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Shaping the Future of Datça Peninsula: Exploring Suitable Settlement Areas and Land-Use Scenarios

Datça Yarımadasının Geleceğini Şekillendirmek: Uygun Yerleşim Alanları ve Arazi Kullanım Senaryolarını Keşfetmek

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Abstract

This study examines land use/land cover (LULC) scenarios and identifies areas suitable for settlement on the Datça Peninsula. Datça is one of the four peninsulas in the Aegean Sea and is administratively part of the Muğla province of Türkiye. Forests prevail across the landscape, especially around the stretch shaped by the Datça–Marmaris highway, while agriculture is concentrated on the Datça Plain, Cumali, and Yaka. This study aims to determine land use scenarios and identify suitable areas for future development and settlement. The GeoSOS-FLUS software package, developed based on Markov Chains and Artificial Neural Networks for land use simulations, was used. Aware of the limitations of simulations that do not consider land suitability, a suitability analysis was performed using the Best-Worst Method (BWM), one of the Multi-Criteria Decision Making approaches. Sixteen criteria within four groups—topography, socioeconomics, location, and environment—were evaluated. The suitability analysis results were compared with simulated land use scenarios, and the most suitable areas for future settlements in the Datça Peninsula were identified. This integrated approach provides important information for the sustainable development of the region and the shaping of land use planning.

Keywords: *Datça peninsula, Land-use/land-cover (LUCL) scenarios, Settlement suitability analysis, BWM*

Özet

Bu çalışma, arazi kullanımı/arazi örtüsü (LULC) senaryolarını incelemekte ve Datça Yarımadası'nda yerleşime uygun alanları belirlemektedir. Datça, Ege Denizi'ndeki dört yarımadadan biridir ve idari olarak Türkiye'nin Muğla iline bağlıdır. Ormanlık alanlar, özellikle Datça-Marmaris otoyolunun oluşturduğu alan çevresinde manzara sunarken tarımsal faaliyetler ise ağırlıklı olarak Datça Ovası, Cumali ve Yaka çevresinde yoğunlaşmaktadır. Bu çalışma, arazi kullanım senaryolarını belirlemeyi ve gelecekteki gelişme ve yerleşim için uygun alanları tespit etmeyi amaçlamaktadır. Arazi kullanım simülasyonları için Markov Zincirleri ve Yapay Sinir Ağları temelinde geliştirilen GeoSOS-FLUS yazılım paketi kullanılmıştır. Arazinin uygunluğunu dikkate almayan simülasyonların sınırlılıklarının farkında olarak, Çok Kriterli Karar Verme yaklaşımlarından biri olan En İyi-En Kötü Yöntemi (BWM) kullanılarak uygunluk analizi gerçekleştirilmiştir. Topografya, sosyo-ekonomik faktörler, konum ve çevresel koşullar olmak üzere dört ana kategoride on altı kriter değerlendirilmiştir. Uygunluk analizi sonuçları simüle edilmiş arazi kullanım senaryolarıyla karşılaştırılmış ve Datça Yarımadası'nda gelecekteki yerleşim yerleri için en uygun alanlar belirlenmiştir. Bu entegre yaklaşım bölgenin sürdürülebilir kalkınması ve arazi kullanım planlamasının şekillendirilmesi için önemli bilgiler sağlamaktadır.

Anahtar kelimeler: *Datça yarımadası, Arazi-kullanım/arazi-örtüsü senaryoları, Yerleşime uygunluk analizi, BWM*

1. Introduction

Land use is defined in different ways in the literature. In an extended definition, land use is defined as people's use of land and resources (such as settlement, agriculture, grazing, logging) (Turner & Meyer, 1994; Meyer, 1995; Mwavu & Witkowski, 2008; Melese, 2016), land use, classification according to its value and determination of the use strategy, or the use of the whole or a specific part of the earth by individuals in various ways and for various purposes (Dağlı, 2021).

Anthropogenic processes affecting land use have profoundly impacted the world's ecosystems and global environmental change (Foley et al., 2005; Kalnay & Cai, 2003). Over the past century, the process of land use change has accelerated significantly due to the intensification of human activities, including deforestation, the opening of new agricultural areas, and urban expansion (Meyer & Turner, 1992; Ramankutty et al., 2006). Concerns about changes in land use worldwide are growing daily. Human activities, including population growth, urbanization, and rapid economic development, have significantly altered the Earth's surface processes. This has led to changes in environmental characteristics, such as climate, soil quality, and biodiversity, at both regional and global levels (Samie et al., 2017). Therefore, solutions for managing limited land efficiently and promoting sustainable development, especially in developing countries, have become crucial for both government planners and researchers (Yang et al., 2020). The environmental impacts of land use have been felt worldwide from the past to the present. For example, land-use practices have played a role in altering the global carbon cycle and potentially the global climate. Indeed, approximately 35% of human-caused CO2 emissions since 1850 have come directly from land use. Changes in land use and cover also affect regional climates through changes in surface energy and water balance. In this sense, humans have also transformed the hydrological cycle to provide fresh water for irrigation, industry, and domestic consumption. Land use also contributes to the loss, alteration, and fragmentation of habitats, as well as soil and water degradation, and the overexploitation of species, resulting in a decline in biodiversity (Foley et al., 2005).

One of the primary sources of such a change in land use worldwide and its impacts is the increase in urbanization rates. According to data from the United Nations (UN), the rate of urbanization worldwide was approximately 30% in 1950, but this rate increased to approximately 65% by 2023. Turkey has also experienced similar changes in land use. Especially after the 1950s, an intense wave of migration from rural areas to cities has led to a transformation of land use in cities, favoring urbanization, which has brought numerous problems, including unplanned settlements and the destruction of agricultural lands. This situation has begun to manifest itself in the Datça Peninsula, the study area, particularly with the recent surge in tourism activity. The fact that it has been removed mainly from tourism for a long time due to its remote location has delayed the change and transformation of land use. However, the increasing number of tourists in recent years has contributed to urbanization and initiated changes and transformations in land use.

Planning land use changes and transformation, and following a path towards it, is essential. Indeed, several land-use/land-cover (LULC) models have been developed in recent years to meet the needs of land management and better assess and predict the future role of land use change in the functioning of the Earth system. Modeling, especially spatially explicit, integrated, and multi-scale, is an essential technique for envisaging alternative pathways into the future, conducting experiments that test our understanding of fundamental processes, and quantifying them. Land-use change models represent part of the complexity of land-use systems. They offer the possibility to test the sensitivity of land-use models to changes in selected variables. They also allow testing the stability of linked social and ecological systems through scenario building. Although no model can capture all aspects of reality, it provides valuable information about the system's behavior under various conditions. Different modeling approaches are adopted in LULC change studies (Veldkamp & Lambin, 2001). Artificial Neural Networks (ANN) and Markov Chain (MC) are essential models used in land use scenarios. In land use scenario analyses, the GeoSOS-FLUS model, proposed by Liu and his team in 2017, is a software that uses ANN and MC together (Liu et al., 2017). The FLUS model uses a multilayer feed-forward artificial neural network algorithm to combine land use types and select variables from natural, social, and economic factors based on initial terrain data. This model generates a probability distribution map associated with the relevant variables for each land use type. However, the ability of traditional cellular automata models to simulate real-world changes is limited because they often assume static land change processes and fail to consider dynamic processes such as urbanization or development adequately. To overcome this limitation and improve simulation accuracy, the FLUS model combines the traditional cellular automata model with artificial neural networks to account for dynamic variables. In this way, the impact of natural processes and human activities on land use types becomes better managed, particularly in the face of more complex and uncertain transformations (Konurhan, 2024). In land use scenarios, a scenario and simulation cannot yet be created according to the suitability of the land. Land use is simulated by the variables determined by the current land use pattern. Therefore, simulation results may not be suitable for land use. For this reason, suitability analyses were also conducted within the scope of the study to determine areas suitable for settlement in the Datça Peninsula.

Suitability analyses are integrated with Multi-Criteria Decision-Making Methods (MCDM) and Geographic Information Systems (GIS) tools. In this study, the Best-Worst Method (BWM), an MCDM method proposed by Rezaei in 2015, was prepared using ArcGIS in an integrated manner (Konurhan, 2024).

There are numerous studies on land use scenarios suitable for settlement analyses using GIS-CCDM methods. Döker (2012), which examines land use scenarios, investigated the determination, monitoring, and modeling of Istanbul's urban growth process. Dağlı (2021) simulated Diyarbakır city development, while Görentaş (2021) simulated the city development on the Mersin-Tarsus-Adana line. Apart from these, numerous studies in the literature have explored land use scenarios (Oğuz & Bozali, 2014; Hamad et al., 2018; Han et al., 2015; Konurhan & Ceylan, 2024). In the literature, studies have also been conducted on determining areas suitable for settlement using GIS and MCDM methods (Foroozesh et al., 2022; Deliry & Uygurçgil, 2020; Luan et al., 2021). This study generates FLUS-based land use scenarios (2026–2044) for the Datça Peninsula by validating them using a long-term Landsat (1990–2022, 30 m) dataset, which is based on a validated SVM classification. It combines it with the spatial overlap/conflict analysis using the settlement suitability surface obtained with BWM-CBS. There are a few studies in the literature that use FLUS and BWM together (Gao et al., 2022); however, most of these studies do not address concrete planning proposals based on long-term Landsat-based validation and pixel-level scenario-suitability matching within the same framework. In this context, the contribution of the article is specific to Datça: (i) the direct application of scenario parameters calibrated in the thesis (Cost Matrix, neighbourhood weights), (ii) the presentation of model reliability with OA=88.74% and Kappa=0.84 reported from 2012–2018 to 2022 prediction -validation from 2012–2018 to 2022, with OA= 88.74% and Kappa=0.84, and (iii) the conversion of these two outputs into concrete recommendations (≤15% slope threshold, agricultural buffer zones, 400–500 m around Palamutbükü, etc.). Additionally, FLUS or similar CA-Markov approaches have been used to generate scenarios for different metropolitan areas, producing decision support with MCDM-based suitability maps. However, most of these studies have not addressed long-term LULC validation and scenario-suitability spatial overlap within the same framework. Indeed, this paper evaluates land use scenarios for the Datça Peninsula alongside BWM-based suitability, indicating not only where expansion should occur but also where it should not.

2. Literature Review

In the literature on land use/land cover (LULC) projections, cellular automaton-based approaches, primarily FLUS and CA-Markov, have been successfully applied in different contexts. Han et al. (2015) predict scenario-based LULC change in Beijing, reporting that urban expansion is concentrated in areas close to transport corridors; Hamad et al. (2018) provide a comparative analysis of LULC change using a two-scenario CA-Markov approach; Lin et al. (2020) integrate FLUS scenarios with flood risk assessment; the theoretical/applied framework of the model was established by Liu et al. (2017), and studies such as Chen et al. (2022) have continued the validation-prediction framework with FLUS across multiple scenarios. Meanwhile, Melese (2016) highlights the effects of LULC changes on forest resources in terms of ecological outcomes, indicating that model results should be evaluated not only in terms of spatial expansion but also from a resource management perspective. While the aforementioned studies detail their methodologies, their outputs are primarily focused on the question of ‘where is growth expected?’ This article follows this line of inquiry but also presents areas of compatibility/conflict for FLUS projections using the MCDM method for land suitability produced at the exact resolution in a decision-support context.

At the national level, Dağlı (2021) in Diyarbakır and Görentaş (2021) in the Mersin-Tarsus-Adana corridor address LULC change and urban growth using time series and CA-based simulations; the findings support patterns of intensive urban expansion around transport hubs. However, most of these theses and international examples either omit or relegate to a secondary level the step of combining projections with an independent suitability layer at the pixel level and mapping the resulting alignment/conflict areas as quantitative ‘priority/avoidance’ zones. This article highlights precisely this reconciliation in the context of the Datça Peninsula, making the spatial variation between projections and suitability visible.

In the context of MCDM and suitability assessment, the literature indicates that classical multi-criteria approaches, such as AHP, are effectively used in conjunction with GIS to weight criteria for urban development. Foroozesh et al. (2022) established a GIS-based hybrid MCDM framework for the city of Karaj, determining criterion weights using group fuzzy BWM and AHP, and prioritising areas using TOPSIS–GIS. The findings indicate that socio-economic criteria—particularly employment—are decisive in suitability and that the method provides practical decision support for planners (Foroozesh et al., 2022). Liu et al. (2014) produced a land suitability map for urban development in Beijing using opportunity/constraint-based indicators and multi-criteria evaluation (IPM/OWA); they tested the robustness of the model by conducting a sensitivity analysis. The results revealed that areas close to the transport network and existing settlement fabric exhibited higher suitability, and that conflicting planning decisions could be spatially distinguished.

Malmir et al. (2016) weighted numerous (approximately 25–30) sub-criteria using a fuzzy logic + ANP approach in Ahvaz District and produced an urban suitability map via WLC. It was emphasised that suitable areas were concentrated in the central and southern parts and that the method provided transferable decision support for different cities. An example of the applicability of the BWM-GIS approach in the context of urban suitability in Turkey is presented in Konurhan (2023). Konurhan (2023) demonstrated that criteria (e.g., slope, elevation, road distance, etc.) can be transparently weighted using BWM-GIS. In this article, scenarios are first generated using the FLUS model, and then the suitability surface for settlement is calculated using the BWM-CBS approach. The two outputs are compared at the pixel level with the exact spatial resolution, and areas suitable and unsuitable for planning are identified.

3. Material and Methods

This study used two different methods to conduct the analysis phase. First, the land-use simulation analysis of the Datça Peninsula was applied. Here, the future land-use status for the specified years was examined. Then, a suitability analysis was carried out for the land class of the settlement areas, as an example in the Datça Peninsula. The recent increase in tourism in Datça has begun to drive the development of urban areas. For this reason, the land class of the settlement areas was selected for the suitability analysis. Finally, these two analyses were compared, and the necessary evaluations were made. The flow diagram of the study is shown in Figure 1.

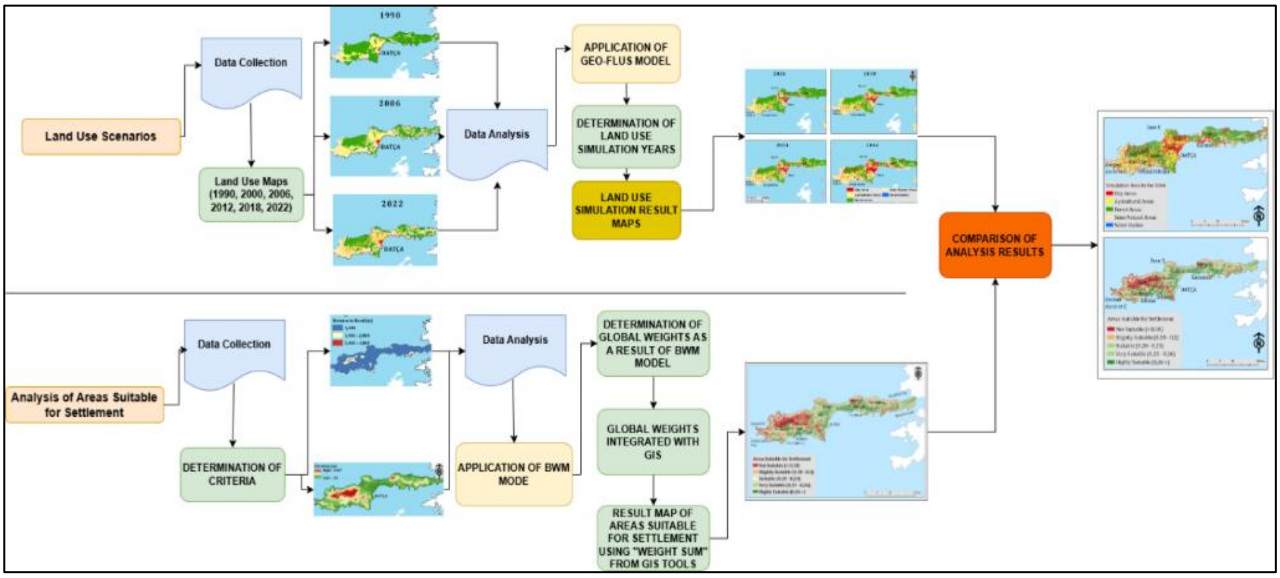

Figure 1. Flow diagram of the study

3.1. Aim of the Study

This study aims to determine the land use scenarios of the Datça Peninsula and the areas suitable for settlement in the peninsula. Another aim of the study is to compare land use scenarios and areas suitable for settlement with each other and to make necessary evaluations. The Datça Peninsula is located near Bodrum, Marmaris, and Fethiye, which are key tourism centers in Turkey. The Datça Peninsula stands out as an essential alternative to these regions due to the increasing number of tourists in these tourism areas in recent years, and the tourists' search for quieter places amid the COVID-19 pandemic. The number of tourists in Datça has increased in recent years. Therefore, the increase in tourists brings with it urbanization. This situation was observed in field studies around Bodrum, Marmaris, and Fethiye. At the same time, in the Datça Peninsula, the expansion tendencies of the settlement areas in and outside the district center have attracted attention in recent years. The expansion of settlement areas around Datça is expected to destroy agricultural and forest areas in the future. For this reason, it is necessary to determine the areas suitable for settlement to ensure the appropriate growth of settlements. In this context, the study aims to determine the areas suitable for settlement.

3.2. Study Area

The study area consists of the Datça Peninsula, located in the southwestern Anatolian part of our country, and administratively includes the Datça district of Muğla province (Figure 2). Datça Peninsula has a thin morphological structure that reaches 20 km in the broadest part, does not exceed 0.6 km in the narrowest part, and extends 70 km. The peninsula is surrounded by the Aegean Sea to the north and the Mediterranean Sea to the south, with Karadağ (627 m), Kırzeytin Mountain (705 m), and Balan Mountain (999 m) to the east. The peninsula, which attracts attention with its rugged terrain, exceeds 1000 m in height at some points. The highest peaks include Bozdağ (1174 m), Kalecik Mountain (881 m), Kocadağ (786 m), Emecik Mountain (704 m) and Yarık Mountain (615 m). Due to lithological differences, the west of the peninsula is hillier than the east. The plains are Karaköy, Kızlan, Mesudiye and Palamutbükü. In the peninsula where the Mediterranean climate prevails, red pine forests and maquis vegetation specific to this climate spread over large areas. When the maquis cover is damaged, furigana (garig) species dominate (Konurhan & Ceylan, 2024).

Figure 2. Location map of the study area

The geographical structure of the Datça Peninsula has a significant influence on tourism. The peninsula features a diverse range of geomorphological characteristics, including shallow bays, expansive sandy beaches, rising hills, and dramatic cliffs. These elements make the peninsula attractive for beach holidays, water sports, and nature tourism. In particular, the shallow bays of the peninsula offer visitors spectacular views and provide an excellent environment for nature activities such as trekking, hiking, and mountain biking. In addition, the coastal and karstic structure of the peninsula harbors many natural beauties that attract tourists with its caves and natural resources. However, the rugged structure of the Datça Peninsula and brutal transport conditions make the region problematic in terms of access. While the Marmaris-Datça highway, which provides access to the peninsula, was narrow and winding until recently, the modernization of this road in 2023 has made transportation somewhat easier. Despite this, access to the ancient city of Knidos, one of the most important cultural sites, remains difficult and limited. Despite all these difficulties, the peninsula's natural structure and geographical advantages offer great tourism potential. A significant increase in domestic and foreign tourists visiting Datça in recent years is notable. Datça is the largest settlement unit on the peninsula.

Settlements have historically exhibited a dispersed structure due to the peninsula's rugged topography and limited transport infrastructure. Significant differences exist between the settlements, particularly along the east-west axis. The eastern regions have a relatively more developed settlement network, while the settlements in the west are more rural and have difficulties in terms of access. Recently, there has been a significant increase in the number of housing units, driven by the demand created by tourism. There is an expansion around Datça towards Reşadiye, Karaköy, and Kızlan (Konurhan, 2024).

3.3. Data Collection

In this study, land-cover maps were produced using the supervised Support Vector Machine (SVM) classification model developed by Konurhan (2024) for the Bodrum-Fethiye coastal belt. Landsat 4–5 TM (1990, 2000, 2006, 2012) and Landsat 7 ETM+ and 8 OLI (2018, 2022) images were obtained at a spatial resolution of 30 m; and were prepared for classification after mosaicking, cropping, and selecting appropriate band combinations (e.g., 7-6-4 'Urban', 5-4-3 'Vegetation'). Training and validation sample areas for the SVM model were selected on an area-based basis to represent at least 10% of the surface area of each land class. Google Earth, Landsat natural colour composites, topographic/orthophotomaps, and CORINE data sets were used together in the sample determination process. This approach was preferred because it provides more reliable results than single-point control. Accuracy assessments of the classification outputs were performed using the Confusion Matrix tool in QGIS 3.32.1 software. Confusion matrices were created for each year, and producer accuracy, user accuracy, overall accuracy, and the Kappa coefficient were calculated. In the 2022 classification, the overall accuracy was found to be 88.74%, and the Kappa coefficient was 0.89; during the 1990–2018 period, the overall accuracy values ranged from 88% to 95%, and the Kappa coefficients ranged from 0.88 to 0.90. The relevant tables (Tables 6–12) and formulas (Table 5) are presented in detail in Konurhan (2024). All analyses were performed using ArcGIS 10.8 and Pro, QGIS 3.32.1 software, and the FLUS package program.

In this article, the classification model presented in Konurhan (2024) thesis was directly applied to the Datça Peninsula, and the classification algorithm, band combinations, and training-validation strategy were integrated into the sub-region without modification. Therefore, the reliability of the classification is maintained, and the model outputs were evaluated directly without further accuracy analysis. Indeed, the requested accuracy data are included in the relevant section of the source thesis and are summarized in this study. Furthermore, as in the thesis, the land cover classes used consist of urban areas, agricultural areas, forest areas, semi-natural areas (scrub/grassland/sparse vegetation), and water surfaces.

In the suitability analyses, the characteristics of the study area and criteria based on the literature were determined. Data were obtained according to the characteristics of each criterion. For example, elevation criterion data was obtained using a Digital Elevation Model (DEM) with a resolution of 30 m. In contrast, data such as roads and rivers were obtained from the OSM platform. Analyses such as buffer, slope, and aspect were applied according to the characteristics of the criteria to prepare the data for analysis. All analyses were performed using ArcGIS 10.8 and Pro software with the FLUS package program.

3.4. Establishment of Land Use Scenarios

Land use scenarios are reasonable and consistent descriptions of land use under different conditions or policy choices. They are used to explore and analyze the potential impacts of various land use decisions and development patterns. Land use scenarios aim to facilitate informed decision-making, identify potential risks and opportunities, and help stakeholders develop robust and adaptable land use plans. Land use scenarios offer valuable insights into the effects of various development strategies, facilitating more sustainable and adaptable land use planning practices. They are an essential tool in urban and regional planning, environmental management, and sustainability assessments, and can be used in various ways. Land use models are needed for the application of land use scenarios. Land use models are tools used to better understand the functioning of the land use system and to analyze the causes and consequences of land use changes, thereby supporting land use planning and policy (Verburg et al., 2004).

GeoSOS-FLUS (referred to as FLUS in the text), which is based on MC and ANN, was used for generating future simulation maps. The FLUS model was developed by Liu Xiaoping's team in 2017 (Liu et al., 2017). Firstly, the model is based on system dynamics and the cellular automaton model. It also integrates the ANN algorithm and random selection mechanism to improve the accuracy of LUCC change simulation (Lin et al., 2020; Wang et al., 2021). This mechanism effectively addresses the complexity and uncertainty associated with the interplay of various factors, including natural, social, and economic factors, and the mutual transformation between various land-use (cover) types (Zhu et al., 2023).

In the FLUS program, it is necessary to determine some variables as input data for simulation analyses. In this sense, a total of 10 natural and human variables affecting land-use change in the study area were determined.

The following variables are considered: elevation, slope, vegetation cover, distance to rivers, distance to roads, distance to power lines, distance to fault lines, distance to city centers, current population density, and distance to lakes/dams. Variables were evaluated and determined based on the characteristics of the study area and relevant literature sources. The determined variables were normalized and shown between 1 (high) and 0 (low) values (Figure 3).

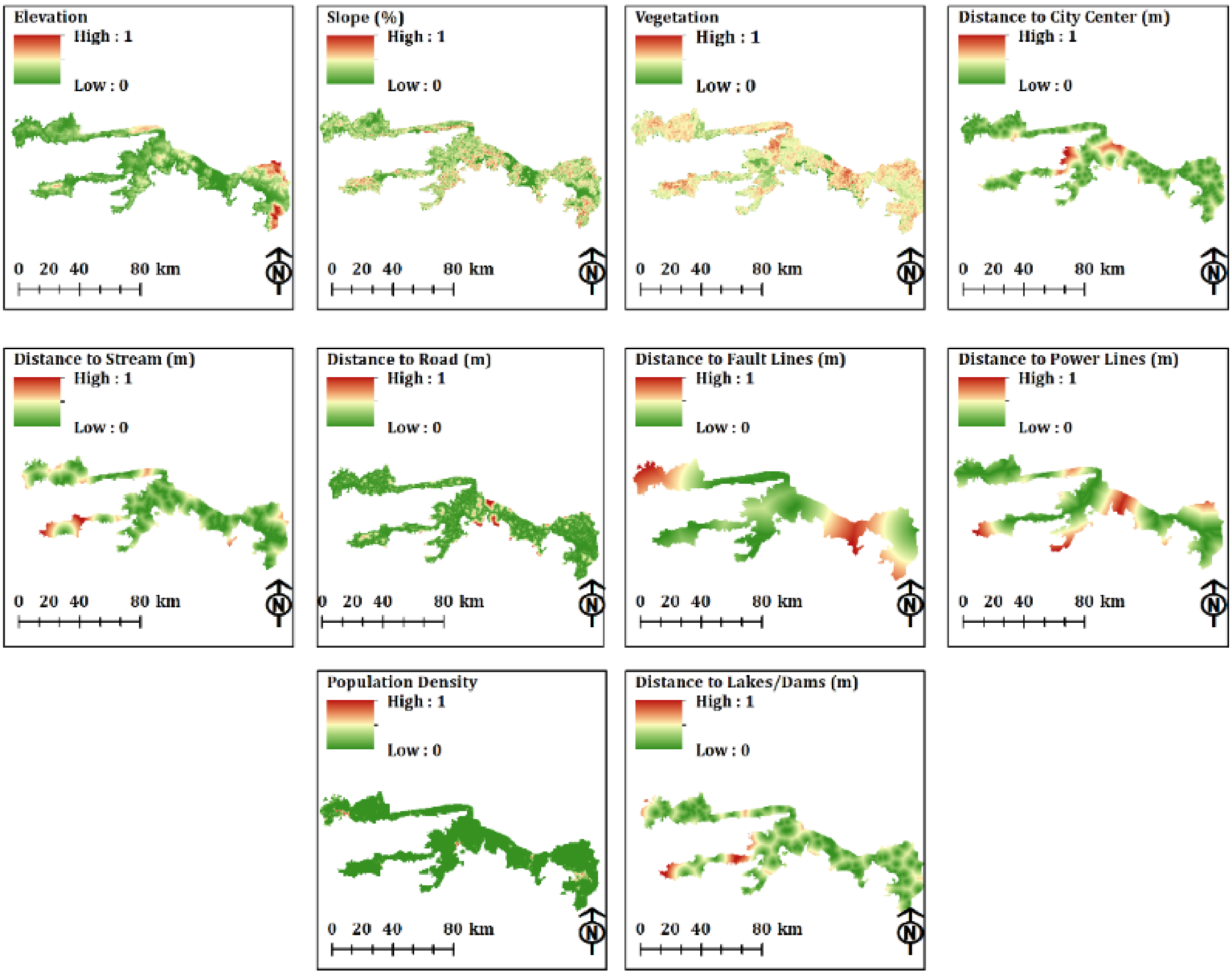

Figure 3. Variables used in land use simulations

Model calibration was performed by selecting the parameter set that provided the highest overall accuracy (88.74%) and FoM (0.27) according to the 2012-2018-2022 validation maps; in this context, water bodies were left stationary (0) in the Cost Matrix, the highest neighborhood weight (Weight = 1) was assigned to the artificial area class. The weights of the other courses were applied according to the values provided in Table 53 of the thesis (Konurhan, 2024).

3.5. Determination of Model Accuracy

Uncertainties are inevitable in land-use simulations. Therefore, it is necessary to determine the accuracy of the initial LULC data used in the simulation. For this purpose, firstly, an existing land-use map should be simulated, and the actual and simulated maps should be compared. In this context, a simulation map for 2022 was created using the land-use maps of 2012 and 2018 for the study area. Figure 4 and Table 1 compare the predicted results and the 2022 land-use map.

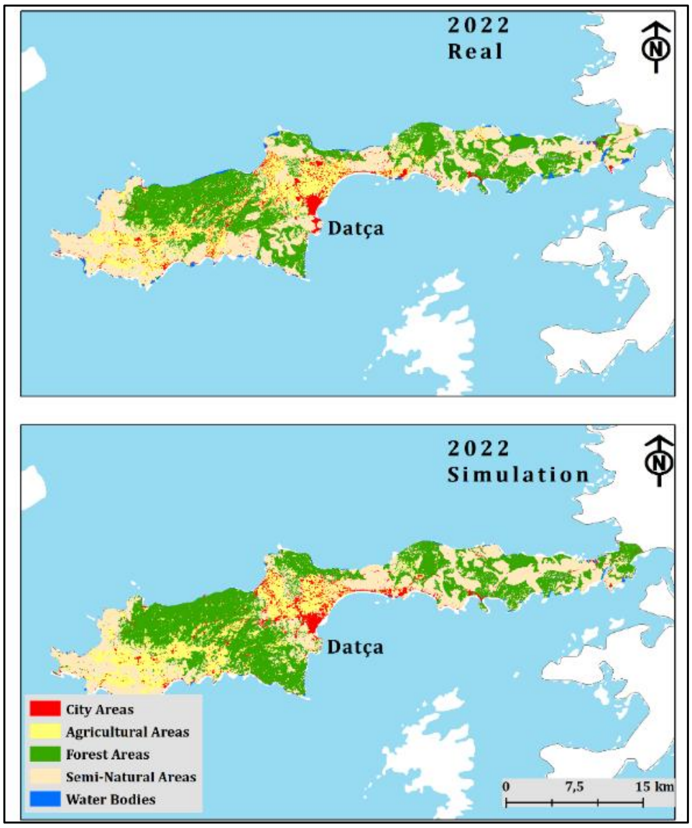

Figure 4. Actual and simulation maps of Datça Peninsula in 2022

Within the scope of the study, the accuracy of land use analyses was assessed using the Kappa coefficient index. The Kappa coefficient was determined by using the verification tools in the FLUS program. Here, the Kappa coefficient is calculated by taking random samples from the maps. Accordingly, the Kappa coefficient was calculated as 0.84. A Kappa coefficient greater than 0.8 indicates that the model accuracy has reached a satisfactory level of statistical significance (Landis & Koch, 1977; Rahnama, 2021; Talukdar et al., 2020). Therefore, according to the Kappa result, the data are suitable for simulation analysis.

Table 1. Comparison of 2022 actual and 2022 simulation land classes of Datça Peninsula

Land Class	2022 Real (km^2)	2022 Simulation (km^2)
City Areas	33,41	41,05
Agricultural Areas	41,13	48,21
Forest Areas	204,42	195,37
Semi-Natural Areas	145,17	139,75
Water Bodies	7,14	6,89
Total	**431,27**	**431,27**

The highest deviation observed in Table 1 is in the urban area class (≈ approximately +7.6 km^2; ≈ approximately 23%). Since this class covers only approximately 7% of the Datça Peninsula's surface area, even a small number of incorrect pixels can result in a high percentage error (Konurhan, 2024). The validation tables in Konurhan (2024), from which the data were obtained, indicate that the producer accuracy for urban areas is 75%, sensitivity is 83%, and specificity is 98%. The model overestimates urban sprawl, particularly in road corridors, due to spectral mixing and neighborhood effects. The 'semi-natural' class was not further subdivided because it consists of the aggregation of scrub-grassland subgroups in CORINE, and water bodies were left unchanged in the Cost Matrix (Konurhan, 2024). Therefore, these factors explain the relative error margin in the urban class, and the model performs in line with the overall model accuracy (overall accuracy: 88.74%; Kappa: 0.84). Overall accuracy and Kappa were calculated across all five classes; sensitivity of 83% and specificity of 98% for the urban class indicate that the primary sources of relative percentage error in the agricultural class may be the 30 m pixel mix and parcel boundaries.

In summary, model calibration was performed using a comparison of 2012–2018–2022 data; for 2022, OA=88.74% and Kappa=0.84 were obtained. Additionally, FoM=0.27 was reported using FLUS validation tools. In scenario design, water bodies were fixed (Cost Matrix=0), artificial area neighbourhood weight was assigned as 1; other class weights were used with the values in Table 53 of the thesis. Thus, the scenarios were supported by thesis-derived calibration parameters and validation against an independent time series.

3.6. Best-Worst Method (BWM)

BWM is a CRM method proposed by Rezaei in 2015. The BWM method is a weighting tool based on pairwise comparisons (2n-3, where n is the number of criteria) that simplifies the evaluation process by eliminating the need to compare all criteria individually. Firstly, the 'best' and 'worst' criteria are identified and then systematically compared with the other criteria. For these comparisons, a scale of 1-9 is used, where '1' indicates equal importance between the two criteria and '9' indicates a highly significant difference. To ensure consistency, two particular vectors are used:' from best relative to others' and 'from worst relative to others' (Rezaei, 2020).

Step 1: The criteria to be evaluated are determined. The requirements for decision-making are denoted by (c1, c2...cn).

Step 2: The best (most important, most desirable) and worst (least important, least desirable) criteria are determined. No pairwise comparison is made at this stage.

Step 3: Using numbers between 1-9, determine how different the best criterion is from the other criteria. The vector for best to other is constructed as follows: $A_B=(a_{B1},a_{B2},...,a_{Bn})$, where a_{Bj} indicates the preference of the best criterion B concerning the criterion. The comparison of the criteria with themselves ($a_{BB}=1$) is formulated in this way.

Step 4: Using numbers between 1-9 determines how different the worst criterion is from the other criteria. The Other-Worst vector is constructed as follows: $A_B=(a_{1W},a_{2W},...,a_{nW})$ where a_{jW} indicates the preference of criterion a_{jW} over the worst criterion.

Step 5: The formula determines the weight: $w_1^*,w_2^*,...,w_n^*$). When the necessary transformation is done, the problem is formed as follows:

$$\min \xi$$
$$\left|\frac{w_B}{w_j}-a_{Bj}\right| \leq \xi \text{ for all } j$$
$$\left|\frac{w_j}{w_W}-a_{jW}\right| \leq \xi \text{ for all } j$$
$$\Sigma w_j=1 \quad w_j \geq 0 \text{ for all } j$$

Optimum weights in problem-solving are calculated by the formulae $w_1^*,w_2^*,...,w_n^*$, and ξ^*. The optimum weight values are transferred to ArcGIS to be used in the study output. Here, in the application phase of the ‘Weight Sum’ analysis, one of the overlapping analyses, each criterion is entered separately, and the resulting map is created.

In line with the BWM method, the consistency ratio (CR) of the weight values obtained from pairwise comparisons of the best and worst criteria was calculated according to Rezaei's (2015) formula, yielding a value of CR = 0.10. Since this value falls within the CR ≤ 0.10 limit accepted in the literature, the pairwise comparisons were considered consistent; surveys that exceeded this threshold in the initial calculation were re-evaluated and adjusted by experts to ensure consistency.

3.7. Selection of Criteria for Areas Suitable for Settlement

Different criteria are considered when determining suitable areas for land use settlements. In this study, the criteria were selected based on the literature and the region's characteristics (Foroozesh et al., 2022; Liu et al., 2014). Using BWM, 16 criteria were defined under four main headings: topography, socioeconomic factors, location, and environmental conditions (Table 2).

Table 2. Criteria determined for areas suitable for settlement

Topography	Socio-Economic Conditions	Location	Environmental and Land Conditions
Elevation	Population Density	Distance to Road Network	Land use
Slope	Distance to City Centers	Distance to Stream	Distance to Dam - Lakes
Aspect	Distance to Beach Areas	Distance to Power Lines	Vegetation
	Distance to Industrial Facilities	Distance to Fault Lines	Distance to Nature Park Areas
		Distance to Shore	

Topography criteria include elevation, slope, and aspect. Elevation is one of the essential criteria frequently used in site selection analyses. Generally, elevations between 0 and 500 m are considered the most suitable values for settlement (Liu et al., 2014; Luan et al., 2021). The topography of the Datça Peninsula is rugged, and elevations increase rapidly over short distances. However, elevations are lower around the Datça Plain and on the southern and southwestern coasts, ranging from approximately 0 to 600 m. These areas are among the most suitable places for settlement. In this context, regions between 0 and 500 m in elevation have been mapped as suitable for settlement. The slope is another critical factor in site selection. High slopes increase construction costs, disrupt slope stability, and increase the risk of erosion and landslides. For this reason, slope degrees of 0-5% are generally considered suitable for settlement (Arnous, 2013; Foroozesh et al., 2022; Luan et al., 2021). The Datça Peninsula has high slope values due to its rugged structure. These areas are unsuitable for settlement, especially since the slope is high in the northern parts. Accordingly, regions with a slope range of 0-5% are considered suitable for settlement. Finally, aspect is also among the topography criteria. The orientation of the settlement affects its capacity to receive sunlight. Since Turkey is located in the northern hemisphere, areas facing north and west receive less sunlight. On the other hand, the south and east directions receive more sunlight and heat in the winter months and are considered more advantageous for settlement (Konurhan, 2023). A map was created in Datça by considering these suitable aspect directions, and areas facing south and east were evaluated as suitable for settlement (Figure 5).

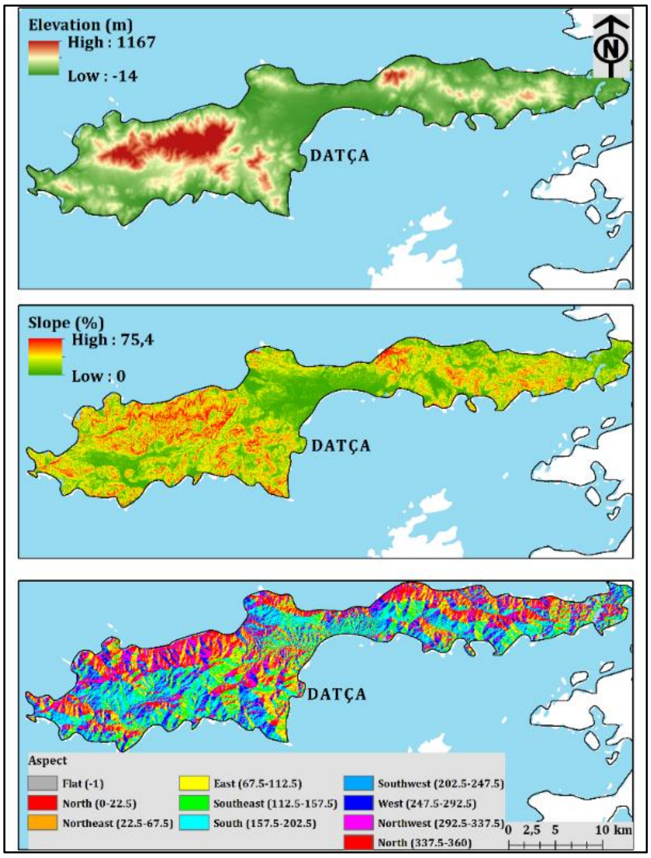

Figure 5. Topography criteria determined for areas suitable for settlement in the Datça Peninsula

The main criterion of socio-economic conditions includes sub-criteria such as population density, industrial zones, existing residential areas, and distance to beaches. High population density can create adverse effects on people, such as stress, aggression, and loneliness (Huang et al., 2019) and can also make municipal services difficult. Therefore, more densely populated areas are needed for new settlements. In the study, areas with a population density of 0-40 people per ha were considered very suitable, and those with a population density of 40-80 people per ha were considered suitable (Foroozesh et al., 2022). Yazıköy, Cumalı, Yaka, Mesudiye, Karaköy, and Kızlan surroundings in the Datça Peninsula were determined as suitable residential areas with low population density. Proximity to existing residential areas is also important because these areas typically have established infrastructure, cultural activities, and a well-defined socio-economic structure (Liu et al., 2014). The proximity to existing urban areas was analyzed for Datça, and suitable residential areas were identified accordingly.

Distance to industrial zones is also an important criterion. Industrial facilities play a critical role in the development of residential areas and the creation of job opportunities. Industrial areas on the Datça Peninsula were identified, and areas at least 1 km away were deemed suitable for residential use (Aburas et al., 2017). Finally, proximity to beaches is a significant advantage, particularly in the tourism industry. Beaches are natural attraction areas that increase tourism mobility. Beach areas on the Datça Peninsula were identified, distance analyses were conducted, and areas close to the beaches were evaluated positively regarding settlement (Figure 6).

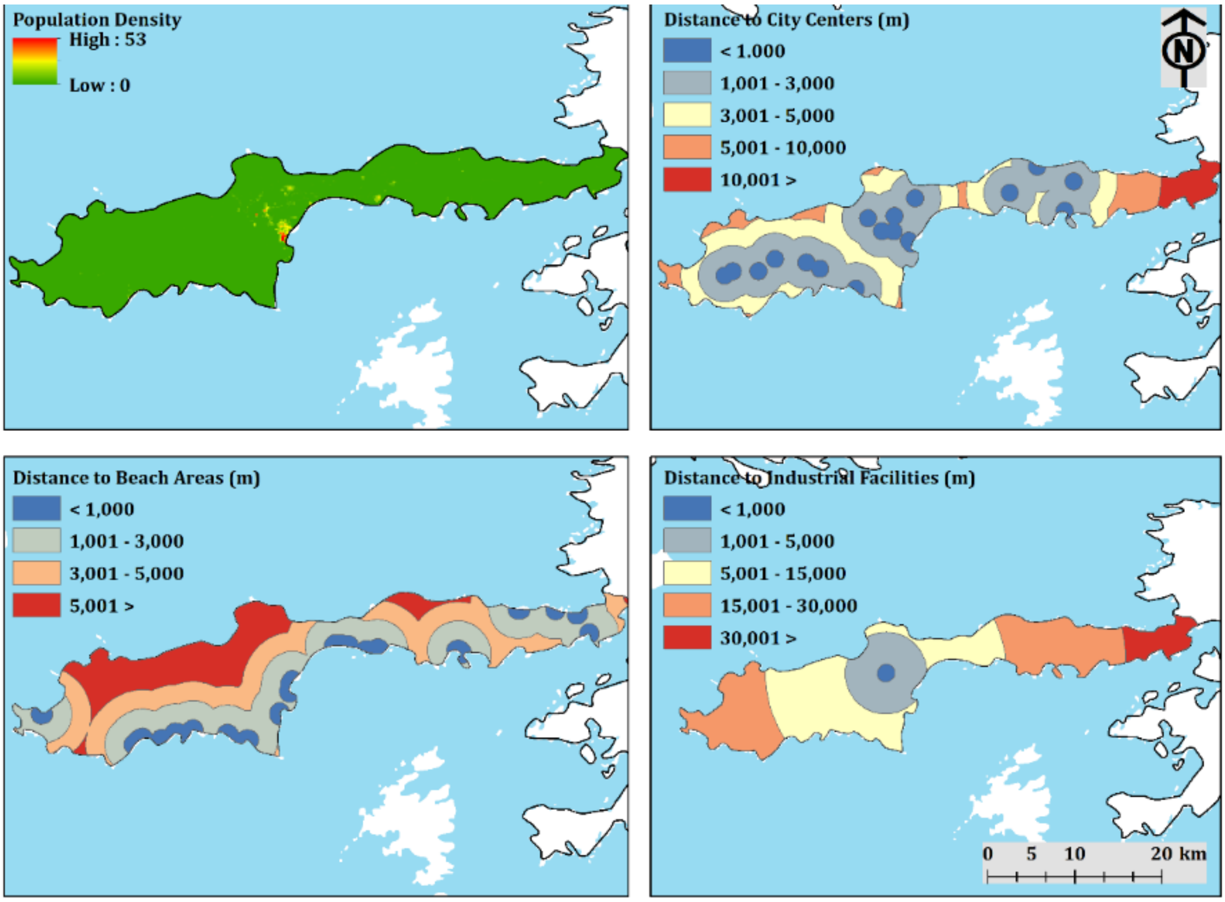

Figure 6. Socio-economic criteria determined for areas suitable for settlement in the Datça Peninsula

The location of settlements plays a critical role in their development. Therefore, location is of great importance in determining settlement areas. Under the location criterion, five sub-criteria were determined, including road network, stream, power lines, fault lines, and distance to the coast. Proximity to the road network is one of the most important of these criteria. Settlements 1 km away from the road network are suitable for settlement (Mahiny & Clarke, 2012; Liu et al., 2014; Luan et al., 2021). As a result of the analysis conducted in the Datça Peninsula, areas located 1 km from the road network were classified as the most suitable.

Proximity to the stream is also essential for settlement, as water resources are vital to the sustainability of settlements. Areas within 1 km of streams have been accepted as the most suitable areas for settlement (Deliry & Uyguçgil, 2020; Chabuk et al., 2019). Another important sub-criterion is the distance to power lines. Access to energy is a basic need for settlements. Areas within 1 km of power transmission lines on the Datça Peninsula have been identified as the most suitable for settlement (Figure 7).

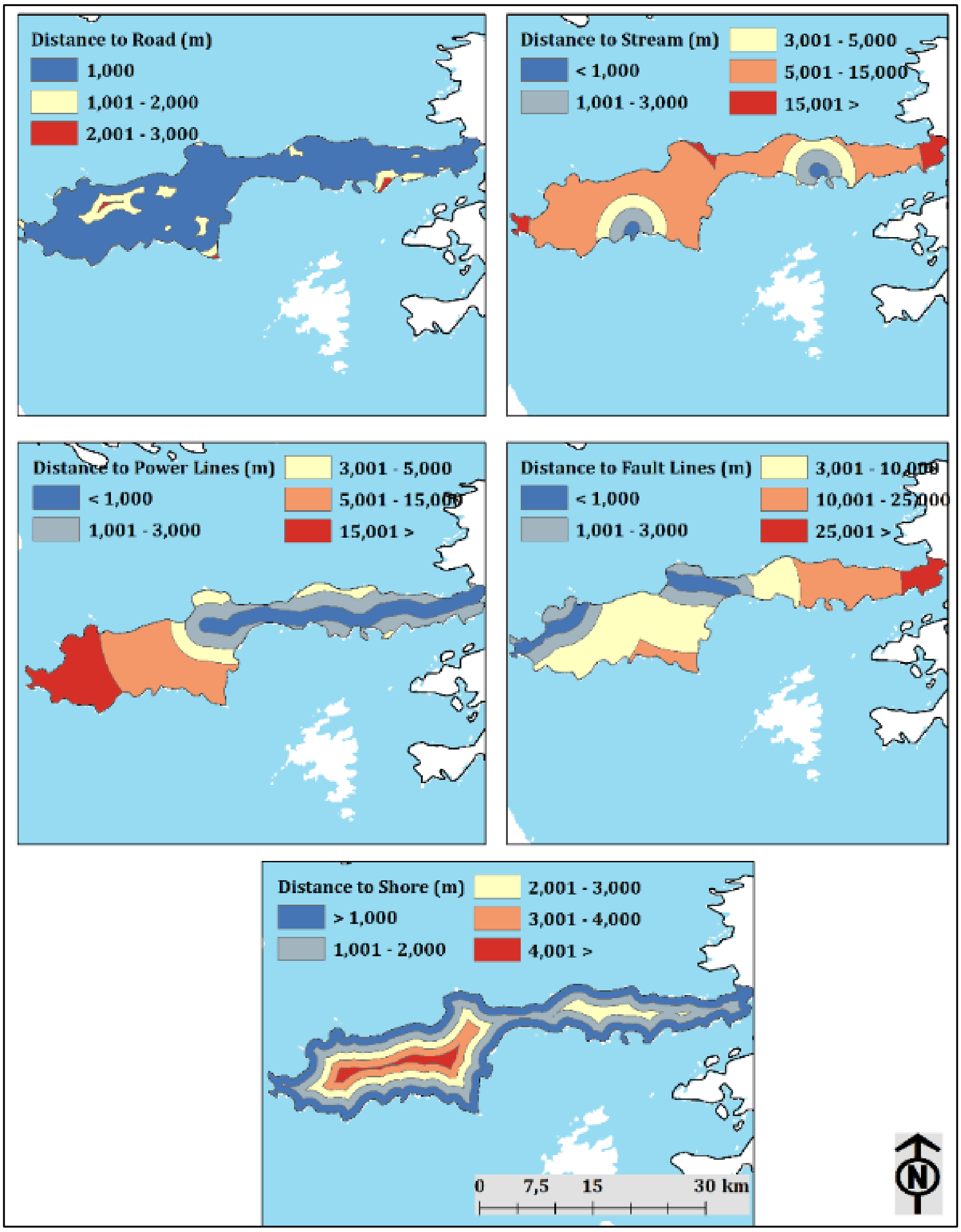

Figure 7. Location criteria determined for areas suitable for settlement in the Datça Peninsula

Due to earthquake risk, distance to fault lines is a critical factor in settlement planning. The Datça Peninsula carries a high earthquake risk due to the Datça Fault and the fault lines in the Aegean Sea and Bozburun Peninsula. Therefore, settlements should be at least 1 km from the fault lines (Sakieh et al., 2015). As a result of the analyses, suitable settlement areas were determined by considering the distance to the fault lines. While the Kızlan area and the skirts of Kocadağ are among the riskiest areas, Yazıköy, Cumalı, Yaka, Mesudiye, Hızırşah, Reşadiye, and Datça center in the southern parts of the peninsula were classified as lower risk areas. Another vital element in the primary location criterion is the distance to the coast. Proximity to the seashore provides advantages to settlements in terms of socio-cultural activities and commercial activities (especially fishing). As a result of the distance analyses conducted on the Datça Peninsula, suitable areas were classified gradually according to their proximity to the coast (Figure 6).

The main environmental and land conditions criteria include sub-criteria such as LULC, distance to dam-lake areas, vegetation, and distance to nature parks. The land-cover/land-use criterion focuses on existing land; bare areas are considered the most suitable for settlement. Agricultural and forest areas are not suitable for settlement. In this context, suitable areas were identified using the 2022 land-use/land-cover map for Datça.

Another vital criterion is proximity to water resources, and although there is no dam on the Datça Peninsula, there are a few small ponds. Distance analysis was performed by considering the distance to these ponds and identifying suitable areas for settlement.

Regarding vegetation, bare areas with little vegetation are preferred for settlement areas. A vegetation map was created for the Datça Peninsula, and bare areas where settlement could be established with minimal vegetation loss were classified as suitable. Finally, the distance to nature parks is an important criterion. While building settlement areas near nature parks is forbidden, density construction in these areas may damage the natural environment. For this reason, it is recommended to establish settlement areas at least 1 km away from nature parks (Malmir et al., 2016; Li et al., 2018). The surroundings of Çubucak and Kovanlık Nature Parks in Datça were not deemed suitable areas, and the areas outside these parks were identified as suitable for settlement (Figure 8).

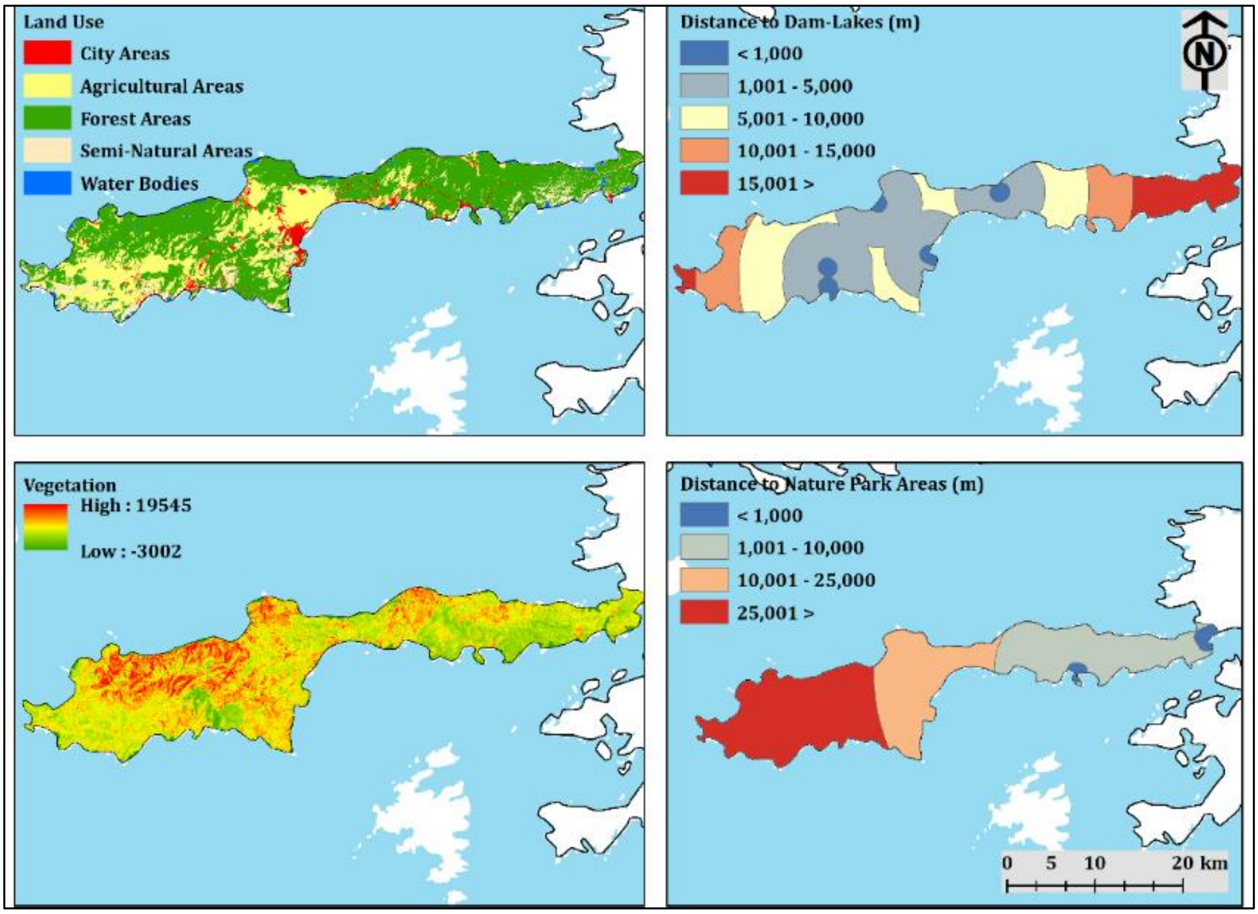

Figure 8. Environmental and land condition criteria determined for areas suitable for settlement in the Datça Peninsula

4. Application Results

4.1 Land Use in Datça Peninsula

Five main classes were determined in the LULC analyses on the Datça Peninsula. These include settlements, agricultural areas, forests, semi-natural habitats, and water bodies. Forests and semi-natural areas dominate the peninsula, which covers an area of approximately 430 km². In 1990, forests covered the largest area, approximately 240 km², followed by semi-natural areas of 110 km², agricultural areas of 68 km², water bodies of 7 km², and residential areas of 5 km². By 2000, forests were again the largest class, regressing to approximately 230 km², while semi-natural areas increased to 120 km². During the same period, the agricultural areas covered 64 km², and the residential areas covered 6 km². Between 1990 and 2000, semi-natural and residential areas expanded slightly, while forests and agricultural areas decreased by approximately 9 km². No significant changes were observed in the water bodies. There was no significant change in the LULC pattern on the peninsula over the 10 years (Figure 9; Table 3).

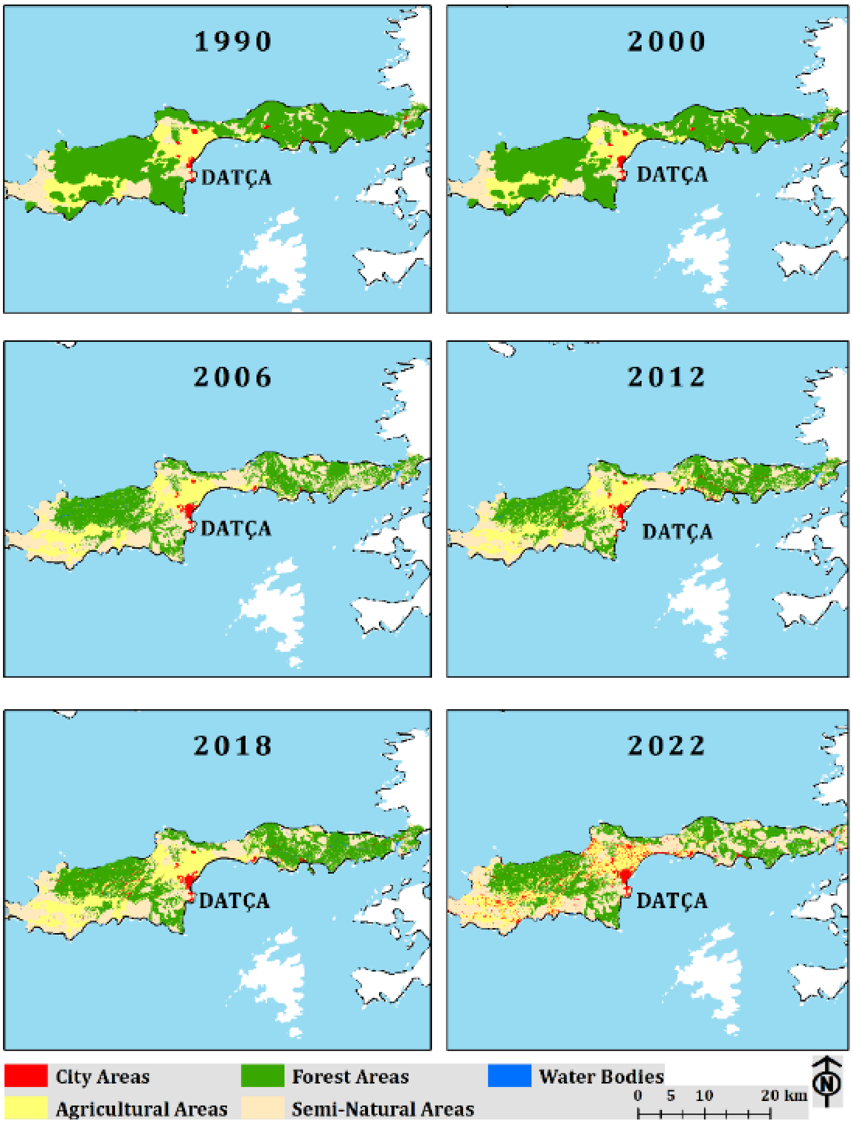

Figure 9. Land-Use/Land-Cover (LULC) composition of the Datça Peninsula, 1990 – 2022

The LULC assessments conducted between 2012 and 2022 showed a significant increase in residential areas. In 2012, forest areas were approximately 220 km², semi-natural areas 135 km², agricultural areas 55 km², residential areas 15 km², and water bodies were around 7 km². In 2022, forest areas reached 205 km², semi-natural areas 145 km², agricultural areas 40 km², and residential areas 33 km². Significant increases were recorded in semi-natural and residential areas, while there was no change in water bodies. In particular, the residential areas land class expanded the most, with an increase of 17 km², while agricultural areas decreased by approximately 14 km² and became the land class that shrank the most (Figure 8; Table 3).

Table 3. Land-use/land-cover (LULC) data of Datça Peninsula between 1990-2022 (km²)

Land Classes	1990	2000	2006	2012	2018	2022
City Areas	4,93	6,02	10,62	16,37	24,88	33,41
Agricultural Areas	68,23	64,08	61,32	55,19	48,47	41,13
Forest Areas	238,45	233,45	228,45	218,07	213,29	204,42
Semi-Natural Areas	112,54	120,20	123,75	134,75	137,21	145,17
Water Bodies	7,12	7,53	7,13	6,89	7,42	7,14
Total	431,27	431,27	431,27	431,27	431,27	431,27

According to LULC data, the residential areas in the Datça Peninsula have gradually increased since 2006 and reached approximately 35 km² in 2022. One of the main reasons for the partial increase in the land class of residential areas in the Datça Peninsula between 2012 and 2022 is the increasing number of tourists. The increase in residential areas is expected to continue in the coming years, as tourist movements are projected to remain high.

4.2. Results of Land-Use Scenarios

In the study, scenarios for the years 2026, 2030, 2034, and 2044 were conducted based on parameters created with FLUS software in a doctoral thesis (Konurhan, 2024). In the thesis, Markov transition probabilities were obtained from land use maps for the years 2012, 2018, and 2022, as well as elevation, slope, vegetation cover, distance to waterways and power lines, distance to fault lines, and distance to settlements. Land use maps for the years 2012–2018–2022. The scenario settings were created entirely according to the values defined in the thesis: water bodies were assumed to be stationary, the highest propagation weight (Weight = 1) was assigned to the artificial area class, and inter-class transition constraints were determined using the Cost Matrix (Konurhan, 2024).

According to LULC simulations conducted on the Datça Peninsula, residential areas are expected to grow in the coming years. The 2026 simulation results indicate that the residential land class will cover approximately 40 km², agricultural areas will encompass 43 km², forest areas will occupy 200 km², semi-natural areas will span 138 km², and water bodies will comprise 7 km². In 2034, residential areas are expected to expand to 61 km², representing a 20 km² increase. Semi-natural areas also increase by approximately 7 km², while agricultural and forest areas constantly decrease. According to the 2044 simulations, residential areas are expected to expand significantly, reaching 78.46 km²; agricultural areas will increase to 21.49 km²; forest areas will increase to 166.68 km²; and semi-natural areas will increase to 156.78 km². A stable situation of approximately 7.86 km² is envisaged for water masses (Figure 10; Table 4).

According to the simulation results, the settlement areas in the Datça Plain spread from the Datça city center to the north towards Reşadiye, Karaköy, and Kızlan. According to the 2034 simulation, the settlement areas are connected from south to north without interruption. The development of the settlement areas began in Datça city and extended to Reşadiye, Karaköy, and the Datça Kairos Marina in the north. This growth has occurred mainly in agricultural areas, which indicates the loss of agricultural land.

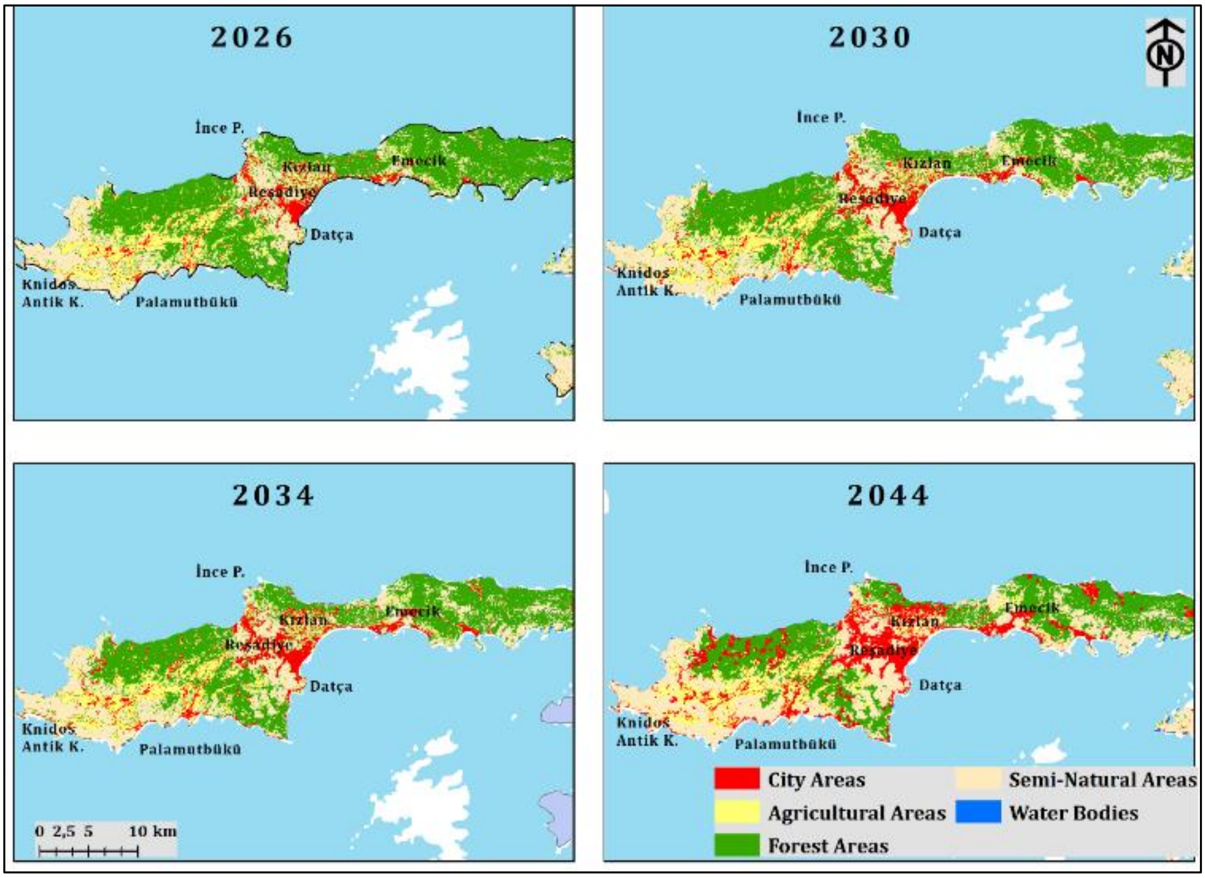

Figure 10. Datça Peninsula land-use simulation results

Table 4. Datça Peninsula land-use simulation (2026-2044) Data (km^2)

Land Classes	2026	2030	2034	2044
City Areas	40,82	53,08	61,18	78,46
Agricultural Areas	43,31	39,15	31,32	21,49
Forest Areas	200,42	190,12	185,06	166,68
Semi-Natural Areas	138,84	141,12	145,87	156,78
Water Bodies	7,88	7,80	7,84	7,86
Total	**431,27**	**431,27**	**431,27**	**431,27**

According to the 2044 LULC simulations, almost all of the Datça Plain is covered by residential areas. In 2034, residential areas expanded towards Reşadiye, Karaköy, and the north. By 2044, this expansion had shifted eastwards to Kızlan. Residential areas spread to include Datça city center, Karaköy, Reşadiye and Kızlan. The expansion generally followed the existing road network and low-altitude areas. It was observed that residential areas in Karaincir and Emecik, located east of Datça Plain, grew parallel to the Marmaris-Datça road route. The expansion towards the west spread to the Karaköy and Hızırşah areas, and these areas were predominantly simulated to be occupied by agricultural lands.

The settlements such as Yazıköy, Cumalı, Yaka, and Sındı located in the west of the peninsula, are in the flat areas on the skirts of Kocadağ. In the south, settlements are found around Palamutbükü and Ovabükü. The reason for these settlements being concentrated in the south is that the north is mountainous and rugged. According to the 2044 simulation results, the settlement areas around Mesudiye Neighborhood and Palamutbükü have also grown by following the existing road routes and low-elevation areas.

Since the Datça Peninsula has a mountainous and rugged topography, settlements are generally concentrated in the flatter, more accessible plain areas. In the land-use simulation, the expansion of settlement areas is modeled based on these flat areas. This is because the variables used in the simulation are compatible with the current land-use pattern. For example, the settlement areas in the study area are generally concentrated at low altitudes, near road routes, and in flat areas. This has led to the simulation results taking shape in this direction. Similarly, the development of settlement areas in Datça has increased in less rugged areas, close to road connections and plains. In this process, settlement areas are simulated to expand by occupying mostly agricultural lands and partly forested areas.

4.3. Determination of Areas Suitable for Settlement

BWM, one of the MCDM methods, was used to determine areas suitable for settlement. In this direction, the weight value of each criterion was calculated using the LINGO 20.0 package program. The calculated weight values were superimposed using the "Weight Sum" tool, one of the ArcGIS 10.8 tools, and suitable settlement areas for the Datça Peninsula were determined.

Among the global weight values calculated with the BWM method, the most important criterion was the "elevation" criterion (0,1318). The elevation criterion was followed by the distances to the road network (0.1071), dams and lakes (0.0966), and power lines (0.0949). The least important criterion was calculated as the aspect criterion (0.0124) (Table 5).

Table 5. Global weight values calculated using BWM

Criteria	Weight Value	Criteria	Weight Value
Elevation	0,1318	Distance to Stream	0,0624
Slope	0,0831	Distance to Power Lines	0,0949
Aspect	0,0124	Distance to Fault Lines	0,0872
Population Density	0,0544	Distance to Shore	0,0145
Distance to City Centers	0,0464	Land use	0,0868
Distance to Beach Areas	0,0154	Distance to Dams-Lakes	0,0966
Distance to Industrial Facilities	0,0743	Vegetation	0,0170
Distance to Road Network	0,1071	Distance to Nature Park Areas	0,0148

BWM weights, obtained by optimizing the ‘best/worst’ comparisons of six experts experienced in regional planning and geography in LINGO, were consistent with CR = 0.10. Since participants emphasized that settlements have developed primarily at low elevations and near roads, elevation (0.138) and distance from the road network (0.107) received the highest weights. Since slope values are already closely related to elevation, they were included in the model with a lower weight (0.084) to avoid duplication. Since the presence of agriculture and forestry was considered in LULC conversion probabilities, the 'land use' criterion was left at a medium level (0.087). Thus, the weights were determined in a manner consistent with field reality and expert opinions.

The base maps, created according to the calculated weight values , were combined to determine suitable areas for settlement in the Datça Peninsula. According to the results, the southern shores of the peninsula stand out as suitable areas for settlement. In particular, the Datça Plain surroundings, the region extending to Ovabükü and Palamutbükü in the southwest, were identified as the most suitable areas for settlement. Kızlan, Reşadiye, Datça district center, and the northern shores of the Datça Plain are also among the most suitable areas for settlement. These areas are among the lowest altitudes of the peninsula. In addition, the existing urbanization, developed road network, industrial site, and coastline have made these areas suitable for settlement (Figure 11).

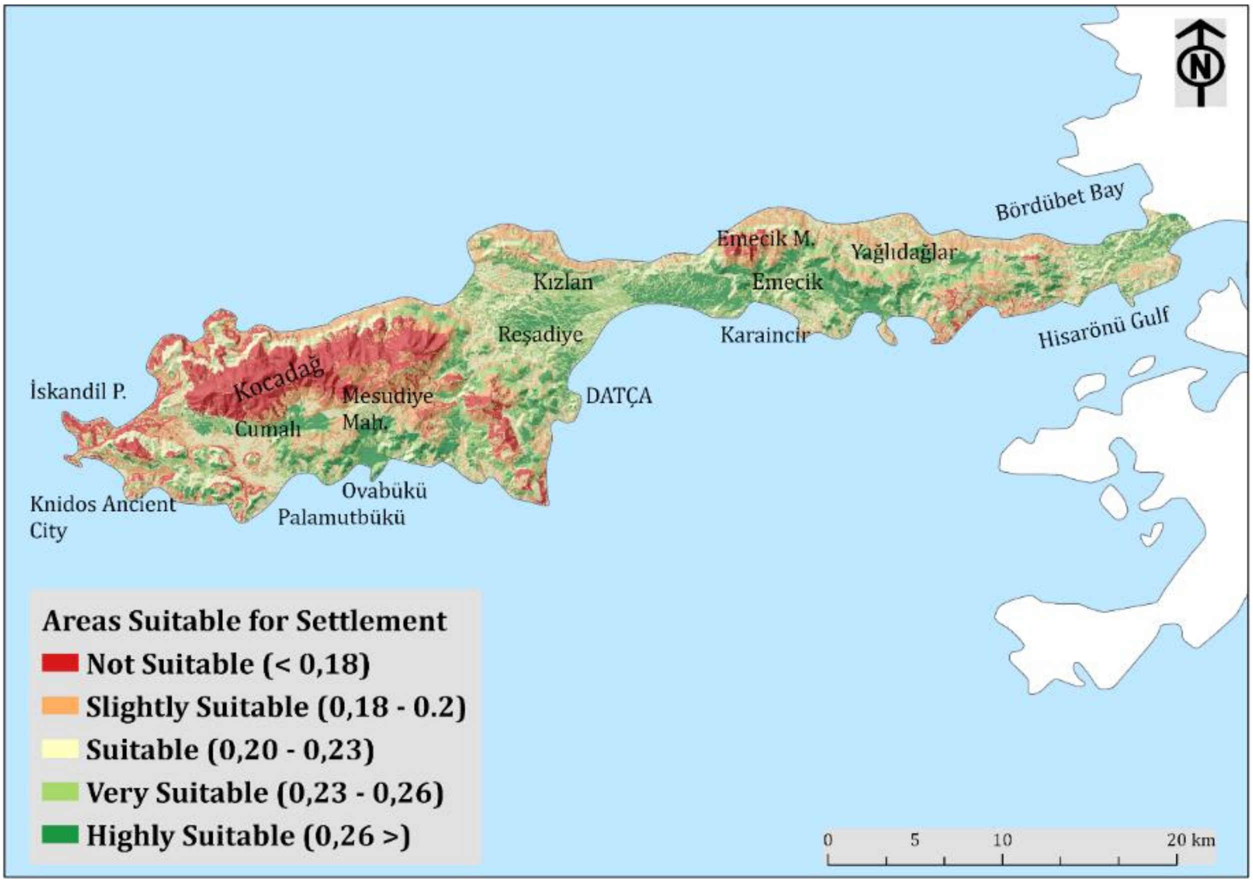

Figure 11. Areas suitable for settlement in the Datça Peninsula

Emecik and Karaincir's surroundings on the Datça-Marmaris road are among the areas suitable for settlement due to their low elevation values. The southern shores of the region, forming the isthmus of the peninsula through which this road passes, have also been generally determined as suitable areas for settlement. Karaincir and Bencik Bay are suitable for settlement, except for some sections where the elevation increases. Although the isthmus area is generally rugged, the elevation on the southern shores mainly varies between 0 and 450 m, and the highest point is Kocadağ, at 747 m, located north of Emecik. Therefore, according to the elevation criterion, these regions are ideal places for settlement. Additionally, the existence of the Datça-Marmaris highway has been a crucial factor in determining whether this region is suitable. Elevation and proximity to the road network are among the most important elements in the criterion evaluation.

According to the analysis results, the northwestern part of the Datça Peninsula, where the elevation and slope are high, the road network is underdeveloped, and it is far from the district center, is unsuitable for settlement. Bozdağ in this region is the highest point of the peninsula with 1162 m and has a very rugged topography covered with forests and no settlements. Therefore, it is not suitable for settlement.

Additionally, the Kocadağ area, located in the north of Emecik, is also among the unsuitable areas. The north of Kargı Bay and the northwest of Datça district center are also classified as other areas unsuitable for settlement.

When the spatial distribution of the outputs is examined, the areas showing high suitability are approximately 37 km², and the very suitable areas are 85 km². These two classes are of great importance for suitable settlement areas, and these areas can be evaluated as suitable for settlement. However, approximately 45% of the Datça Peninsula is not suitable for settlement (Table 6).

Table 6. Suitability classes and spatial distribution in Datça Peninsula

Suitability Classes	Suitability Value	Area	
		km²	%
Highly Suitable	0,26 >	37,23	8,62
Very Suitable	0,23- 0,26	86,07	19,95
Suitable	0,20-0,23	112,54	26,09
Slightly Suitable	0,18-0,20	119,75	27,76
Not Suitable	< 0,18	75,68	17,54
Total		**431,27**	**100**

5. Discussion

According to the simulation results, the development of settlements in the Datça Peninsula is primarily directed to the north and east of the Datça Plain. This situation leads to the destruction and disappearance of agricultural lands in the plain. A similar process has occurred in the past, and the city of Datça has continuously expanded to agricultural lands.

Figure 10 and Table 4 simulation outputs for 2026–2044 reveal a striking concentration around the Datça Plain. Model results indicate that settlement areas will increase from 40.8 km² to 78.5 km² (+92%) over the four scenario years, while agricultural areas will decrease by half, from 43.3 km² to 21.5 km², and forest areas will decline from 200.4 km² to 166.7 km² (-17%). Urbanisation is primarily developing in the 0–150 m elevation band and within 1 km of the existing road network, forming a continuous strip along the north-south axis from Datça city centre to Reşadiye, Karaköy, and Kızlan; it extends as far as Palamutbükü and Ovabükü in the southwest. The 2044 scenario suggests that nearly the entire Datça Plain, which serves as the backbone of agricultural production, will face significant settlement pressure, while forested and semi-natural areas on the steep northern slopes will remain relatively protected. This scenario highlights the need to guide settlement expansion within a balance between conservation and use; particularly by defining a ≤ 15% slope limit for agricultural lands and agricultural buffers, and shifting new residential areas to the sparsely vegetated maquis belt at an elevation of 400–500 metres around Palamutbükü emerges as a sustainable scenario.

According to the simulation results of the settlement suitability analysis conducted for Datça, the Datça Plain is one of the prominent areas. This area stands out in both the simulation and suitability analyses due to its low elevation and slope values. Urban development is more accessible in such flat and low-cost areas. However, suitability analyses indicate that the Datça Plain and regions such as the northwest of the district center, the west, and the southwest coast are suitable for settlement. In addition, the southern shores of the isthmus on the Datça-Marmaris highway are suitable for settlement, except for certain altitudes (Figure 12).

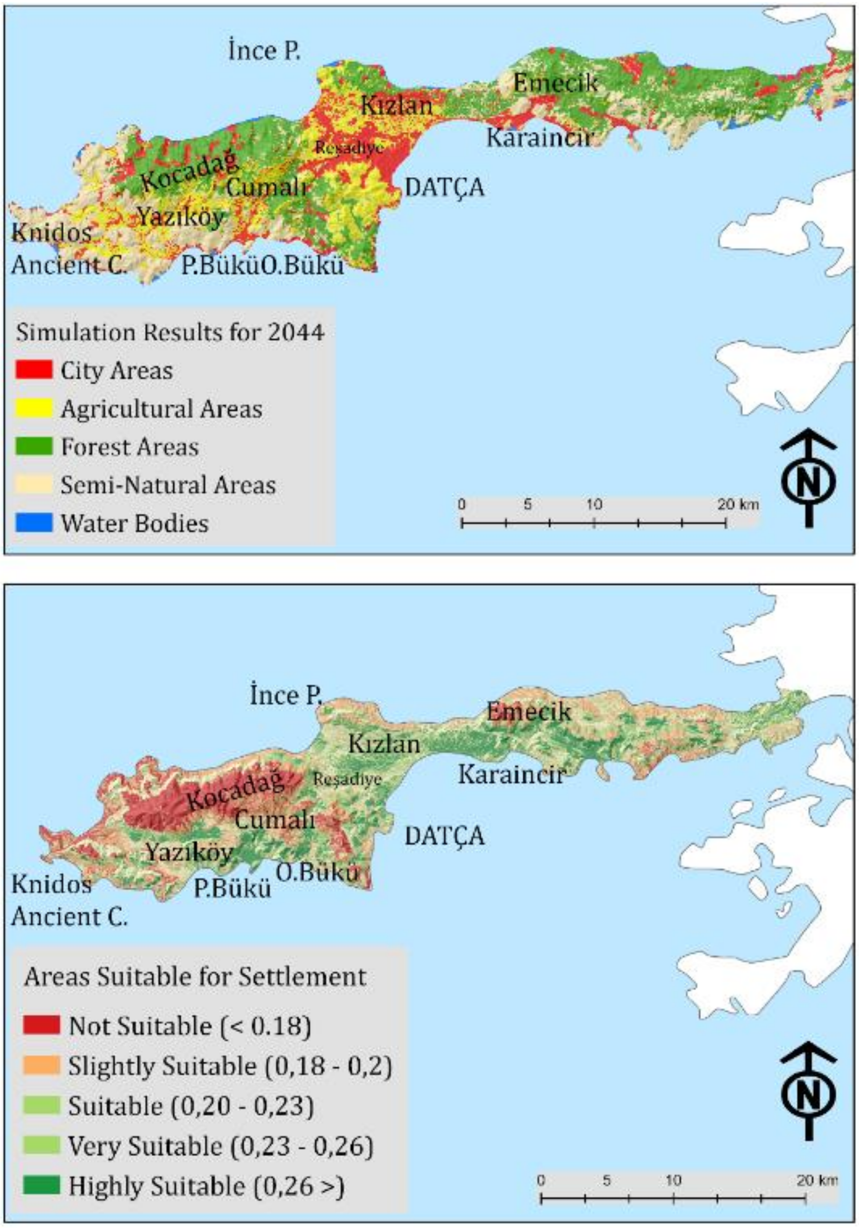

Figure 12. Areas suitable for settlement with 2044 simulation results of Datça Peninsula

The current situation and simulation results show that settlement areas are destroying agricultural lands. However, land suitability analyses reveal regions with higher altitudes and sparse forest cover outside agricultural areas. Especially the areas between Yazıköy and Mesudiye Neighborhood, as well as the surroundings of Palamutbükü and Ovabükü, fall into this category. Necessary examinations can be conducted in these regions, and suitable locations can be identified for settlement. Thus, sustainable urban development can be carried out in suitable areas by protecting agricultural lands. Today, construction has started around the Balcahisar and İskele Locations in the northwest of Datça and İçkoru Location in the southeast. It is important for urban development that this construction continues in suitable areas without damaging agricultural and forest areas.

Considering the increasing tourism activities in recent years, new alternative settlement areas need to be created outside the Datça district center. According to the analysis results, the Palamutbükü area stands out in this regard. New settlements can be developed at altitudes of 400-500 meters without damaging agricultural and forest areas. There are already old settlements in this area. For example, areas with little vegetation and hilly areas around Palamutbükü attract attention. Places such as Sakızyayla Ridge and Karabalık Hill (381 m) can be considered suitable for new settlement areas (Figure 13).

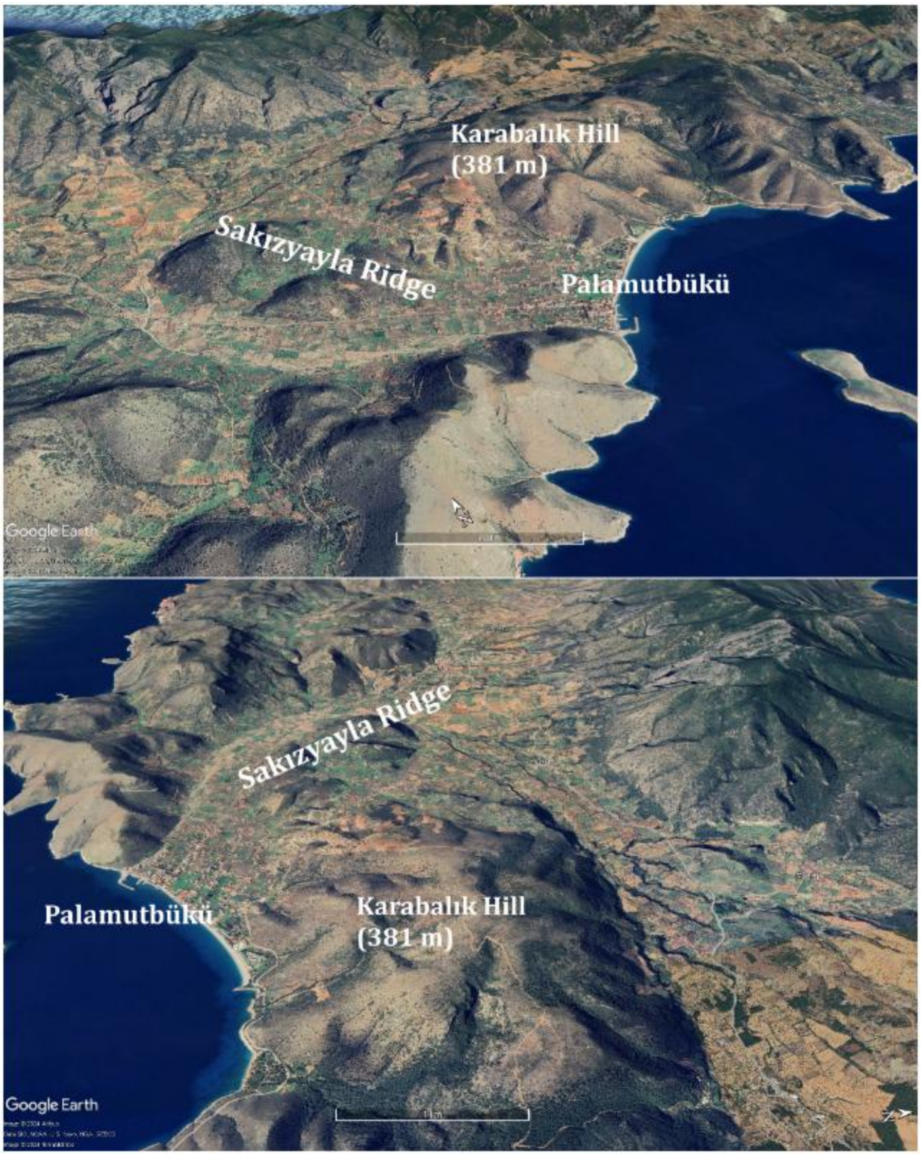

Figure 13. View of Datça Peninsula Palamutbükü and surroundings

Consequently, there are areas on the Datça Peninsula where the simulation results coincide with areas suitable for settlement. These overlaps are particularly evident in the Datça Plain. According to the simulation, areas with less intensive urban development on the southwestern and southeastern coasts of the peninsula are suitable for new settlements. Therefore, the development of settlements in Datça should be planned in a way that prioritises the protection of agricultural and forest areas and strikes a balance between conservation and use. On the other hand, the output results are consistent with land use scenarios considered in other studies. Simulations conducted for Beijing show that urban expansion is concentrated around low elevations and transport networks (Han, 2015). CA-Markov-based studies emphasize that scenario assumptions have significant effects on agricultural/forest conversions (Hamad et el., 2018). In the Guangzhou case, FLUS scenarios were evaluated in conjunction with flood sensitivity, highlighting expansion pressures in low-lying areas (Lin et al., 2020). Studies in Diyarbakır (Dağlı, 2021) and Mersin-Tarsus-Adana (Görentaş, 2021) in Turkey also indicate that growth is concentrated around plain bases and road networks. Similarly, scenarios obtained for the Datça Peninsula show that settlement pressure is concentrated in the 0–150 m elevation band and areas close to the road network. That conversion from agricultural land is significant. The divergent results for the peninsula are that geographical constraints and tourism pressure shape the direction of growth. While there is a tendency for expansion in coastal and plain strips, steep forest-semi-natural belts are relatively protected. Unlike scenario outputs in literature, this study aligns FLUS projections with suitability surfaces produced at the exact resolution at the pixel level, making areas of compatibility/conflict clearly visible. Thus, it assesses not only the question ‘where is growth expected?’ but also ‘where should growth not occur?’ from a planning perspective.

6. Conclusion

The study focused on the land-use scenarios of the Datça Peninsula and identified areas suitable for settlement. The Datça Peninsula has recently emerged as an alternative to the surrounding regions, including Bodrum, Marmaris, and Fethiye. The increase in the number of tourists in recent years is a clear indication of this. This has caused an increase in population and construction in certain parts of the peninsula. In particular, the city of Datça has begun to expand and grow towards Kızlan and Reşadiye on the plain. Indeed, while the settlement areas in the peninsula were approximately 5 km² in 1990, this area increased to approximately 33 km² by 2022. According to the land-use scenario results, this rate is expected to increase and reach approximately 78 km² by 2040.

The Datça Peninsula has a rugged topography that is generally covered with forest areas. Only certain areas are suitable for settlement. As part of the study, areas suitable for settlement were identified throughout the peninsula. Accordingly, the ratio of very suitable and highly suitable areas on the peninsula is approximately 30%. These areas are generally located on the southern shores of the peninsula because the northern shores are very mountainous. The Datça Plain and its surroundings, including Karaincir, Palamutbükü, Mesudiye, Cumalı, and Yazı, are among the most suitable areas for settlement on the peninsula.

When the land-use scenario and settlement suitability analysis results are compared, certain areas overlap, such as Datça Plain and its surroundings. However, the increase in settlements in Datça Plain and its surroundings leads to the destruction of almond trees and agricultural areas, are important species for Datça. Therefore, within the scope of this study, it is recommended that settlement areas expand towards certain heights around Palamutbükü, which are suitable for settlement according to the analysis results. These areas can be suitable for settlement due to their low elevation and barren maquis communities.

Landsat assessments for the period 1990–2022 show that settlement areas increased by +28 km² (≈ 560%), while agricultural land decreased by –27 km² (≈ 40%), and forests decreased by –34 km² (≈ 14%). The FLUS scenario predicts that this trend will continue, increasing the settlement area to 78 km² by 2044, with approximately half of this coming from converted agricultural land. Seventy percent of the increase will be concentrated in the 0–150 m elevation band and within < 1 km of roads.

These findings underscore the importance of measures such as a ≤ 15% slope limit, agricultural buffer zones, and post-fire development restrictions on northern slopes in maintaining the balance between conservation and use in the Datça Plain. Additionally, the sparse maquis belt around Palamutbükü at an elevation of 400–500 meters could be planned as an ‘alternative settlement area. This would enable simultaneous management of agricultural production, forest ecosystems, and tourism pressures.

The study provides important information for future research by analyzing land use scenarios and identifying areas suitable for settlement on the Datça Peninsula. In future studies, higher-resolution and multi-source fusion approaches can be evaluated; classification can be retrained, and scenario parameters (transition costs and neighborhood weights) can be recalibrated; and the scenario-suitability integration presented here can be tested with more detailed local models. More comprehensive integration of factors such as climate change, natural disaster risk, and ecological balance could significantly contribute to the development of sustainable settlement strategies. Furthermore, incorporating surveys conducted with the participation of local communities and other stakeholders into these analyses could further strengthen their socio-economic dimensions.

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