Analysis of Land Use/land Cover Changes and Prediction of Future Changes With Land Change Modeler: Case of Belek, Turkey

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Abstract

In the areas declared to be a tourism center, a rapid tourism-related development occurs depending on the investments in tourism, which causes a dramatic land use and land cover changes. Determining, monitoring, and modeling of land use and land cover changes are required in order to ensure the conservation-use balance and sustainability within such vulnerable areas that are under the development pressure. This study consists of four steps. In the first step, the Landsat images dated 1985, 2000, and 2021 were classified using the maximum likelihood method and the land use and land cover of Belek Tourism Center located in Turkey were determined. The second step included the identification of areal and spatial changes between the land use and land cover classes for the periods between 1985 and 2000, 2000 and 2021, and 1985 and 2021. In the third step, the land use and land cover changes in Belek Tourism Center for 2040 were modeled using the Land Change Modeler. Last step evaluated the relationship between the modeled spatial development pattern and the current planning decisions. According to the results obtained through a 36-year research, the rates of settlement, forest, and water body areas have increased by 11.91%, 13.67%, and 0.82%, respectively whereas the rates of barren land and agricultural areas have reduced by 22.25% and 4.15%, respectively. The land use map modeled for 2040 predicts the settlement areas to expand by 5.46% and the agricultural areas to shrink by 4.21% by comparison with 2021.

Introduction

Changes of the land use and land cover consist of a complex and dynamic process that occurs under the influence of natural or anthropogenic activities, affecting the entire ecosystem. Constituting an important part of the ecosystem and being one of the primary scarce resources, coastal areas require planned development to ensure their sustainability and conservation-use balance. These ecologically vulnerable areas should be monitored for their change process over time and their land use models for future should be generated.

A sustainable development requires settlement systems to be comprehensively analyzed and modeled (Sakieh et al., 2015). Urban development leads to intense changes in the spatial distributions, amounts, and types of land uses and has an impact on the shrinkage and distortion of natural areas (Xu et al., 2016; Oliveira et al., 2018). As indicated in the final declaration of Rio Conference held in 1992 (Agenda 21), a sustainable spatial planning is one of the most important practical methods to support the planned development of settlements and to ensure environmental, social, and economic sustainability. Spatial planning processes are realized through collection and analysis of basic environmental, geological, socio-economic, etc. data regarding the areas to be planned, synthesis of these data in line with the aims and visions of the plans, and finally identification of the types of spatial use. In these processes, however, natural areas such as agricultural areas, forests, and coasts are only considered to be a land cover. This causes the real importance of natural areas to be ignored, the ecological limits to be mostly exceeded, and the resources to be overused or polluted. In this point, changes regarding the spatial uses also affect sustainability. One of the primary topics of the planning process is the effects of the plans, key components of spatial development, on the area in which they are implemented. Changes in the natural areas through spatial development provide significant inputs in analyzing sustainability and identifying restrictive factors towards potential developments. Directing the spatial planning process accordingly would offer more rational results for conservation-use balance and sustainable development.

In this regard, management and land use policies should be developed for the sustainability of the areas, depending on the urbanization-oriented land use changes (Perminova et al., 2016). Considering the abovementioned point, natural areas should be managed by focusing on sustainability and the management process should be combined with spatial planning process in order to keep potential ecological distortion under control through spatial planning and to efficiently use the space (Perminova et al., 2016). From the sustainability-related perspective of urban development in an environmental context, predicting how spatial plans within the implementation area affect natural areas gains importance to make planning decisions (Sumarga & Hein, 2014). In the decision-making process for the type of use to be introduced through these plans, analysis of the results brought by development and determination of the growth model are among critical steps. The number of innovative and future simulation-focused studies on sustainable development and land use models (Batty, 1989) is gradually increasing (Onsted & Chowdhury, 2014; Zhou et al., 2020). Diversification of spatial data sets and the increase in their usability allow for computer-based softwares to be developed, various alternatives regarding land use planning to be compared, and simulations for determination of the best option to be created (Sakieh et al., 2015). Through simulation models, natural and anthropic factors affecting land use are included into system analyses in the form of inputs, then these turn into outputs and predict and explain the space (Çağlıyan & Dağlı, 2015). In order to maintain sustainable development, simulation results provide critical information to review the plans, to direct urbanization, to identify the areas open to urbanization in a spatial manner, and to support decision makers and planners regarding the designing of new plans (Karakuş et al., 2015).

Numerous studies addressing the inclusion of spatial planning policies into land use change models exist in the literature (Zhou et al., 2020). Simulations of changes in urban land use provide useful information for decision makers but on the other hand, the integration of the planning into land use change modeling is weak (Domingo et al., 2021). Within this framework, all planning partners, especially practitioners and decision makers, should focus on studies towards learning from previous practices and providing sustainable development decisions.

These changes should be investigated and monitored to ensure a land management in which sustainable urban growth and development exist. In order to integrate planning into simulations on changes of land use, the starting point can be the formation of a spatial modeling frame (Domingo et al., 2021).

Recently, understanding the concept of the land use system and modeling the changes in the LULC to take necessary measures against potential future problems have been among the most commonly discussed topics. Using the previous classification maps, it is possible to form a model to predict the trends regarding the changes in the LULC for a certain period of time. Formation of these change models is a necessity to predict the classes that have a dominant role in the future changes in land use and land cover and in sustainable planning studies that create visions for the urbanization process. These models simplify the group of complex socioeconomic and biophysical factors affecting the rate of changes in the LULC and provide the prediction of the effects of these changes (Hasan et al., 2020).

A number of studies used the Geographic Information Systems (GIS) and Remote Sensing (RS) techniques to detect the changes in land use and land cover in a rapid and reliable manner (Al-sharif & Pradhan, 2014; Butt et al., 2015; Adhikari & Hansen, 2018; Mansour et al., 2020; Al Rıfat and Liu, 2022). Thanks to these advanced techniques, the temporal and spatial changes in land use and the direction of these changes have become analyzable. Today, numerous simulation models including Artificial Neural Networks (ANN) (Almeida et al., 2008; Martínez-Vega et al., 2017), Cellular Automation (CA) (Brown et al., 2012; Farjad et al., 2017), Support Vector Machine (SVM) (Were et al., 2015), Markov Chain (MC) (Pocewicz et al., 2008; Yang et al., 2012), SLEUTH Model (Mahiny & Clarke, 2012), hybrid models (Guan et al., 2011; Subedi et al., 2013;Xu et al., 2022), and Machine Learning (ML) (Aburas et al., 2019) have been developed regarding the modeling of the changes in the LULC and urban growth. Several studies have noted that the Land Change Modeler which combines the Markov Chain and the Multilayer Perceptron models is a strong model to predict the changes in the LULC (Öztürk, 2015; Wang & Maduako, 2018). This is because outputs of neural networks, acquired through the weights of evidence technique (where a user can select and modify the weights) (Perez-Vega et al., 2012), more effectively show the transition of different types of land cover than do individual probabilities.

This study aims to discuss the policies for spatial planning by examining the relationship between current planning decisions and the spatial development pattern created by the future simulation that is formed based on the monitoring of the changes in land use and the current trends. It also aims to determine the potential efficiency of the land use modeling in terms of sustainable urban development and, through contributing to the planning process, to underline the effects of the plans on the space's environmental sustainability potential. Therefore, this study differs from other similar studies as it combines different perspectives from different disciplines.

In Turkey, a "Tourism Center" and the "Culture and Tourism Conservation and Development Regions (CTCDR)" are the regions whose borders are identified to conserve and use the areas where historical, natural, and cultural values exist intensively or that have a high potential of tourism potential, and to ensure sectoral and planned development in these areas. In the determination process of these regions, the country's natural, historical, archaeological, and socio-cultural values, winter and water sports, health tourism, and other tourism-related potentials are considered. Investors are provided with support and promotions to ensure the development of tourism in these regions. In the areas declared to be a tourism center, a rapid tourism-related development occurs depending on the investments in tourism, which causes a dramatic land use and land cover (LULC) changes. Being a barren area at first, the coast has been opened to settlement through investments in tourism. It has also triggered urban development in the coast and the areas behind the coast to meet the service needs of tourism facilities. The development of the second housing concept that is increased due to the need for shelter of the employees working at the tourism facilities and the attractiveness of the area depending on and the investments for infrastructure has also escalated the changes in the LULC. It is critical for decision-makers, planners, practitioners, and researchers to monitor the changes in the LULC in order to ensure the conservation-use balance in such vulnerable areas that are under the pressure of development.

This study determined the changes in the land use and land cover of the Belek region after being declared to be a tourism center, modeled the changes in the LULC for 2040, and assessed the relationship between this model and planning decisions.

Materials And Methods

Study steps

This study consisted of four steps and aimed to determine the changes in the LULC of Belek Tourism Center, to simulate the land use and land cover model for 2040, and to assess the relationship between the model and the planning decisions.

-In the first step, land use and land cover of Belek Tourism Center were determined for 1985, 2000, and 2021.

-The second step included the identification of areal and spatial changes between the land use and land cover classes for the periods between 1985 and 2000, 2000 and 2021, and 1985 and 2021.-

-In the third step, a model was formed regarding how the land use and land cover would change in 2040 in the event that the previous trends (1985-2021) would be sustained.

-The fourth step included the comparison between the planning decisions for Belek Tourism Center, the changes in the LULC from past to present, and the model for 2040, and the assessment of the relationship between the spatial development pattern which was formed through this comparison and the current planning decisions.

Study area

Belek Tourism Center, which is determined to be the study area, is located in the district of Serik in Antalya, Turkey. There are a total of 170 tourism centers declared by the Ministry of Culture and Tourism in Turkey. With its twenty-two tourism centers, Antalya has the highest number of tourism centers in Turkey. Belek Tourism Center is thirty kilometers away from the center of Antalya and is one of the tourism centers with the oldest date of declaration in the region (Declaration Date: 21.11.1984).

Belek Tourism Center is located in the south of Turkey between the north latitude of 36° 54' 3" – 36° 50' 28" and the east longitude of 30° 55' 34" – 31° 07' 08". Tourism center has Aksu River on the west, Acısu River on the east, Mediterranean on the south, and the Antalya-Alanya highway on the north (Fig. 1).

Belek Tourism Center is 6,336.7 hectares and its length of coastline is approximately twenty kilometers. The built-up areas of Kadriye and Belek are located in this tourism center. The total population of these built-up areas is 16,191 for 2020. Belek Tourism Center has forty-seven hotels, fifteen golf courses, and various social and cultural facilities. It hosts approximately 1.5 million visitors from different regions of the world every year and is the leading tourism center that attracts the highest number of tourists in Turkey.

Belek Tourism Center is one of the most important seventeen nesting sites in Turkey for loggerheads (caretta caretta) which are classified as an endangered species by the International Union for Conservation of Natura (IUCN). One study performed by the Belek Tourism Investors Union (BETUYAB) with several universities has indicated that Belek Tourism Center has 109 bird species, one endemic fish species (Aphanius anatoliae), and a total of 574 plant species belonging to 104 families including twenty-nine endemic families and one relict endemic family (Serik Pear) (Camgöz, 2008).

The study area has low values of altitude and slope, ranging from zero meter to thirty-seven meters and from 0% to 5%. It has a Mediterranean climate with hot and dry in summers and warm and rainy in winters. The mean yearly temperature of the study area is 18.8 ºC. Belek Tourism Center has a total of 285 sunny days in one year and welcomes its visitors every season thanks to its climate. The dominant vegetation in the study region is dune vegetation and stone pine forests along the coasts and maquis and shrubs in the inland areas. Forests, especially stone pine trees (Pinus pinea) and Turkish pine trees (Pinus buritia), are created to prevent sand dunes in the eastern and western parts of the study region and cover a large area (Çakıcı, 2002).

Determination of the land use and land cover of Belek Tourism Center from past to present

Data acqusition

Data used in this study were acquired through various resources. In order to determine the land use/land cover of the study area, satellite images from the Landsat 5 TM dated 1985, the Landsat 7 ETM dated 2000, and the Landsat 8 OLI dated 2021 were used (Table 1). These satellite images were obtained from the United States Geological Survey (USGS) data portal. All satellite images have a 30m spatial resolution. With the aim of mitigating the effects of the seasonal changes on the land cover and obtaining less cloudy images, the satellite images were selected from the same season (summer) and within close dates. Digital elevation model (DEM), slope, distance to road networks, distance to river, and distance to built-up area were used as independent variables for the prediction of the future LULC of the study area. The DEM was created through the Shuttle Radar Topography Mission (SRTM) data. The slope data of the study area were generated using the DEM. The data of the distance to road network and the distance to river were obtained from the Open Street Map (OSM). The data of the built-up area were digitized using the 1:25,000 topographic maps. All data were transformed into the Universal Transverse Mercator (UTM) Zone 36N projection system.

Table 1 Details of satellite images used in this study

Dataset	Spatial resolution	Date of acquisition	Source
Landsat 5 TM (Path/row: 178/034)	30 m	20.08.1985	United State Geological Survey (USGS)
Landsat 7 ETM (Path/row: 178/034)	30 m	21.08.2000	United State Geological Survey (USGS)
Landsat 8 OLI (Path/row: 178/034)	30 m	23.08.2021	United State Geological Survey (USGS)

Image classification and accuracy assessment

The satellite images were classified using supervised and unsupervised classification methods. Both classification methods refer to the statistical categorization process of the reflection values of the pixels. The supervised classification method classifies an image considering the statistical characteristics of the education pixels collected for each class determined by the user. Maximum likelihood classification (MLC) approach is being widely used for land use change assessment (Rawat & Kumar, 2015; Tadesse et al., 2017; Islam et al., 2018). This method hypothesizes that the bands of the image to be classified are normally distributed and all classes have the same probability of classification. The MLC approach is based on the principle of determining the equal probability curves for the determined classes and assigning the pixels to be classified to the class with the highest probability. In this method, a candidate pixel's probability of being assigned to each class is calculated separately and each pixel is assigned to the class that has the highest probability (Mather & Koch, 2011; Örmeci & Ekercin, 2007).

The LULC classes in this study were determined considering the land cover classification system identified by the Europe Environment Agency (EEA) and the characteristics of the region. The LULC was classified into five groups as agriculture, barren, built-up area, forest, and water body. Table 2 shows the definitions of the LULC classes. The training data were gathered by drawing polygons around the areas that represent each LULC class. The researcher, with their personal knowledge and experiences regarding the study area, collected the training data using Google Earth, aerial photographs, and topographic maps. The images were classified using MLC supervised classification method. LULC maps belonging to three different dates were created (Fig. 3). The classification analyses were made using the ArcGIS software. The raster data were transformed into vector data and the area and change percentages of the land use classes belonging to each period were calculated (Table Y).

Table 2 Description of LULC classes

LULC Class	Description
Agriculture	All cultivated, uncultivated and greenhouse agricultural areas such as farmlands, crop fields including fallow lands/plots and horticultural land.
Barren	Lands with exposed soil, sand or rocks, and never has more than 10% vegetated cover during any time of the year such as Bare ground, bare exposed rocks, beaches, sandy areas other than beaches, strip mines, quarries, gravel pits and transitional areas.
Built Up Area	Residential, commercial services, industrial area, socio-economic infrastructure, transportation, roads, mixed urban or built up lands.
Forest	Mixed forest lands and forest on customary land, protected forest, plantations, deciduous forest.
Water Body	Seas, lakes, rivers, streams, permanent open waters, ponds and reservoirs, marshy land and swamps.

The accuracy of the supervised classification results should be analyzed (Hudson & Ramm, 1987). The accuracy analysis is a control method based on the statistical comparison of the pixel values determined through classification with the points considered to be reference (Gülersoy, 2013). The classification results and the reference data are statistically compared using confusion matrices. The accuracy analysis is performed by utilizing producer's accuracy, user's accuracy, overall accuracy, and the Kappa coefficient, which are generated from the confusion matrix. The Kappa coefficient was developed by Cohen (1960) and ranges from 0 to +1. Landis and Koch (1977) characterized the Kappa values as follows: <0 as indicating no agreement, 0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement.

This study performed the accuracy analyses of the LULC maps from 1985, 2000, and 2021 and calculated their Kappa coefficients. A total of sixty reference data was generated for each year that was analyzed using the satellite images from Google Earth, aerial photographs, and topographic maps. The accuracy analysis of this study was performed by comparing each of the sixty reference points on the images that were classified separately. Table 4 shows the classification accuracy of the LULC maps.

Detection of the changes in the LULC

Change detection analysis

The change analysis detects the areal change of gains and losses between the land types considering the types of land use at the same region in different periods of time. This analysis is frequently used in the identification of various changes regarding different classes of land use such as an increase in the urban built-up areas and a decrease in the agricultural areas (Sundarakumar et al., 2012; Hassan et al., 2016). This study utilized land use maps from 1985, 2000, and 2021, and detected the changes between the types of land use by means of a “from-to” analysis that allows comparison on a pixel level. The changes in land use between 1985 and 2000, 2000 and 2021, and 2021 and 1985 were calculated, respectively. Then, these changes were classified as spatial and areal (Table 3, Fig. 4).

Prediction of the future land use and land cover of Belek Tourism Center

LULC modeling and future scenarios

The Land Change Modeler (LCM) module integrated into the TerrSet software is designed to analyze the changes in land use and land cover and to predict potential future changes. This model is based on the artificial neural network (ANN), Markov Chain matrices, and transition suitability maps, generated by training multilayer perceptron (MLP) or logistic regression (Megahed et al., 2015; Ansari & Golabi, 2019). The LCM utilizes historical maps of LULC to empirically model the association between LC transitions and driver variables to map future LULC modeling (Eastman & Toledano, 2018). The LCM predicts the future changes in land use and land cover in four steps: (1) analysis of the past changes in the LULC, (2) identification of the transition potential and driver variables, (3) modeling of the future LULC, and (4) validation of the model. This study predicted the land use and land cover changes in Belek Tourism Center for 2040 using the LCM.

Transition potential and driver variables

Transition potential maps determine the future change probability of a specific type of land use. These maps are generated by analyzing the artificial neural networks of a single transition sub-model or a group of transition sub-models. A transition sub-model can consist of a single land use transition or a transition group that is assumed to have identical driver variables (Addae & Oppelt, 2019). LCM allows choosing the optimal threshold for selecting the optimal number of sub-models where the users can overlook small changes (Eastman & Toledano, 2018). This study generated the transition sub-models by ignoring the LULC changes below 120 hectares (less than 1.5% of the study area). Three sub-models were used to predict the LULC for 2021 (barren to built-up area, barren to agriculture, barren to forest), whereas five sub-models were used to predict the LULC for 2040 (agriculture to urban, built-up area to forest, forest to built-up area, barren to forest, and barren to built-up area).

For each sub-model, driver variables were identified as inputs to predict LC maps (Motlagh et al., 2021). The driver variables are expected to have a significant impact on the future LULC changes. Cramer’s V is used to calculate the importance of each variable. The value of Cramer’s V ranges from 0 to 1. Jin et al. (2013) state that Cramer's values close to 0.4 and above of it are considered as the appropriate value for a driver variables and values less than 0.15 are considered its weak ability to predict for a driver variable. However, Cramer's V does not guarantee a strong model performance because it cannot account for the mathematical specification of the modeling approach used as well as the intricacy of the relationship (Eastman, 2015). Cramer’s V helps to determine whether a specific driver variable should be used for the prediction of the LULC changes. The driver variables in this study were identified considering the studies in the literature (Anand et al., 2018), characteristics of the region, and the experts’ opinions. The driver variables used in this study were the DEM, slope, distance to road networks, distance to built-up area, and distance to river. Figure 2 shows the maps of the driver variables. Cramer’s V values of the driver variables are introduced in Table 6. The DEM and slope are among the key topographic factors that influence the urban development. The urban sprawl is accepted to occur in regions where the values of altitude and slope are lower. The “distance to built-up area” variable was included in this study because regions that are surrounded by built-up areas but have not been opened for settlement yet have higher probability to turn into a built-up area within years. The distance to river limits the urban sprawl. The distance to road networks has a key role in urban sprawl as it facilitates the access to daily needs. Distance to built-up area and distance to road networks are modeled as a dynamic variable because they change and develop in the course of time.

Change prediction

Change prediction is analyzed using the Markov Chain model and the Cellular Automata (CA) algorithm. The Markov Chain model is a stochastic model used to predict land use and land cover. This model predicts the LULC starting from a t=1 time to another t+1 time depending on the transition area matrix and the transition probability matrix between the LULC classes. The Markov Chain does not solely suffice by itself to predict the LULC changes because it does not take the spatial distribution of the LULC classes and the spatial aspect of growth into consideration (Ghosh et al., 2017). Therefore, the CA-Markov method that combines the Markov Chain model, CA, and the Multi-Criteria Analysis (MCA) is adopted to predict future land use and land cover. The CA includes a regular grid of cells that manage how each cell's neighbors affect the future class of each cell (Aviv & Sipper, 1994). These models typically simulate changes in cells that are near the borders among classes (Benenson & Torrens, 2004). CA-Markov method adds spatial proximity structure and the knowledge of land use geographic distribution to the Markov chain analysis. This study used the CA-Markov method to predict future changes in the LULC. This method uses the data listed below for the prediction of the LULC changes;

- The LULC data belonging to two different periods of time,
- The transition area matrix generated using the Markov Chain model,

- The transition potential map created using the MCA method,
- A 5x5 neighborhood filter

Validation

Model validation is required to test the reliability regarding the prediction of the land use and land cover changes. There are two different methods (visual and statistical) in the literature used for model validation (Pontius & Malanson, 2005). This study utilized the Kappa statistical method to assess accuracy. The first step of the model validation included the prediction of the land use for 2021 using land use maps from 1985 and 2000, transition potential maps, and transition probability matrix. Then, the model validation was performed through the analysis of the predicted land use map for 2021 and the actual land use map for 2021 using the Kappa statistical method. Following the validation of the model's predictive power for the land use and land cover for 2021, the LULC of Belek Tourism Center for 2040 was predicted using the land use maps from 2000 and 2021, transition potential maps generated for this period, and transition probability matrix.

Relationship between the LULC modeling for 2040 and planning decisions

Planned developments within Tourism Centers may be possible if long-term spatial planning and capacity use decisions of these areas are considered. In this regard, planning process of the study area with lower and upper scale plans environmental plan, land use plan, etc.) were analyzed. These plans constituted the material of this step. Materials were obtained from the Municipality of Belek, Antalya Metropolitan Municipality, Ministry of Culture and Tourism, Ministry of Environment, Urbanization and Climate Change, individual interviews, and online scanning. Assessing the situation with a planning perspective, land use decisions of the plans regarding Belek tourism region were briefly identified.

Results

Determination of the LULC

LULC classification and accuracy assessment

Figure 3 shows the spatial distribution of the LULC of Belek Tourism Center for 1985, 2000, and 2021. Areal statistics of the LULC classes are indicated in Table 3. The total surface area of the region analyzed is 8,390.56 hectares.

According to Table 3, the distribution of LULC classes of the tourism center;

- Accordingly, in 1984, 38.5% of the tourism center was agricultural area, 25.5% barren area, 24.4% water body area, 9.8% forest, and 1.8% built-up area,

- In 2000, 40.4% of the tourism center was agricultural area, 24.9% water body area, 15.8% forest, 11.3% barren area, and 7.6% built-up area,

- In 2021, 34.3% of the tourism center was agricultural area, 25.2% water body area, 23.5% forest, 13.7% built-up area, and 3.3% barren area.

Table 3 Area statistics of LULC classes for the years 1985, 2000 and 2021 and percentages of change

LULC classes	1985		2000		2021		Changes in 1985-2000	Changes in 2000-2021	Changes in 1985-2021
	ha	%	ha	%	ha	%	(%)	(%)	(%)
Agriculture	3228.02	38.5	3385.97	40.4	2879.76	34.3	1.88	-6.03	-4.15
Built-up area	152.03	1.8	641.18	7.6	1151.10	13.7	5.83	6.07	11.91
Barren	2138.75	25.5	952.02	11.3	272.16	3.3	-14.14	-8.10	-22.25
Forest	824.63	9.8	1323.16	15.8	1971.87	23.5	5.94	7.73	13.67
Water body	2047.13	24.4	2088.23	24.9	2115.67	25.2	0.50	0.33	0.82

Table 4 shows the accuracy results. Accordingly, the overall classification accuracy values were 88.0%, 85.7%, and 90.0% for 1985, 2000, and 2021, respectively. The Kappa coefficient values were 85.0%, 82.0%, and 88.0% for these three periods, respectively. The producer's and user's accuracy values regarding the LULC classes ranged from 40% to 100% in 1985, from 60% to 100% in 2000, and from 71% to 100% in 2021. These results indicate that the supervised classification is accurate and reliable for all three periods.

Table 4 Classification accuracy assessment of each land use maps

LULC Classes	1985		2000		2021	
	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)	Producer's accuracy (%)	User's accuracy (%)
Agriculture	62.50	40.00	100.0	100.0	85.71	100.0
Built-up area	100.0	100.0	100.0	85.71	100.0	100.0
Barren	100.0	100.0	83.33	71.43	83.33	83.33
Forest	100.0	100.0	60.00	85.71	71.43	83.33
Water body	100.0	100.0	100.0	85.71	100.0	83.33
Overall accuracy (%)	88.00		85.71		90.00	
Kappa coefficient	0.85		0.82		0.88	

Detection of the changes in the LULC

Change analysis

The LULC changes of Belek Tourism Center were grouped into three periods as 1985-2000, 2000-2021, and 1985-2021. Table 5 shows the direction and rate of the changes between the LULC classes in detail. The LULC change maps for each period is demonstrated in Figure 4.

Table 5 Change of area between LULC classes for the years 1985-2000, 2000-2021 and 1985-2021

Changes between LULC classes	1985-2000 (ha)	2000-2021 (ha)	1985-2021 (ha)
Agriculture to barren	10.51	21.54	16.31
Agriculture to forest	34.86	109.11	50.58
Agriculture to built-up area	119.32	392.78	452.73
Agriculture to water body	24.61	50.41	54.45
Barren to agriculture	181.51	5.46	160.93
Barren to forest	732.50	569.31	1191.52
Barren to built-up area	396.96	201.2	503.86
Barren to water body	62.47	30.54	59.71
Forest to agriculture	37.98	4.87	5.71
Forest to barren	159.40	30.20	9.25
Forest to built-up area	74.57	124.33	103.78
Forest to water body	11.27	27.93	20.04
Built-up area to agriculture	104.88	43.73	72.41
Built-up area to barren	-	37.68	0.05
Built-up area to forest	1.22	133.85	2.09
Built-up area to water body	0.04	3.75	0.16
Water body to agriculture	22.88	13.57	16.76
Water body to barren	16.80	38.23	23.82
Water body to forest	13.17	23.77	41.83
Water body to built-up area	4.44	10.62	13.41
Not change	6381.17	6517.67	5591.16

When the change values are examined;

- a shrinkage was detected in the barren area by 14.14%, whereas an expansion was observed in forests by 5.94%, in built-up areas by 5.83%, in agricultural areas by 1.88%, and in water body areas by 0.50% for the period of 1985-2000. The change analysis of the LULC classes showed that the expansion in the built-up and forest areas was arisen from the barren area. Of the barren area, 732.50 hectares were transformed into forests and 396.96 hectares were transformed into built-up areas. No changes were observed in the area with 6,381.17 hectares within this period.

- In the period of 2000-2021, the barren areas continued to shrink with a rate of 8.10%. On the contrary to the previous period, a remarkable shrinkage was observed in the agricultural area with a rate of 6.03% in this period. (Table 3). The forests and built-up areas continued to expand with the rates of 7.73% and 6.07%, respectively. Within the same period, an expansion was detected in the water body areas with a rate of 0.33%. It was found that the expansion in the built-up areas were mostly arisen from the agricultural and barren areas, whereas the expansion in the forests were mostly arisen from the barren area. In this period, 392.78 hectares from agricultural areas and 201.2 hectares from barren areas were transformed into built-up areas. A total of 569.31 hectares from barren areas was transformed into forests. No changes were observed in the area with 6,517.67 hectares.

- During the 36-year period (1985-2021), the biggest change was detected in barren areas. Barren areas shrunk by 22.25% in this period. Agricultural areas also shrunk by 4.15%. An expansion was noted in forests by 13.67%, in built-up areas by 11.91%, and in water body areas by 0.82% during this 36-year period. Of the expansion in the built-up areas, 452.73 hectares were arisen from agricultural areas and 503.86 hectares were arisen from barren areas. Similarly, the expansion in the forests were mostly arisen from barren areas (1,191.52 hectares). No LULC changes were observed in an area with 5,591.16 hectares of Belek Tourism Center from 1985 to 2021.

Prediction of the future and LULC of Belek Tourism Center

Transition analysis and validation of LULC simulation model

Table 6 shows the potential explanatory power of each driver variable that is represented by Cramer's V coefficient regarding the LULC changes.

Table 6 Cramer's V values of driver variables

Variables	Cramer's V
DEM	0.3964
Slope	0.3801
Distance to roads	0.4144
Distance to rivers	0.4184
Distance to built-up area	0.3467

Results indicated that each variable had a sufficient level of explanatory power (Cramer's V>0.15). The variables with the highest level of explanatory power were distance to road networks (41.44%) and distance to river (41.84%). Other variables were also determined to be a significant driving force behind urban growth. Following the selection of the driver variables, the determined land class transitions were modeled in a single transition sub-model and transition potential maps were generated. The accuracy of the transition potential maps ranged from 40% to 95%.

This study created transition probability matrices for 2021 (using the LULC maps from 1985 and 2000) and 2040 years (using the LULC maps from 2000 and 2021). Table 8 shows the transition probability matrices for these periods. The transition probability matrix for 2021 indicated that the most stable class was built-up areas (94.65%), whereas the most dynamic classes were barren areas (21.45%) and forests (52.55%). The LULC changes were towards built-up areas, followed by the transition of barren areas into forests. The transition probability matrix for 2021 showed consistency with the change analysis results indicated in the Section 3.2.

A model validation was performed to assess the reliability of the prediction regarding the LULC changes for 2040. During the accuracy analysis of the model, the actual LULC map for 2021 and the simulated LULC map for the same year were compared. The accuracy analysis was conducted using the Kappa statistics and overall accuracy. This analysis calculated the Kappa value as 0.79 and the overall accuracy of classification as 0.83. These results indicate that this model may be utilized for the LULC projection of Belek Tourism Center for 2040 (Kappa coefficient>0.60). Figure 5 shows the actual and simulated LULC maps for 2021 and Table 7 indicates the area and change statistics of the land use and land cover classes. Table 7 explains that in the simulated map, agricultural areas were overestimated by 25.28%, whereas built-up areas, barren areas, forests, and water body areas were underestimated by 20.99%, 19.50%, 14.70%, and 6.78%, respectively.

Table 7 Comparison of changes between actual and simulated LULC classes of 2021

LULC classes	Actual 2021 LULC (ha)	Simulated 2021 LULC (ha)	Differences between actual and predicted	
			Δ (ha)	Δ (%)
Agriculture	2879.76	3607.82	728.06	25.28
Buit-up area	1151.10	909.45	-241.65	-20.99
Barren	272.16	219.10	-53.06	-19.50
Forest	1971.87	1682.09	-289.78	-14.70
Water body	2115.67	1972.10	-143.57	-6.78

The transition probability matrix for 2040 predicts 97.32% of the built-up areas, 96.57% of the water body areas, and 87.28% of the forests to be more stable by 2040. Moreover, the barren areas (18.51%) are expected to be the most dynamic class (with the highest probability of change). A certain part of the agricultural areas (12.30%) is predicted to be under the pressure of built-up areas.

Table 8 Transition probability matrices of LULC classification from 1985 to 2000 for predicting the 2021 LULC and from 2000 to 2021 for predicting the 2040 LULC

2021					
Classes	**Agriculture**	**Built-up Area**	**Barren**	**Forest**	**Water Body**
Agriculture	0.8878	0.0819	0.0028	0.0097	0.0178
Built-up Area	0.0277	0.9465	0.0011	0.0006	0.0241
Barren	0.1563	0.2198	0.2145	0.3804	0.0289
Forest	0.1101	0.1104	0.2363	0.5255	0.0176
Water Body	0.0290	0.0186	0.0436	0.0212	0.8876
2040					
Classes	**Agriculture**	**Built-up Area**	**Barren**	**Forest**	**Water Body**
Agriculture	0.8297	0.1230	0.0053	0.0285	0.0135
Built-up Area	0.0053	0.9732	0.0045	0.0167	0.0003
Barren	0.0055	0.1539	0.1851	0.6249	0.0306
Forest	0.0034	0.0830	0.0211	0.8728	0.0197
Water Body	0.0062	0.0041	0.0157	0.0082	0.9657

Simulated LULC changes

Table 9 indicates the results regarding the LULC changes of Belek Tourism Center for 2040.

Table 9 Comparison of LULC changes between 2021 and 2040

Classes	2021		2040		2021-2040	2021-2040 changes
	Area (ha)	% of total area	Area (ha)	% of total area	Area (ha)	% changes
Agriculture	2879.76	34.32	2526.59	30.11	-353.17	-4.21
Built-up area	1151.10	13.72	1609.06	19.18	457.96	5.46
Barren	272.16	3.24	56.75	0.68	-215.41	-2.56
Forest	1971.87	23.50	2079.05	24.78	107.18	1.28
Water body	2115.67	25.22	2119.11	25.25	3.44	0.03

Figure 6 shows the simulated map of the spatial distribution of the region’s LULC for 2040. This simulation map for 2040 predicts that Belek, Kadriye, and Kumköy built-up areas will expand towards agricultural areas, and that the entire coastline except for the conserved areas will be transformed into built-up areas (housing, second housing, tourism facility, etc.).

The statistics for 2040 year predict that of the total area, 30.11% will be agricultural area, 25.25% water body area, 24.78% forest, 19.18% built-up area, and 0.68% barren area. Within the period of 2021 and 2040, it is expected that built-up areas and forests will expand by 5.46% and 1.28%, whereas agricultural areas and barren areas will shrink by 4.21% and 2.56%, respectively. The future changes in the water body areas (0.03%) are predicted to be insignificant. The results of the transition probability matrix show that the trend of change is expected to be mostly from barren areas to forests and from agricultural areas to built-up areas (Table 8). To summarize, this study indicated that the built-up areas in the inland and coastal zones would continue to expand within the next 20 years in the event that the LULC pattern and trend of Belek Tourism Center from 1985 to 2021 would be sustained.

Relationship between the LULC modeling for 2040 and planning decisions

The first planning in the region was conducted by the Scandinavian Planning and Development Associates on behalf of the State Planning Organization within the scope of the West Mediterranean (an international project) in 1967. Being known as the Ole Helweg Plan or the Western Antalya Project, this planning is considered the first tourism master plan in Turkey and covers a 1,000-kilometer part of the coastal area in Muğla and Antalya. This planning assessed the analysis of the tourism potential of the coastal areas in Antalya and Muğla, the infrastructure and superstructure studies, determination of the development areas, and preparation of the master plans. The Belek region was chosen as one of the primary development areas within the plan. Its total number of beds was determined to be 5,000 (Almaç, 2005). This plan was followed by the Serik-Antalya-Alanya Environmental Plan approved by the Ministry of Public Works and Settlement in 1981.

The Law for the Encouragement of Tourism (law no: 2634) that was put into force in 1982 in Turkey allowed the ongoing developments in the tourism industry to be supported with the legislation, the terms “tourism area, tourism region, and tourism center” to be added in the tourism planning terminology, and the mass tourism to rapidly increase. In accordance with this law, Belek was declared to be a tourism center in 1984. The border of the tourism center was determined by excluding the built-up areas (Kumköy, Kadriye, Belekköy) in 1984. After being declared to be a tourism center, the region raised its bed capacity to 13,000 (Acar İnam, 2009). Belek Tourism Center was announced to be a tourism investment area in 1986. Within the same year, the Belek Tourism Center Land Use Plan (1/25,000) was approved. This plan separated Belek Tourism Center into two regions as east and west (Tezcan, 2008). In accordance with the planning decisions, the first tourism investments were made in 1987.

The land use plan dated 1986 showed that land uses were arranged for their intended purpose, zoning method was used to determine the borders of tourism-related development, natural values were conserved, and the needs of the local community were taken into consideration (regional park).

The Serik-Manavgat-Antalya Environmental Plan (1/25,000), the first environmental plan for this region, was approved in 1981. In 1990, the Serik-Manavgat-Antalya Environmental Plan was revised, and the Eastern

Antalya Environmental Plan (1/25,000) was approved. In 2002, a planning revision was made for Belek Tourism Center and its surroundings through the Eastern Antalya Environmental Plan Belek Revision (1/25,000). A number of revisions were performed on the same plan in 2004, 2005, 2006, and 2007 (Acar İnam, 2009). Through the revisions on the plan and the changes in land use decisions, camping areas were transformed into tourism facility areas, forests were transformed into golf courses, and the bed capacity was raised.

The latest arrangement regarding Belek Tourism Center and its surroundings is the Antalya-Burdur-Isparta Planning Region Environmental Plan in 2014 (1/100,000) and the revisions made on this plan in 2019 and 2022 (Fig. 7). This plan also includes tourism, optional area of use, and housing uses. Within the scope of the changes made in the plan in 2022, a rearrangement was performed for the transfer of the 1/25,000-scale Land Use Plan decisions approved and revised between 2017 and 2021 into the 1/100,000-scale Environmental Plan. After the plan in 2014, however, no planning decisions that would change the land use decisions for Belek Tourism Region were found. Development towards agricultural areas was recommended in the Belek Tourism Center region.

This study compared the planning decisions for 2022 with the modeling for 2040. According to the comparison results, the areas that continue to be used as agricultural area in the plan are predicted to be opened to settlement in the modeling for 2040. Considering the current trends, the model predicts Kadriye and Belek built-up areas to be merged. Golf courses that are in the forest LULC class in the model are in included the built-up area LULC class in the planning decisions. Therefore, golf courses are predicted to shrink from the north and south directions, whereas they are considered to be in the built-up area LULC class in the planning decisions and no shrinkage is predicted accordingly. This difference is due to the variation in the variable of LULC classes.

Discussion

When the reasons for the changes given in Table 3 are examined,

- it was determined that built-up areas expanded over time and their need for area to expand was mostly met from barren areas and agricultural areas. The main reason behind this expansion during the 36-year period is that this region was declared to be a tourism center in 1984 and became an attractive area, leading the tourism facility investments and second housing development to start rapidly. The increasing population and developing service areas (such as logistics) in parallel with tourism-related developments also affected the growth of the built-up area. According to the population census results, Belek and Kadriye had a population of 2,586 and 3,400 in 1997 while their current population is 8,667 and 9,126, respectively. Rapidly developing tourism and increasing population accordingly led to a bidirectional change in land use. On the one hand, structuring of the tourism facilities on the coastline affected barren areas. On the other hand, agricultural areas were transformed into built-up areas depending on the satisfaction of the housing demand.

- Within the aforementioned period, changes in the water body areas (0.82%) were determined to be insignificant. This partial expansion in the water body areas was due to the construction of artificial ponds with landscape in golf courses.

- The forests were the land use class with the highest rate of growth between 1985 and 2021 (13.67%). The planting works which were conducted by the Ministry of Agriculture and Forestry to prevent sand and coastal erosions were effective in the expansion of the forests. A transformation from barren areas to forests occurred through these planting works. The state-owned area in the Kumköy coast was declared to be a “strictly protected sensitive area” and was not opened to be a tourism facility. Being barren in 1985, this area has now turned into a forest thanks to the planting works. Inclusion of the golf courses in the forest class was another reason of the growth. The first golf course planning decision within Belek Tourism Center was introduced through the Eastern Antalya Environmental Plan approved by the Ministry of Public Works and Settlement in 1990. A total of five golf courses was planned for this area at first. Today, there are fifteen golf courses in the region.

- Agricultural areas constitute the biggest LULC class in the study area despite showing a shrinkage at a rate of 4.15% during the 36-year period. A large part of the agricultural areas is located in the vast plains with arable fields in the north of the tourism center. Green housing is common in this region. The convenient conditions of the Mediterranean climate increase the agricultural production in the region and directly meet the need for food of the tourism facilities. The agricultural areas expanded by 1.88% between 1985 and 2000, whereas they shrunk by 6.03% between 2000 and 2021. This shrinkage within the last 21 years was due to overpopulation and the increasing demand for second housing. These demands caused rural areas to turn into built-up areas with master plans.

The predicted LULC map of the study area for 2040 shows that the entire coastline except for the conserved areas will be opened to settlement through tourism. The predicted LULC map for 2040 indicates that a large part of the urban growth expected to occur between 2021 and 2040 will serve as an extension of the built-up areas in 2021, and that this growth will be in the core of the built-up areas (Belek, Kadriye).

The planning decisions and land use changes regarding Belek Tourism Center and the model for 2040 were compared; then, the relationship between trends and planning decisions was assessed. Integrating the land use simulations into the planning process will guide the decision-makers, practitioners, and planners to assess the accuracy of the decisions made for ensuring the sustainable urban development. The comparison between the planning decisions for Belek Tourism Region and the simulation for 2040 introduced the necessity to limit the current trends in terms of the conservation of the agricultural areas. This output will help manage the urban growth and ensure the conservation-use balance regarding the spatial planning decisions.

Conclusion

The planning decisions and land use changes regarding Belek Tourism Center and the model for 2040 were compared; then, the relationship between trends and planning decisions was assessed. Integrating the land use simulations into the planning process will guide the decision-makers, practitioners, and planners to assess the accuracy of the decisions made for ensuring the sustainable urban development. The comparison between the planning decisions for Belek Tourism Region and the simulation for 2040 introduced the necessity to limit the current trends in terms of the conservation of the agricultural areas. This output will help manage the urban growth and ensure the conservation-use balance regarding the spatial planning decisions.

The second part of this study simulated the land use and land cover of Belek Tourism Center for 2040 using the Land Change Modeler extension of the IDRISI software. The future prediction was performed using the CA-Markov model. The simulated LULC map for 2021 was compared with the actual LULC map for 2021 to test the accuracy of the model. The Kappa value regarding the accuracy of the model was 0.79. The results of the model predict that the biggest LULC change between 2021 and 2040 will be in the built-up area class, whereas the smallest LULC change will be in the water body areas class. Considering the total area, agricultural areas and barren areas are expected to shrink while forests and water body areas are expected to expand between the years 2021 and 2040. The urban development is predicted to be towards agricultural areas.

The purpose of the planning is to predetermine the potential problems and to help address these problems. Studies on determining and modeling of the LULC changes will give the opportunity to determine the land use-related situations to occur in the event that the current trends will continue and to assess the relevant results in planning decisions. This study determined that the declaration of the tourism center created a pressure on the current land use and land cover. The policymakers and planners should take this pressure into consideration when they make decisions regarding the region. The pressure caused by the human settlements increasing due to tourism-related investments is one of the primary problems to take measures against. In this regard, policymakers, planners, and practitioners should work coordinately for this problem, and the land use models should be generated considering the results of this study. These models to be generated using the RS and GIS techniques will help to reveal the negative activities from past to present, to prevent the repetition of the mistakes, and to eliminate the present problems. In this way, it will be possible to take decisions related to sustainable urban development. This paper is believed to be a model study in which the LULC changes detected using the RS and GIS techniques and modeled for future can be used in order to develop planning strategies.

Declarations

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Availability of data and material The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Authors' contributions Halil Burak Akdeniz: conceptualization, methodology, investigation, formal analysis, writing—original draft, visualization. Neslihan Serdaroğlu Sağ: supervision, conceptualization, methodology, writing—review and editing. Şaban İnam: data acquisition, methodology, writing—review and editing.

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Figures

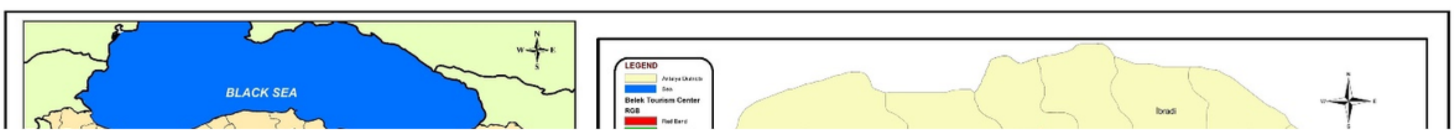

Figure 1

Study area

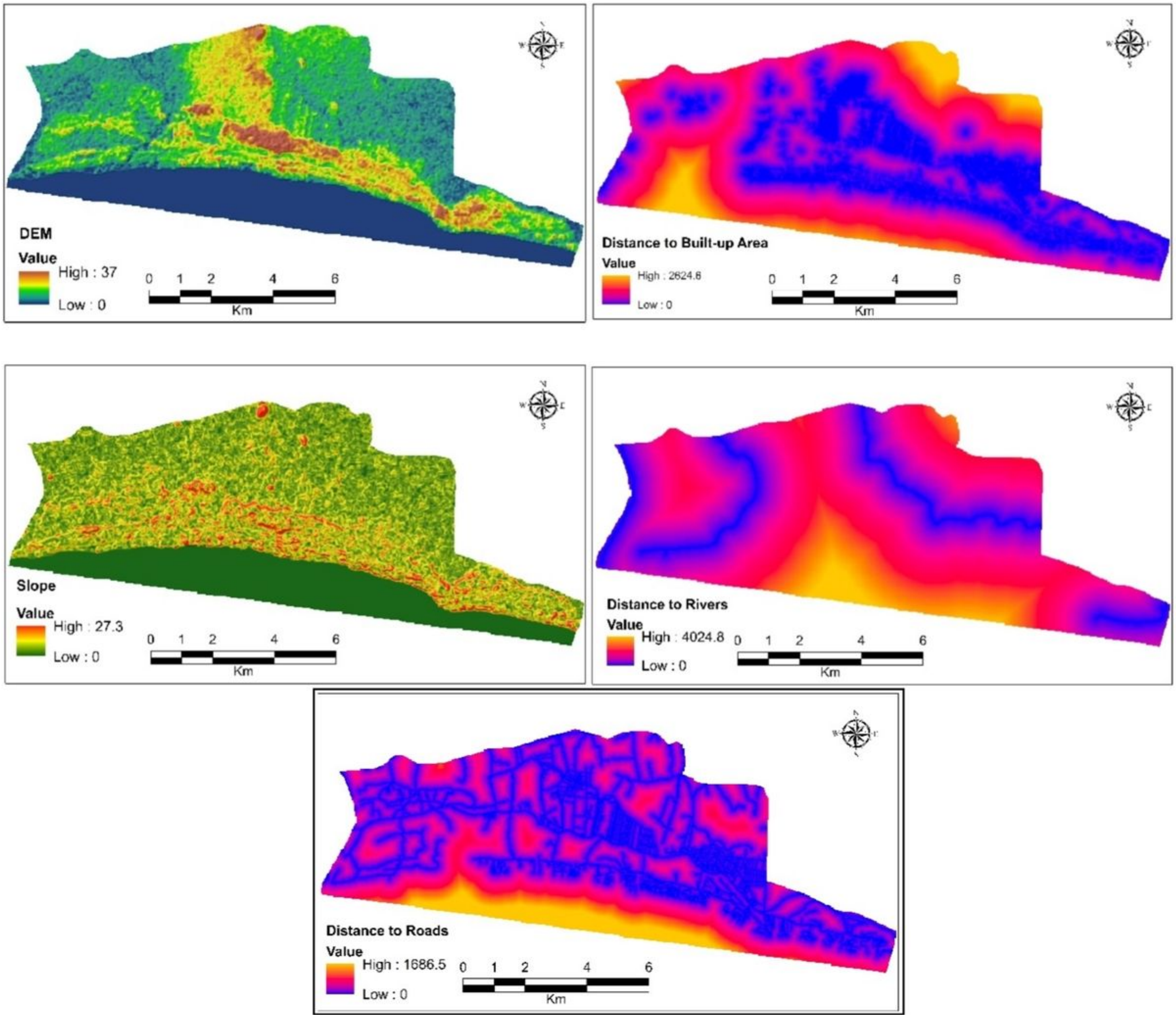

Figure 2

Maps of driver variables used for land change modeling

Figure 3

1985, 2000 and 2021 LULC maps of Belek Tourism Center

Figure 4

Changes between the LULC classes for the periods of 1985-2000, 2000-2021, and 1985-2021

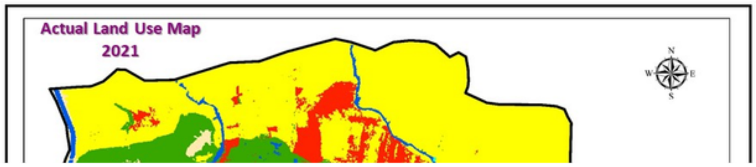

Figure 5

Actual and simulated LULC maps for the year 2021

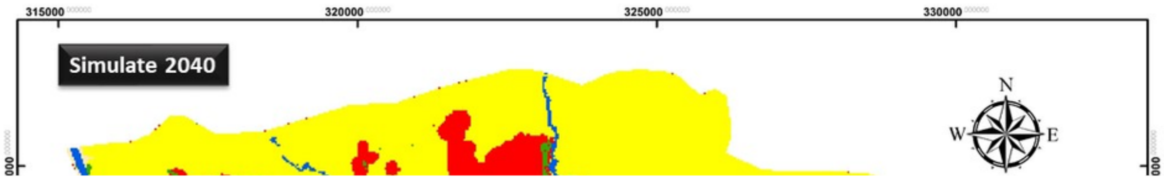

Figure 6

Simulated LULC map for the year 2040

Figure 7

The 1/100,000-scale environmental plan of the Antalya-Burdur-Isparta planning region