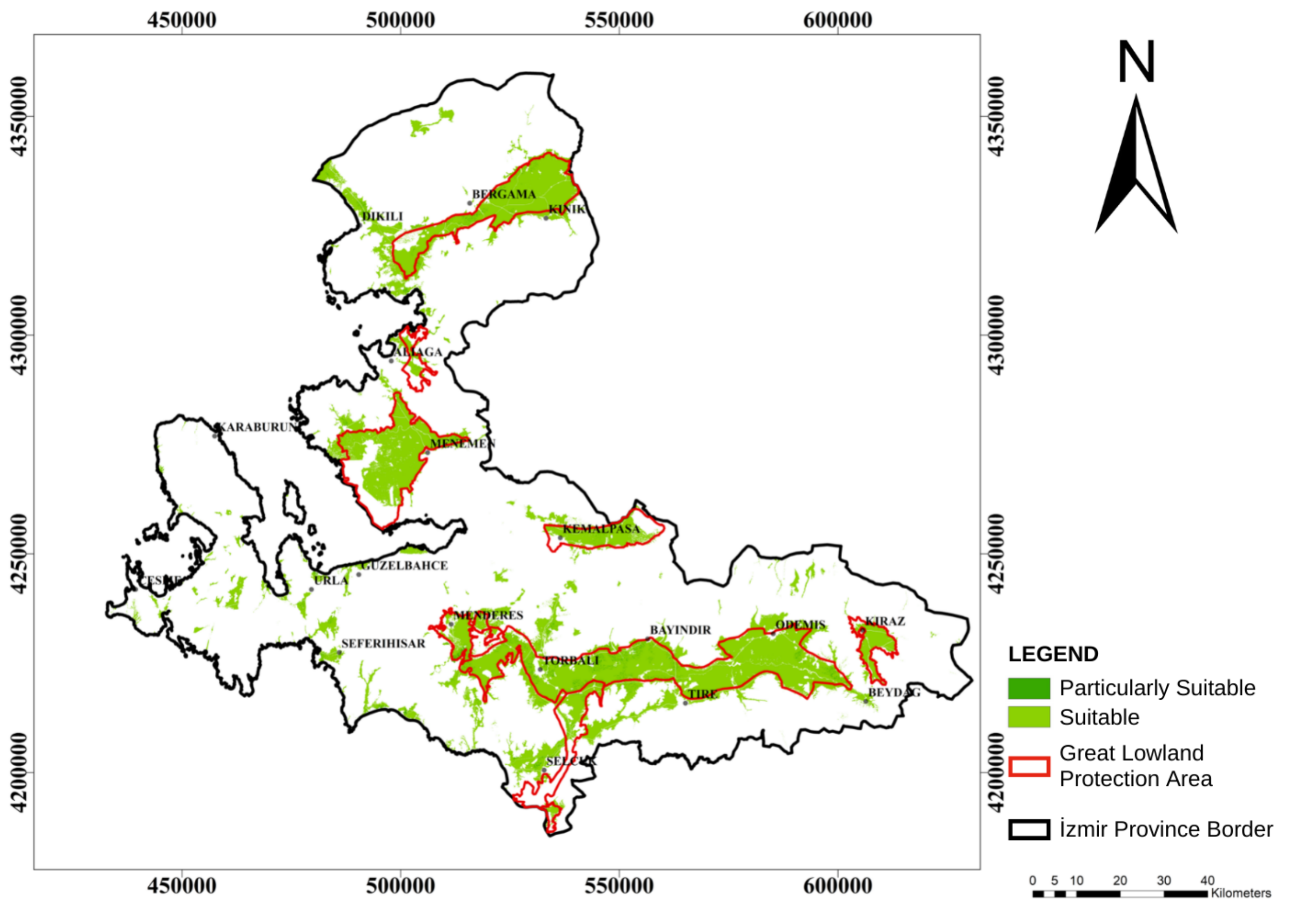
COMPARISON BETWEEN THE FINAL SUITABILITY MAP AND 1/100000 SCALED ENVIRONMENTAL PLAN

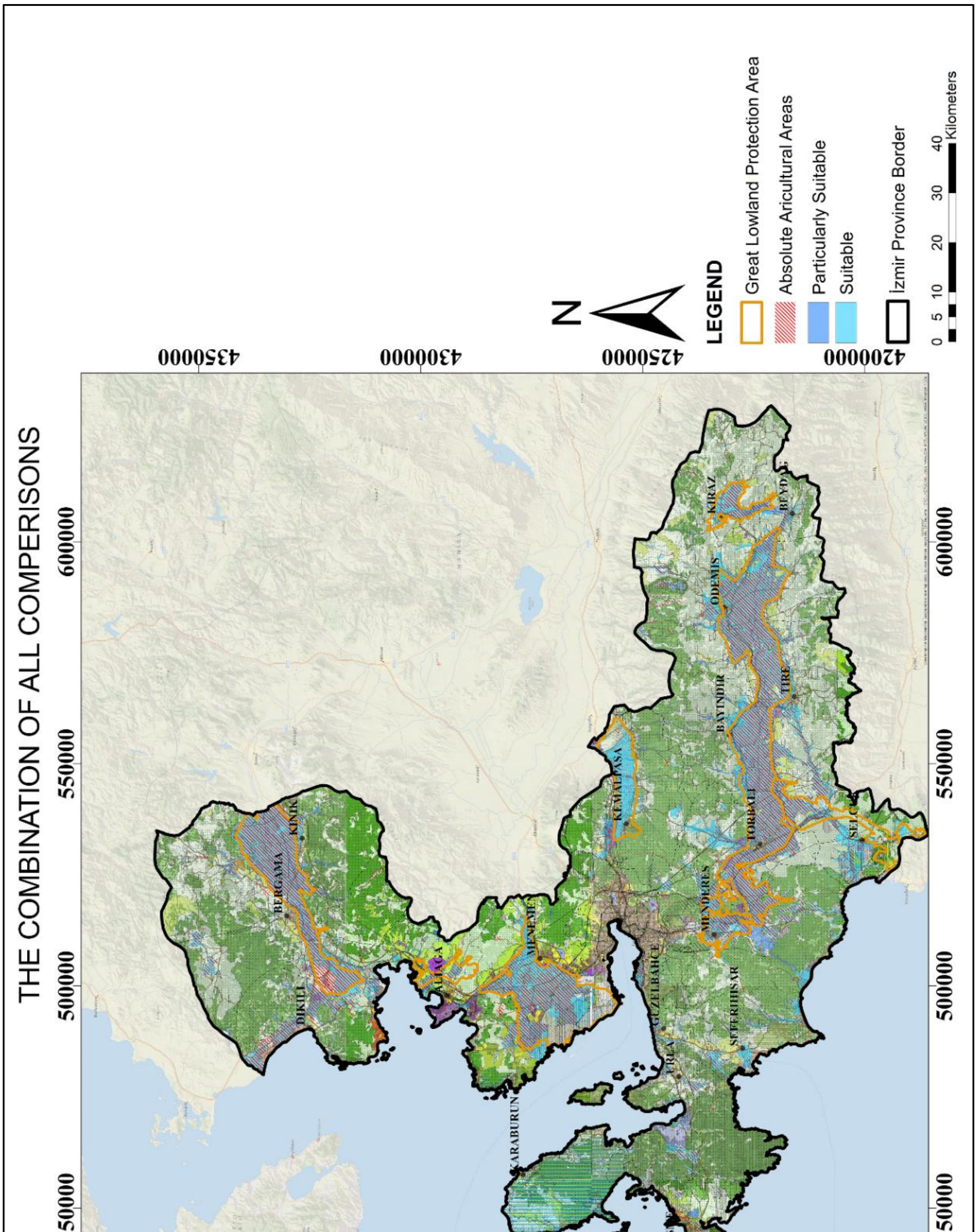


COMPARISON BETWEEN THE FINAL SUITABILITY MAP AND ABSOLUTE AGRICULTURAL AREAS (LAW NO: 5403)



COMPARISON BETWEEN THE FINAL SUITABILITY MAP AND THE GREAT LOWLAND PROTECTION AREAS




THE COMBINATION OF ALL COMPERISONS
LEGEND
Great Lowland Protection Area
Absolute Aricultural Areas
Particularly Suitable
Suitable
İzmir Province Border
0 5 10 20 30 40
Kilometers
N
450000
500000
550000
600000
4200000
4250000
4300000
4350000
BERGAMA
KINIK
DIKILI
ALIAĞA
MENEMEN
KARABURUN
GÜZELBAHÇE
URLA
SEFERIHISAR
MENDERES
TORBALI
SELÇUK
BAYINDIR
TIRE
ÖDEMIŞ
KIRAZ
BEYDAĞ
KEMALPAŞA

APPENDIX C

LEGEND OF 1/100000 SCALED ENVIRONMENTAL PLAN