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LAND USE COVER CHANGE ANALYSIS (1985-2020) OF AYVALIK DISTRICT BALIKESIR TURKEY USING GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING

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ABSTRACT

Changes in use of the urban and rural areas are increasing each passing day based on the rapid population growth and urbanization along with the developments in industry and technology. Direction and rate of this change can be detected through the calculation of the changes by the virtue of developments in technology and science. In this study, it is aimed to detect the changes which have occurred in usage of the areas between the years 1985 and 2020 in Ayvalik district, Turkey with the aid of remote sensing and geographical information systems. The land use changes calculated as the results of the study indicated that 668.6 % of the increase took place in the highway transportation network of the district, 420.7 % of which in tourism and entertainment areas, 152 % of which in the residential areas covering both the district center and villages, 133.8 % of which in the industrial areas and 32.2 % of which in the ports areas in a period of 35 years. The land use change results also showed that there has been a decrease of 19.3% in the total amount of forests that covered the landscape. Regarding the examination of the land use change on the agricultural basis, it was found out that the irrigated agricultural areas have increased by 33.4 % whereas the dry agricultural areas and the cultivated agricultural areas have decreased by %38.1 and 20.1 %, respectively.

KEYWORDS:
Land use change, remote sensing, geographic information systems, image classification, maximum-likelihood classification, landsat

INTRODUCTION

Land use and change of land cover are important tools for the evaluation of different temporal and spatial changes on a global scale [1, 2, 3, 4, 5]. It has been revealed that the changes in land cover largely take place as a result of the anthropogenic activities such as deforestation, urbanization, intensification of agriculture and further destruction of land uses and etc. Particularly when the phenomenon of urbanization is considered in terms of space and time scales, it is seen that urbanization itself is the predominant anthropogenic factor which has impact on the world and its environment.[6,7,8]. The excessive population growth and the urbanization phenomenon have caused changes in urban area use and led unhealthy development of urbanization [9]. At the same time, urban land change is not only restricted to the core city, but also includes many new urban-rural spaces functionally tied to the city. The urban land change also has many impacts on rural lands and therefore deserves more attention in land-change science [10, 11, 12]

Determining the change in land use/cover in a region is the process of determining the situation of that region at different times and revealing the differences between them. To this end, accurately processed remote sensing images of different times are very important data sources [13].

Remote sensing of images has been successfully applied in many fields, such as classification process and land change detection. At the same time, the developments in satellite technologies have also made it possible to evaluate the changes that occur in urban and rural areas in the recent years. [14, 15]. Image classification is an important part of remote sensing, image analysis and pattern recognition. In some cases, the classification itself can be the subject of the analysis [16, 17]. Images received from satellites can be converted to land use and crop pattern maps by virtue of classification methods [18].

Land use/ cover maps are provided through classification of remote sensing images and they are an important part of the data which is an input to Geographic Information Systems for analysis and modeling studies [19, 20, 21]). Geographic Information Systems (GIS) is a means of an information system which provides the service of solving problem(s) by collecting data of positional units. It can also attribute data of such positional units in a portion of the earth while it can also provide their storage, maintenance, analysis, evaluation, provision and acquisition of new information in this way [22, 23, 24]. The classification process in remote sensing may consist of several phases. These phases are as follows: determination of appropriate classification algorithm, data pre-processing, collecting training samples, feature extraction and post- classification processing [25].

MATERIALS AND METHODS

Ayvalik district which is subject of this study is located within the borders of the Balikesir province on the southern coast of the Edremit Gulf and in North West part of Turkey. Location of Ayvalik district is shown in Figure 1. The district is geographically located between 39°18’54.85” and 39°17’35.17” Northern latitudes and 26° 42'52.87"-26° 45'11.38" eastern meridians [26].

The Ayvalik District which has 293 km² of acreage has a population of 70.720 according to the 2020 census data and 21.381 according to the 1985 census data issued by Turkey Statistics Institute [27] Ayvalik’s winters are warm and rainy while its summers are hot and dry because of its location in the Aegean region. The dominant winds are the southwest and northeast winds. Ayvalik is one of the major tourist attraction sites of region and Turkey for its cultural and natural structure. There are many bay and headland formations in Ayvalik based on the unique feature of the Aegean region where the mountains are lined perpendicular to the sea cost. These bay and headland formations have also a positive effect on the tourism activities within the district [28].

In this study, land use changes which have occurred between the years 1985-2020 of Ayvalik district were examined. In order to examine the land use changes, remote sensing and geographical information systems were used.

Processes such as data set procurement, data pre-processing, collecting training samples, performing necessary digitization operations, classification of field uses, calculation of change and accuracy assessment were used in this study.

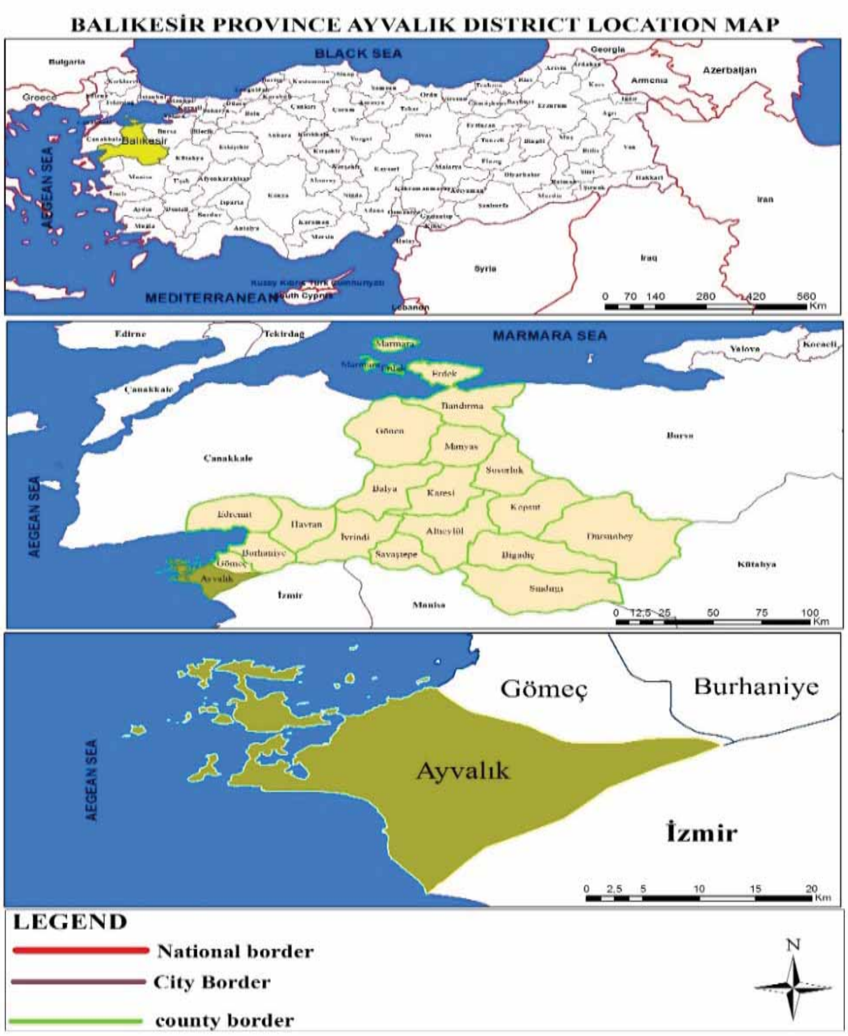

FIGURE 1
Location of Ayvalık district

TABLE 1
Features of satellite images

Satallite	*Sensor*	*Path-Row*	*Acquisition Date*	*Number of Bands*	*Data Sources*
Landsat 5	*TM*	*181-033*	*21.05.1985*	*7*	*Landsat 4-5 TM C1 Level-1*
Landsat 5	*TM*	*181-033*	*19.05.1990*	*6*	*Landsat 4-5 TM C1 Level-1*
Landsat 5	*TM*	*181-033*	*17.05.1995*	*6*	*Landsat 4-5 TM C1 Level-1*
Landsat 7	*ETM*	*181-033*	*22.05.2000*	*6*	*Landsat 7 ETM + C1 Level-1*
Landsat 5	*TM*	*181-033*	*12.05.2005*	*6*	*Landsat 4-5 TM C1 Level-1*
Landsat 5	*TM*	*181-033*	*26.05.2010*	*6*	*Landsat 4-5 TM C1 Level-1*
Landsat 8	*OLI_TIRS*	*181-033*	*24.05.2015*	*8*	*Landsat 8 OLI/TIRS C1 Level-1*
Landsat 8	*OLI_TIRS*	*181-033*	*24.05.2020*	*8*	*Landsat 8 OLI/TIRS C1 Level-1*

Data set procurement, data pre-processing and collecting training samples. In order to determine the land uses correctly and perform the necessary digitization processes, the following maps have been used:

Static, Stand and Function maps received from Republic of Turkey Ministry of Agriculture and Forestry,

Dams, streams and the ponds maps received from Republic of Turkey Ministry of State Water Works,

Google earth images and aerial photographs.

Landsat satellite images were utilized in order to determine the changes in the land use/cover of the Ayvalik district. A total number of 8 Landsat images belonging to the corresponding five year periods between 1985 and 2020 were used. Features of satellite images are presented in Table 1.

First, all images were checked against any defects such as striping and then all images were clipped with the purpose of covering the study area. After that, all images were corrected geometrically and radiometrically. The dark pixels in images belonging to the study area were exposed to radiometric correction using the Radiometric Correction module in the Arc Map 10.3 software program.

Classification of land uses. For the classification of land uses, Maximum Likelihood algorithm which is one of the Pixel-based classification methods was used in the study. Different algorithms such as Maximum Similarity, Maximum Neighborhood and etc. have been utilized in the literature for Pixel-based classification methods. Maximum Likelihood algorithm is the most commonly utilized method in pixel-based classification. Statistical values such as mean value, variance and covariance etc. are taken into account in this method. The equivalent probability curves for classes are defined and the pixels to be classified are assigned to the one with the highest probability of membership in the Maximum Similarity classification method. Furthermore, the variance-covariance matrix which will not only create brightness values of pixels, but also make differentiation for each class is formed in this method [7].

In the present study, seventeen different land cover/land use types were identified and created by using ArcMap 10.3 software. The types of land cover/land use classes are industrial areas, village centers, district centers, tourism and entertainment areas, broad-leaved forests, coniferous forests, cultivated agriculture areas, irrigated agriculture areas, dry agriculture areas, bare surfaces, lake, stream, grassland, steppe, shrubbery and meadows, highways and ports. Many representative samples were collected for each class by using area interest tool. When the signature file was created, the pixels of the image were classified into classes according to the samples by using a maximum likelihood classification. Thereby, the supervised classification command on a raster image was executed by using the signatures respectively.

Calculation of change. Change detection can be defined as the process of identifying differences in the state of an object or phenomenon by observing it at different times. In general, change detection involves the application of multi-temporal data sets to analyze the temporal effect quantitatively [29]. Post-classification comparison methods use separate classifications of images acquired at different times to produce difference maps. “From–to” change information can be generated. It explains to us how much change have occurred or what areas have changed during the from to period [29, 30]. In this study, post-classification change detection is employed after the eight images are classified separately.

Accuracy Assessment. One of the most important final steps at classification process is accuracy assessment. The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct land cover classes. An accuracy assessment for the pixel-based land use classification was done for the images by using Arc Map 10.3 software. Reference pixels were used in order to assess the accuracy of the classification. The classified maps were statistically validated with the random validation samples collected from the Landsat satellite images. In the first phase, each and every point had specific color tone and the pixel value which was recognized by the software itself when the data sets were trained during pixel-based land use classification. These values were considered as reference values. All the randomly generated points were then identified by the user and assigned in different classes. The correctly identified points were considered as classified values. This process was done for the 8 pixel-based classification images. In the second phase, user, producer and all accuracy matrices were run in order to assess the accuracy. User accuracy was obtained by dividing all correctly classified cells by total reference points. Producer accuracy were also obtained by dividing total correctly classified cells of land use land cover classes by total ground pixels. In order to obtain the overall accuracy, all correctly classified cells were divided by all pixels.

RESULTS

As a result of the analysis of the changes in the land uses over the years, it has been revealed that the structural areas such as residential, industry, tourism, highways and ports have increased on a hectare basis. The classified maps of the land use of Ayvalik district are shown in Figure 2 and Figure 3.

The results of the study showed that there has been an increase of 668.6% in the highway transportation network of the district while an increase of 420.7% in tourism and entertainment areas, an increase of 152% in the residential areas in the center and villages, an increase of 133.8% in the industrial areas and an increase of 32.2% has taken place in the port areas of the district.

When the forest areas were examined, it was seen that the coniferous forest areas have increased, whereas the broad-leaved forest areas have decreased over the years. An overall 19.3% of decrease has taken place regarding the total amount of forested areas.

In line with the information obtained from the Ayvalik Forestry Directorate, it was stated that the dominant species of the area were broad-leaved forest trees until 1985. However, after 1985 broad-leaved forest trees were cut within the scope of the silvicultural implementations and the coniferous forest tree species of Pinus brutia and Pinus pinea were planted instead.

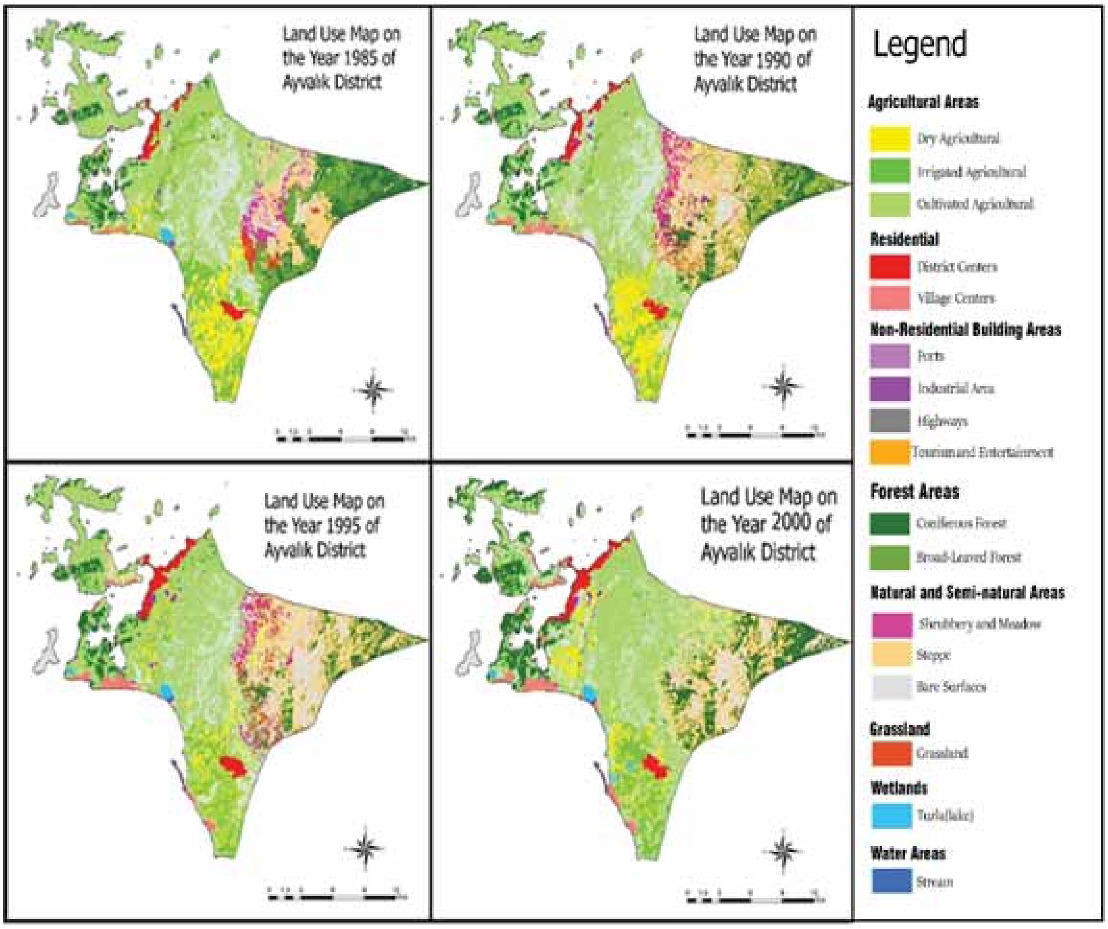

FIGURE 2
Land use maps over the years (1985-1990-1995-2000) of Ayvalik district.

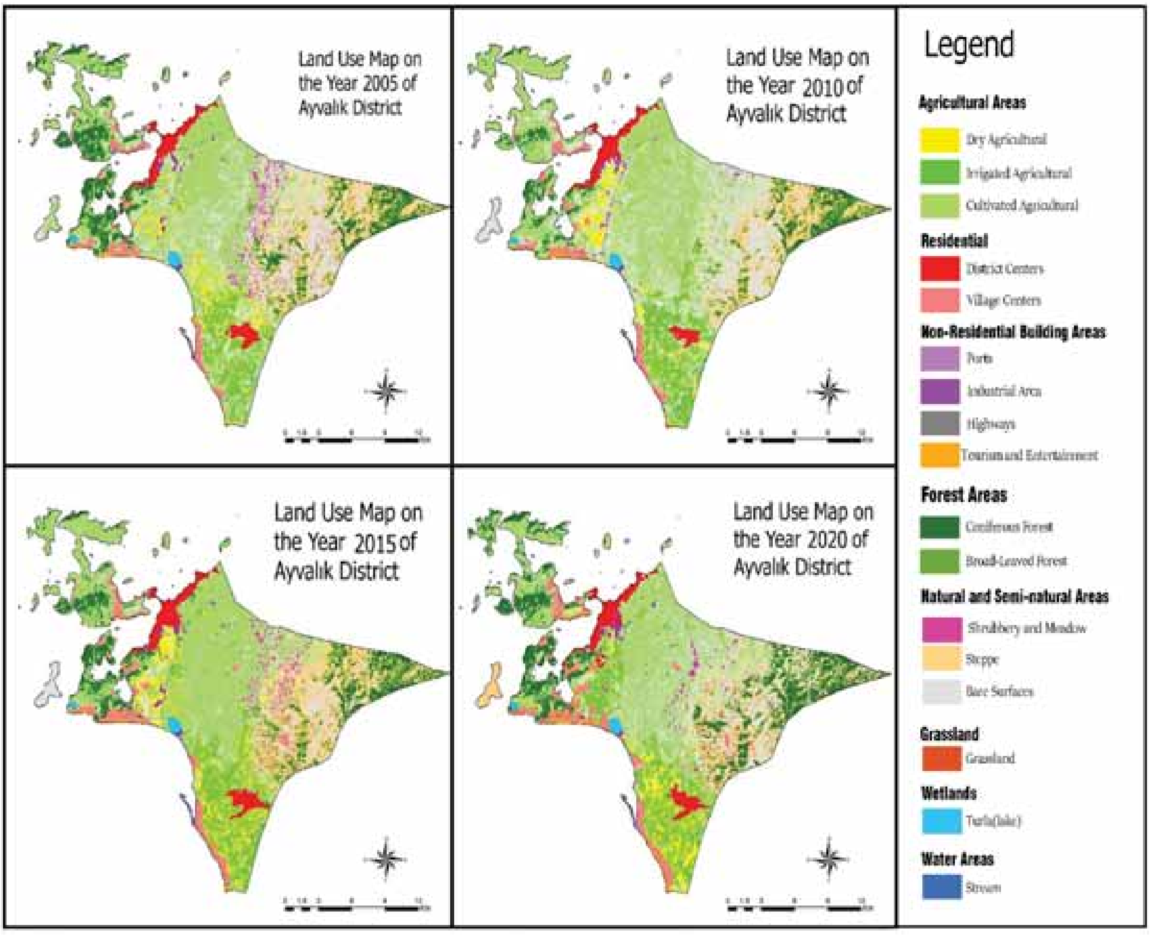

FIGURE 3
Land use maps over the years (2005-2010-2015-2020) of Ayvalik district.

TABLE 2
The amount of land use/cover change between 1985 and 2000

Land uses (Ha)	1985	1990	1995	2000
Industrial area	59.88	71.5	97.84	107.9
Village centers	159.71	409.8	515.27	704.46
District centers	453.27	493.22	695.1	713.63
Tourism and entertainment	65.9	38.61	43.73	51.68
Broad-leaved forest	2295.69	1721.7	1011.22	715.45
Coniferous forest	2849.69	2610.33	2160.84	3953.91
Cultivated agricultural	10488.78	9762.92	10947.84	11108.77
Irrigated agricultural	1841.45	972.04	1374.22	1409.84
Dry agricultural	2119.19	2010.71	1383.34	1287.84
Bare surfaces	5812.11	6214.43	6223.66	5367
Lake	102.67	19.21	105.92	118.19
Stream	37.62			
Grassland	271.89	441.23	443.56	
Steppe	2021.02	3863.32	3525.74	3474.95
Shrubbery and meadow	616.78	525.8	648.57	58.52
Highways	61.58	122.6	77.94	180.84
Ports	52.41	32.22	54.85	56.66
Toplam	29309.64	29309.64	29309.64	29309.64

TABLE 3
The amount of land use/cover change between 2005 and 2020

Land uses (Ha)	2005	2010	2015	2020
Industrial area	120.66	117.17	152.57	140.01
Village centers	754.38	858.18	1191.12	1341.29
District centers	791.61	764.65	958.27	931.3
Tourism and entertainment	150.59	153.16	162.65	343.19
Broad-leaved forest	1076.43	1059.25	1201.49	723.28
Coniferous forest	3072.26	1654.6	2504.66	3915.72
Cultivated agricultural	9668.82	10903.71	10975.24	8384.3
Irrigated agricultural	1506.62	1888.6	2143.6	2457.15
Dry agricultural	1219.03	995.23	1835.61	1310.58
Bare surfaces	7046.11	7895.1	3502.62	5784.95
Lake	109.62	110.91	111.51	120.28
Stream	16.55	30.82	27.61	30.72
Grassland	109.45		205.6	174.6
Steppe	2880.75	2449.86	3515.44	2884.37
Shrubbery and meadow	449.83	58.21	395.2	225.28
Highways	279.02	312.54	371.19	473.32
Ports	57.91	57.65	55.26	69.3
Toplam	29309.64	29309.64	29309.64	29309.64

TABLE 4
Land use land cover changes of Ayvalik district during 1985–2000, 2000–2020, and 1985–2020

Land use	Area change (ha)			Percentage change (%)		
	1985-2000	2000-2020	1985-2020	1985-2000	2000-2020	1985-2020
Industrial area	+48.02	+32.11	+80.13	+80.2	+29.7	+133.8
Village centers	+544.75	+636.83	+1181.58	+341.1	+90.3	+739.8
District centers	+260.36	+217.67	+478.03	+57.4	+30.5	+105.4
Tourism and entertainment	-14.22	+291.61	+277.29	-21.5	+564.2	+420.7
Broad-leaved forest	-1580.24	+7.83	-1572.41	-68.8	+1.1	-68.5
Coniferous forest	+1104.22	-38.19	+1066.03	-38.7	-1	+37.4
Cultivated agricultural	+619.99	-272.47	-2104.48	+6	-2.4	-20.1
Irrigated agricultural	-431.61	+1047.31	+615.7	-23.4	+74.2	+33.4
Dry agricultural	-831.35	+22.74	-808.61	-39.2	+1.7	-38.1
Bare surfaces	-445.11	+417.95	-27.16	-7,6	+7.7	-0.5
Lake	+15.52	+2.09	+17.61	+15.1	+1.7	+17.1
Stream	-37.62	+30.72	-6.9	-100	+100	-18.3
Grassland	-271.89	+174.6	-97.29	-100	+100	-35.7
Steppe	+1453.93	-590.58	+863.35	-71.9	-16.9	+42.7
Shrubbery and meadow	-558.26	+166.76	-391.5	-90.5	+284.9	-63.4
Highways	+119.26	+292.48	+411.74	+193.6	+161.7	+668.6
Ports	+4.25	+12.64	+16.89	+0.08	+22.3	+32.2

The examination based on agricultural areas revealed that the irrigated agriculture areas have increased by 33.4%, whereas dry agricultural areas have decreased by 38.1% while the cultivated agricultural areas have decreased by 20.1%. The increase in irrigated agricultural activities is caused by the developments in agricultural irrigation system technologies along with the Madra dam which was built for the purpose of agricultural irrigation activities of the district. At the present time, olive groves agricultural areas constitute 80% of the total amount of the cultivated agricultural land in the district. However, population increase and the growth of the urban areas, the olive groves agricultural areas have been replaced by residential and tourism areas.

The temporal change of the land use of Ayvalik district is shown on hectare basis in Table 2 and Table 3.

The amount of land use change on hectare basis showed that there has been a decrease in grassland, shrubbery and meadow, bare surfaces and stream while there has been an increase in the steppe and lake areas (Table 4). Summary of pixel-based classification accuracy for the 8 different time frames found from accuracy assessment is shown in Tables 5–7. The highest accuracy was found for 2020 pixel-based classification (92,1% accuracy) and the lowest for 1985 (84.7% accuracy).

TABLE 5
The accuracy matrix for classified images 1985, 1990,1995 and 2000

	1985		1990		1995		2000	
Classes	Producer accuracy	User accuracy	Producer accuracy	User accuracy	Producer accuracy	User accuracy	Producer accuracy	User accuracy
	%	%	%	%	%	%	%	%
Industrial area	75	80	81.2	86.6	81.2	86.6	81.2	86.6
District centers	80	80	100	86.6	100	86.6	100	86.6
Tourism and entertainment	73.3	73.3	80	80	92.8	86.6	75	80
Coniferous forest	85.7	80	65	86.6	93.3	93.3	93.3	93.3
Cultivated agricultural	85.7	80	92.3	80	86.6	86.6	100	80
Irrigated agricultural	86.6	86.6	72.2	86.6	81.2	86.6	60	80
Dry agricultural	92.8	86.6	92.8	86.6	76.4	86.6	80	80
Bare surfaces	81.2	86.6	81.2	86.6	81.2	86.6	100	86.6
Lake	93.3	93.3	93.7	100	93.7	100	77.7	93.3
Village centers	85.7	80	100	73	100	73.3	100	86.6
Stream	100	93.3	100	93.3	100	93.3	92.8	86.6
Grassland	92.8	86.6	86.6	86.6	72.2	86.6	80	80
Steppe	70.5	80	86.6	86.6	100	86.6	66.6	80
Shrubbery and meadow	81.2	86.6	100	86.6	86.6	86.6	85.7	80
Broad-leaved forest	100	100	86.6	86.6	87.5	93.3	100	86.6
Highways	86.6	86.6	80	80	85.7	80	86.6	86.6
Ports	80	80	100	86.6	100	93.3	100	86.6

TABLE 6
The accuracy matrix for classified images 2005, 2010, 2015 and 2020

	2005		2010		2015		2020	
Classes	Producer accuracy	User accuracy	Producer accuracy	User accuracy	Producer accuracy	User accuracy	Producer accuracy	User accuracy
	%	%	%	%	%	%	%	%
Industrial area	76.4	86.6	100	93.3	100	93.3	82.3	93.3
District centers	93.3	93.3	100	80	100	93.3	100	100
Tourism and entertainment	100	80	88.2	100	77.7	93.3	93.3	93.3
Coniferous forest	100	86.6	86.6	86.6	92.8	86.6	87.5	93.3
Cultivated agricultural	100	93.3	100	86.6	100	86.6	87.5	93.3
Irrigated agricultural	62	86.6	78.9	100	73.6	93.3	100	93.3
Dry agricultural	85.7	80	100	80	92.3	80	100	86.6
Bare surfaces	76.4	86.6	86.6	86.6	100	86.6	81.2	86.6
Lake	87.5	93.3	93.3	100	83.3	93.3	100	100
Village centers	100	80	100	86.6	100	86.6	83.3	100
Stream	100	93.3	87.5	93.3	100	93.3	88.2	100
Grassland	76.5	86.6	92.8	86.6	86.6	86.6	100	93.3
Steppe	80	80	92.8	93.3	93.3	93.3	92.8	86.6
Shrubbery and meadow	85.7	80	86.6	86.6	100	80	92.3	80
Broad-leaved forest	85.7	80	86.6	86.6	87.5	93.3	86.6	86.6
Highways	81.2	86.6	92.8	86.6	83.3	100	100	93.3
Ports	85.7	80	92.8	86.6	87.5	93.3	100	86.6

TABLE 7
Over all accuracy matrix for classified images 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020

	1985	1990	1995	2000	2005	2010	2015	2020
Over all accuracy %	84.7	85.8	87.8	84.7	85.5	89.4	90.2	92.1

CONCLUSIONS

The district of Ayvalik is one of the most important tourism and agricultural locations in Turkey. As of 2017, Ayvalik has been recorded to the temporary list of UNESCO World Heritage.

The land use changes which have occurred in the district are of significant importance not only for the region but also for Turkey, in terms of economic and social development. In terms of its natural and cultural characteristics, the district has a place that should not be ignored regarding the protection and use balance. There has been a great increase in tourism, residential and industrial areas in the district, particularly after the year 2000. The increase in industrial, residential and tourism areas have caused an increase in the built-up areas and thus, urban sprawl has gradually been accelerated. The zoning for construction of many olive groves within the scope of protected areas affected agricultural activities adversely. However, the increase of the modern irrigated agricultural technologies has positively affected the general agricultural activities. The results also revealed that the forest covered areas have decreased since 1985 till the present day.

It is foreseen that this study will shed light on sustainable and future-oriented ecological, economic, social and cultural planning in this research field by determining the land use changes in Ayvalik District. The excessive population growth, urbanization, developments in industry and technology, expansion of transportation networks, natural or human activities cause disasters to change the ecosystem directly or indirectly, they have also affected and continued to affect the urban or rural areas being a part of the ecosystem.

With the increasing number of studies on determining the changes in area uses, the changes in the ecosystem can be determined over time and correct and sustainable plan decisions can be made. Studies on the determination of changes in land use can assist for making correct and sustainable plan decisions in urban and rural areas.

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