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**QUANTIFYING THE EFFECT OF LANDUSE CHANGE  
ON OLIVE TREE CULTIVATION IN THE VICINITY OF EDREMIT  
BETWEEN 1979 AND 2006 USING GIS AND RS TECHNIQUES**

Recep Efe<sup>1</sup> - Abdullah Soykan - Süleyman Sönmez - İsa Cürebal



Angerstr. 12  
85354 Freising - Germany  
Phone: ++49 - (0) 8161-48420  
Fax: ++49 - (0) 8161-484248  
Email: [parlar@psp-parlar.de](mailto:parlar@psp-parlar.de)  
[www.psp-parlar.de](http://www.psp-parlar.de)

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# QUANTIFYING THE EFFECT OF LANDUSE CHANGE ON OLIVE TREE CULTIVATION IN THE VICINITY OF EDREMIT BETWEEN 1979 AND 2006 USING GIS AND RS TECHNIQUES

Recep Efe, Abdullah Soykan, Süleyman Sönmez and İsa Cürebal

Department of Geography, Faculty of Arts and Sciences, University of Balıkesir, 10145 Balıkesir, Turkey

## ABSTRACT

In Edremit region, located on the northwest of Turkey, tourism activity, which has started in 1970's, has caused landuse changes. Because of the construction of secondary houses and touristic facilities in the coastal zone, olive fields had been replaced with buildings. From 1990's, olive fields have been reestablished in the slopes of Kaz Mountain on the altitudes between 300-500 m in marginal lands. By comparison of Balıkesir Province land map for 1979 and satellite images of Landsat ETM+ for 2006, transformed areas for landuse were determined. According to this, 2482 hectares of olive cultivation land have been transformed into residential areas and 116 hectares have been transformed to barren lands and pastures. While the area covered by residential areas was 4720 hectares in 1979, it has arisen to 8185 hectares in 2006. 99.7 % of the land, which has been transformed to other forms of landuses from the olive cultivation areas, is located within 0-200 m of coastal zone. 5610 hectares of olive fields, where ecologically olive best grows, have been transformed to other forms of uses. While the olive groves in the coastal zone, which had been lost because of the transformation to residential areas, were being reestablished, forests dominated by Red pines (*Pinus brutia*) have been destructed. In these areas, which were natural occurrence areas of Red pine and ecologically not suitable for olive tree cultivation, 4133 hectares of forest area had been transformed to olive groves over the past three decades.

**KEYWORDS:** Kaz mountains, land-use change, olive cultivation, second houses, tourism development, marginal lands.

## INTRODUCTION

The olive tree (*Olea europaea* L.) is one of the most ancient domestic, cultivated plants characteristic of the Mediterranean Basin [1]. The crop (*O. europaea* subsp.

*europaea*) has been of immense importance as the principal source of edible oil for the peoples of the Mediterranean region for many millennia [2-6].

Land-use is only one such aspect, but knowledge about land-use and land-cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important natural properties, and loss of habitats [7, 8]. Land-use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved, or maintained at current levels [9]. The results of a study demonstrate that in communities, where tourism plays an important role, olive tree cultivation is preserved and the population is stable. The preservation of the agroecosystem is assured while the olive groves remain productive. Simultaneously, the landscape, which provides specific attractions for tourism, is not altered [8, 10-14].

The modernization of agriculture and the development of other economic sectors have prompted the abandonment of cultivated areas, which are marginally productive. Specifically, olive groves in Edremit area are transformed into settlements due to their location in accessible coastal zone regions where secondary houses and tourism facilities are increasing [15, 16]. The Kaz Mountains (Mt. Ida) have limited possibilities of development, agricultural activities, grazing, due to inaccessible landscape, except for their national park where the growth of tourism is possible. The objective of this study was to investigate the impact of tourism activities and settlements on olive tree cultivation and the human population of the Edremit and its environs. Land-use change caused also change in density of settlements. Until the middle of the 20th century, the population density of the region was very low. Then, it increased tremendously during the next 50 years. Nowadays, people start to return but mainly using this region for second homes, for vacations or weekends, and prices for houses increased tremendously.

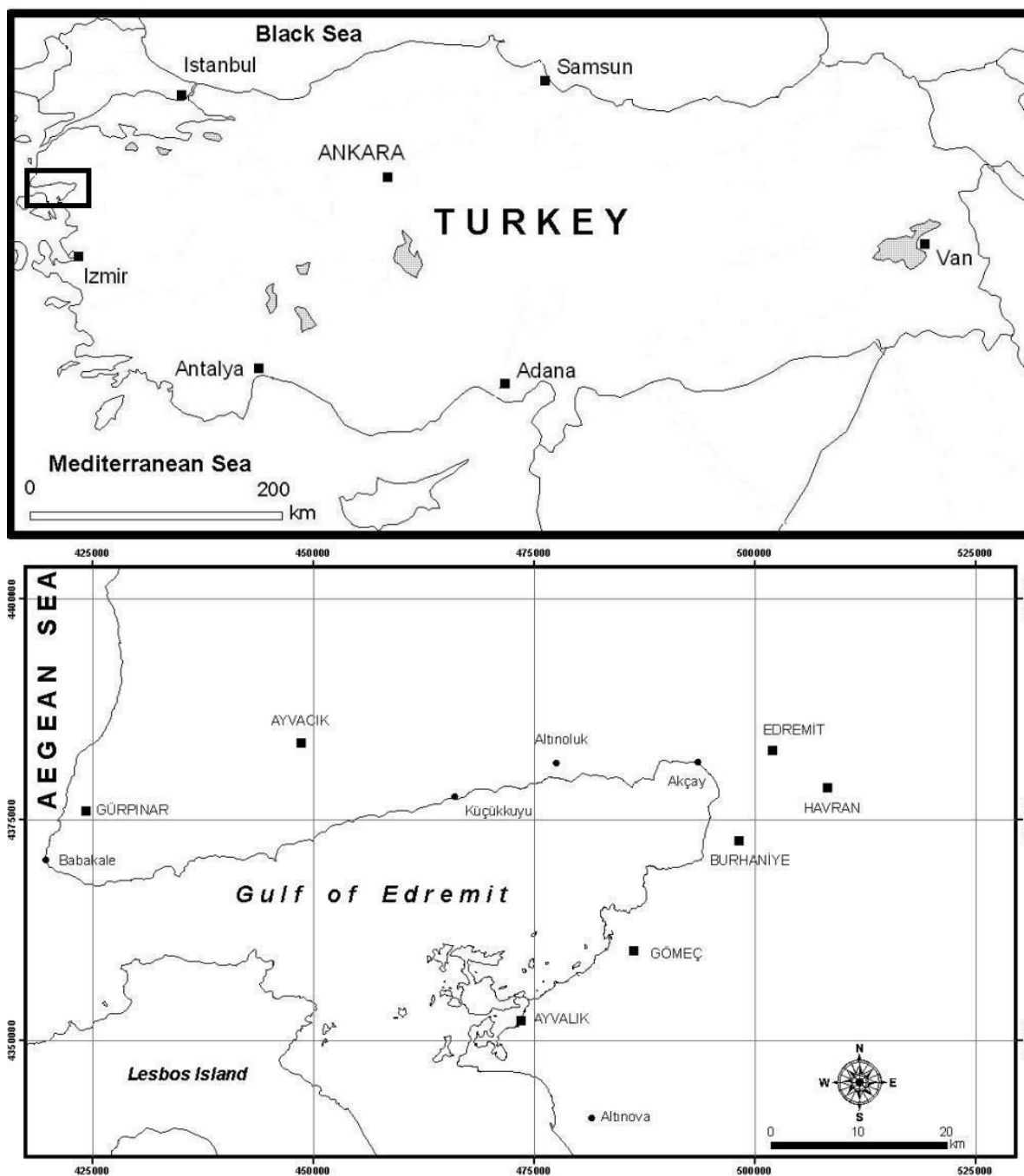


FIGURE 1 - Study area.

This study examines evidence on the relationship between natural environment - human in terms of land-use changes in the Edremit region of Turkey over three decades, using historical maps and contemporary satellite data. Olive areas` change was analyzed with reference to elevation levels.

**Description of the study area**

This study aims to determine the olive cultivation land changes between 1979 and 2006 in the Edremit subregion

located in the northwest of Turkey, a part of the Aegean Region occupying parts of western Turkey (Figure 1). The study area itself covers 2040 square kilometers. Edremit subregion is a basin surrounded with Kaz mt., Gürgen mt, Eybek mt on the north, Şapçı on the east, as well as Belen mt., Musluk mt., Şabla mt. and Yaylacıkdede mt. on the south. The lower parts of the study area are delineated by Aegean Sea [17]. The study area is located 455000-525000 east and 4340000-4395000 north (UTM Zone 35N- WGS84) coordinates around the Gulf of Edremit, on the northwest

of Turkey (Figure 1). Edremit vicinity is composed of marginal olive agriculture-based areas with documented deforestation and agricultural extensification.

The climate of the region is predominantly Mediterranean which is distinguished by warm, dry summers and mild, wet winters. Average annual precipitation ranges from 500 to 1200 mm on higher elevations. It is on the dry sub-humid zone with 600 mm [18, 19].

The olive tree (*Olea europaea*), Red pine (*Pinus brutia*), Turkish oak (*Quercus cerris*), Dyer's oak (*Quercus infectoria*) and maquis elements, such as strawberry tree (*Arbutus unedo*), eastern strawberry tree (*Arbutus andrachne*), large-leaved jasmine (*Phillyrea latifolia*) and kermes oak (*Quercus coccifera*) are dominant plant species in the study area [20].

## MATERIALS AND METHODS

Cartographic materials, satellite images and also field studies and observations had significant contributions to this study for determination of changes in the areas where olive cultivation is done in the vicinity of Edremit. Land assets maps belonged to 1979 [21, 22] and 1/25.000-scaled topographical maps were used in order to determine the land-use in 1979. For determination of landuse in 2006, image of Landsat Enhanced Thematic Mapper Plus (ETM+) had been considered as basis and the digital elevation model with 100-m intervals had been made. To confirm the landuse and observe the details closely, field studies were carried out between November 2006 and August 2007.

To this end, first of all, topographical maps from land assets inventory maps of Province of Balıkesir have been scanned to compute the environment. For overlapping and processing the maps, ArcGIS Desktop v.9x was used. Mentioned maps were coordinated as UTM (Universal Transverse Mercator – UTM - WGS84), a standard map projection. By using ArcMap v9.2, layers were established by the method of screen digitalization on the map which was coordinated by considering olive groves and landuse which had interacted with olive areas.

For the purpose of overlapping, previously coordinated and prepared data with Landsat ETM+ satellite image belonging to 2006, as well as ground control points (GCP's) have been selected on topographical maps, and Root mean square error – RMS error has been decreased below 1 pixel. By the method of screen digitizing, olive groves and residential areas belonging to 2006 have been transformed to layers from Landsat ETM+ image.

By overlaying the data of both years, 1979 and 2006, changes in olive areas have been determined primarily. During this process, the transformations between olive cultivation areas and other forms of uses have been determined. Obtained data were calculated as hectares in prepared tables. To determine the distribution of changes oc-

curing in olive cultivation areas according to the elevation levels, data which have been obtained from digitalization of topographical maps by using ArcScene v9.2 software, were transformed to 100-m interval Digital Elevation Model – DEM.

Data obtained by overlapping 1979 and 2006 data were overlaid with digital elevation model, and, as the result of this process, changes in the olive groves were determined as areal according to the elevation levels. Obtained data, by the end of this process, were worked up into tables by calculating as hectares.

In the last stage of the study, data belonging to the changes occurring in olive cultivation areas and data obtained in field studies were brought together and explained.

## RESULTS AND DISCUSSION

Human activities in the Edremit basin have increased substantially in the past three decades, causing significant impacts on the agricultural land. Agriculture had been a part of the study area economy until 1980s. Akçay, Güre, Altınoluk and Ören are experiencing rapid population growth that shows no signs of slowing. Between 1980 and 2006, population in the region doubled. The population increased from 46000 in 1980 to 93000 in 2000. The population of the region now exceeds 97000 people. Population growth results in urbanization, which directly and indirectly affects natural systems and landscape processes. Already this growth has exacerbated the tension between people and the environment.

The Edremit region has significant advantages and opportunities for some agricultural enterprises including access to reclaimed water (from rivers and ground), proximity to labor, markets and freight facilities and, for some horticultural crops, favorable climatic and soil conditions not found elsewhere in Turkey. The further loss of these areas to residential and tourism development potentially represents the loss of a valuable natural resource for Turkey. One of the most significant changes in landuse over the past two decades has been an increase in the area occupied by tourism developments and secondary houses, often with an associated loss of agricultural land.

For the past 28 years, the proportion of forests in the study area has decreased by 3925 ha. Olive area shifting largely affected forests within the forest belt and areas located immediately above this belt. Changes in landuse were largely related to a decline in olive cultivation and have occurred along with population growth. As a result, olive agriculture has been replaced by secondary houses and tourism developments to meet growing demands.

During the 1970s and 1980s, the tangerine and olive were the dominant crops in the region. From 1975 to present, the Edremit subregion and its environs have witnessed a shift from agriculture to tourism; tourists were



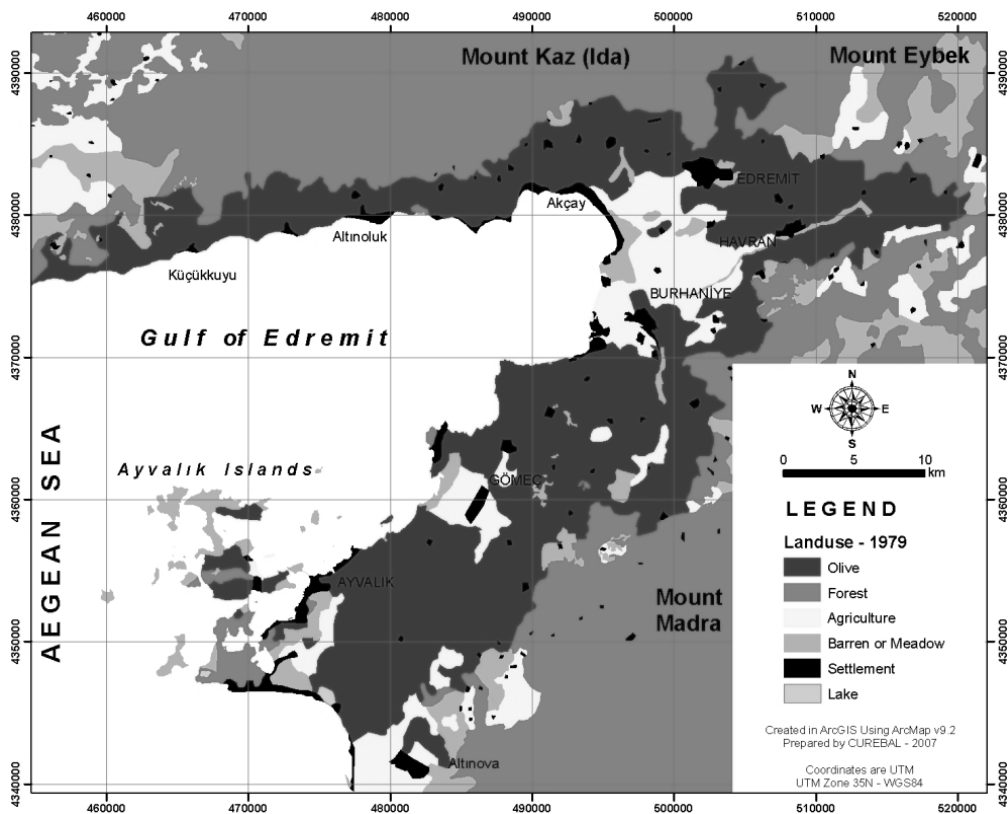


FIGURE 2 - Landuse in the vicinity of Edremit in 1979.

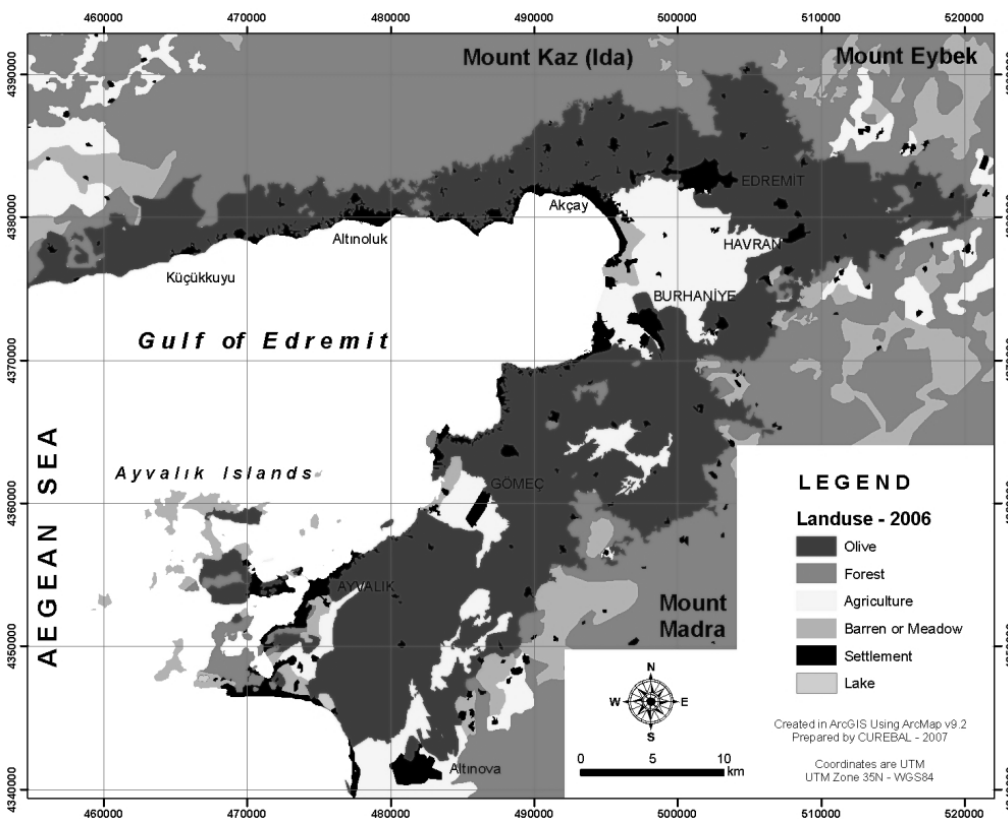


FIGURE 3 - Landuse in the vicinity of Edremit in 2006.

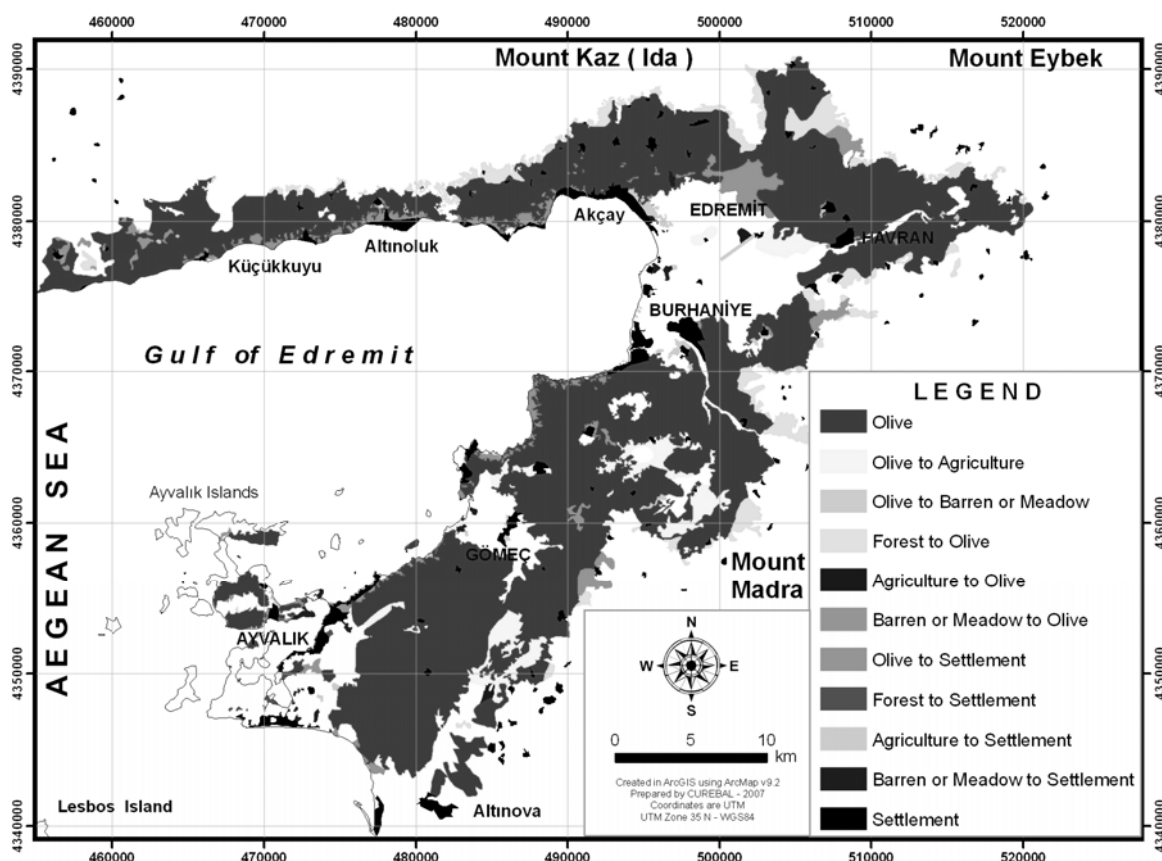


FIGURE 4 - Landuse changes in the Edremit Subregion between 1979 and 2006.

attracted to the coastal area but many farmers entirely dependent on their agricultural production were forced to go away towards the slopes of Kaz Mountain. Tourism, however, is only seasonal and the number of tourists at the area is relatively small to sustain the annual income of the local population.

Transformation of olive groves and other forms of landuse between 1979-2006 in the vicinity of Edremit, have shown a progress against olive cultivation both as areal (horizontal and vertical) and ecologically. Therefore, the area of olive groves in 1979 was reduced from 62497 to 62450 ha in 2006 (Table 1a). Olive cultivation areas de-creased by 0.08 % in that period, whereas especially residential areas and secondary housings increased by 73.41 % in this period (Table 1b).

As the result of landuse change, especially in olive groves in the vicinity, an area of 5610 hectares has been transformed from olive groves into agricultural, residential and barren lands. In the transformed terrains, the percentage of agriculture (53.69 %) and residential and secondary housings (44.24 %) are quite high (Table 2). In the transformations between olive groves and other landuse forms in the vicinity of Edremit, significant elevation level, as well as type of land-use percentage changes occurring, are of particular interest. In this range, it was aimed to determine the distribution of land-use changes according to

the elevation levels, achieving them to the results summarized below.

According to the data from the areas which have been transformed from olive groves to other forms of landuse, such as agricultural, residential and barren lands, cover an area of 5610 hectares, 8.97 % of total olive groves. All destruction of olive groves took place between 0–300 m. Within these transformed lands, the biggest change occurred in the zone of 0–100 m (73.80 %). The percentage of the zone 101–200 m was 25.90 %, and least change (0.3 %) occurred in the zone of 201–200 m (Tables 3a, b).

In the distribution of the areas transformed from olive groves to residential areas and secondary housings within the elevation levels, the elevation level 0–100 has a high percentage of 97.86 % with 2429 hectares. It is seen that a very big part of the olive groves were destroyed in the coastal zone which is located between 0–100 m. The cause of this is that the coastal zone is preferred for secondary housings and tourism facilities.

At the area of 1662 ha transformed to other agricultural areas, the olive was sold with low value in some periods and olive trees were removed for alternative crops. The possibility of transforming these places to residential and touristic construction sites is high.

**TABLE 1a - Landuse changes in olive cultivation and settlements between 1979 (land registration data) and 2006 (Landsat ETM+ satellite image).**

Landuse	Year		Change ( ha )	Rate ( % )
	1979	2006		
Olive cultivation	62497	62450	— 47	0.08
Settlements	4720	8185	3465	73.41

**TABLE 1b - The lands transformed from other landuse types to settlements in 1979 – 2006.**

	1979	2006	Area ( ha )	Rate ( % )
Olive			2482	71.63
Forest			97	2.80
Agriculture		to Settlements	564	16.28
Barren or meadow			322	9.29
<b>Total</b>			<b>3465</b>	<b>100.00</b>

**TABLE 2 - Landuse shifts from olive cultivation to other landuse types between “1979 and 2006”**

1979	2006	Change ( ha )	Rate ( % )
	Agriculture	3012	53.69
Olive to	Settlements	2482	44.24
	Barren or meadow	116	2.07
<b>Total</b>		<b>5610</b>	<b>100.00</b>

**TABLE 3a - The distribution of the landuse change from olive groves to other landuse types between “1979 – 2006” according to Elevation Levels (ha).**

1979	2006	Area ( ha )	ELEVATION LEVELS ( 100 m )				
			0-100	101-200	201-300	301-400	401-500
Olive to	Agriculture	3012	1662	1341	9	-	-
	Settlements	2482	2429	53	-	-	-
	Barren or meadow	116	49	59	8	-	-
	<b>Total</b>	<b>5610</b>	<b>4140</b>	<b>1453</b>	<b>17</b>	-	-
<b>Rate ( % )</b>		<b>100.00</b>	<b>73.80</b>	<b>25.90</b>	<b>0.30</b>	-	-

**TABLE 3b - The distribution of landuse change from olive groves to other landuse types between “1979 – 2006” according to Elevation Levels (%).**

1979	2006	Rate ( % )	ELEVATION LEVELS ( m )				
			0-100	101-200	201-300	301-400	401-500
Olive to	Agriculture	53.69	55.18	44.52	0.30	-	-
	Settlements	44.24	97.86	2.14	0.00	-	-
	Barren or meadow	2.07	42.24	50.86	6.90	-	-
	<b>Total ( % )</b>	<b>100.00</b>					

Between “1979–2006”, an area of 5563 ha had been transformed from other landuse types to olive groves. Within the transformed land, the percentage of the areas which had been transformed from forests to olive groves was 79.29 % in total (Table 4).

According to the data from fields, which had been transformed from forest, agricultural and barren lands to olive groves, cover 5563 hectares. This change had occurred between elevations of 0–500 m. Within the transformed land, the biggest change occurred at elevation levels 101–

200 m (39.12 %) and 201–300 m (35.36 %). The least change (2.01 %) occurred between 401–500 m (Tables 5a, b).

Within the fields transformed from other landuse types to olive groves, lands which had been transformed from forests to olive groves are significant by 4133 ha (74.29 %). It is seen that changes show intensity in elevation levels of 100–200 m and 201–300 m within these transformed lands, and percentage of lands transformed from forests to olive groves is 4133 ha (74.93 %).

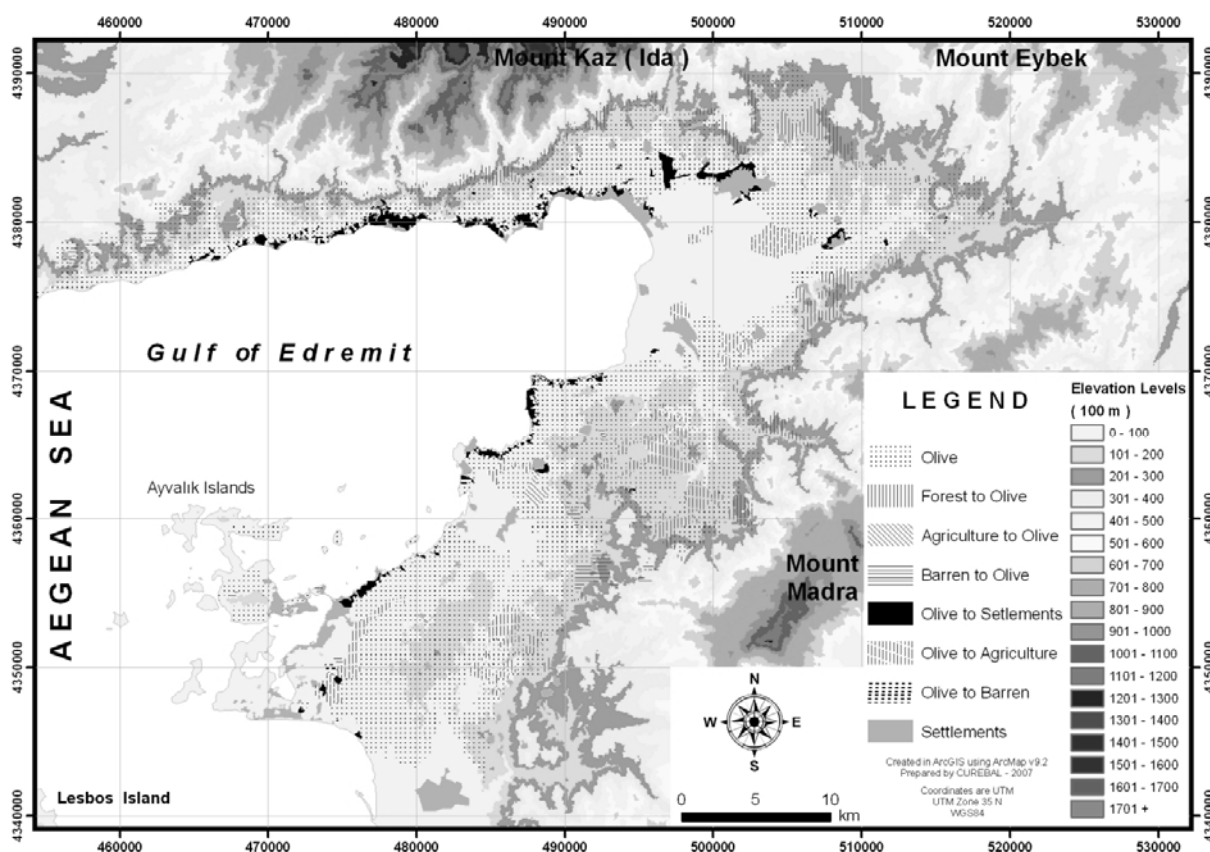


FIGURE 5 - Shifts between olive cultivation and the other landuse types “1979-2006”.

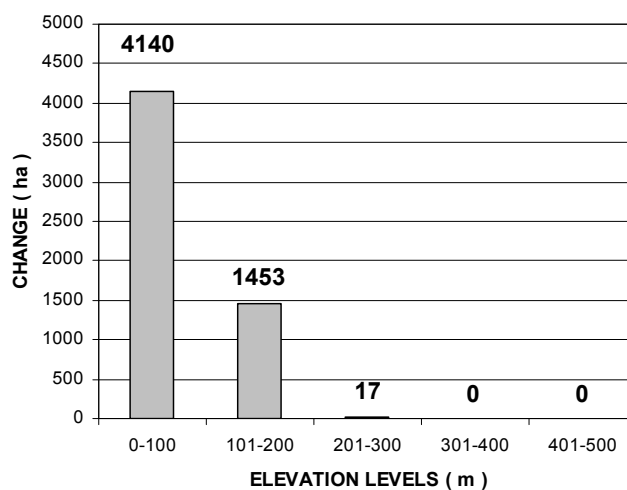


FIGURE 6 - The distribution of the landuse change from olive groves to other landuse types between “1979 – 2006” according to the Elevation Levels (ha).

TABLE 4 - Landuse shifts from the other landuse types to olive cultivation between “1979 and 2006”

1979	2006	Area ( ha )	Rate ( % )
Forest	to Olive	4133	74.29
Barren or meadow		1320	23.73
Agriculture		110	1.98
<b>Total</b>		<b>5563</b>	<b>100.00</b>

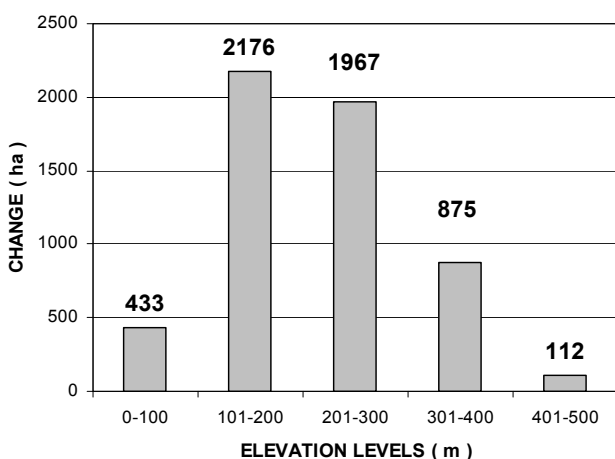


**TABLE 5a - The distribution of landuse change from other landuse types to olive groves between "1979 – 2006" according to the Elevation Levels (ha).**

1979	2006	Area ( ha )	ELEVATION LEVELS ( 100 m )				
			0-100	101-200	201-300	301-400	401-500
Forest	to Olive	4133	185	1523	1574	756	95
Barren or meadow		1320	142	649	393	119	17
Agriculture		110	106	4	-	-	-
<b>Total</b>		<b>5563</b>	<b>433</b>	<b>2176</b>	<b>1967</b>	<b>875</b>	<b>112</b>
<b>Rate ( % )</b>		<b>100.00</b>	<b>7.78</b>	<b>39.12</b>	<b>35.36</b>	<b>15.73</b>	<b>2.01</b>

**TABLE 5b - The distribution of landuse change from the other landuse types to olive groves between "1979 – 2006" according to the Elevation Levels (%).**

1979	2006	Rate ( % )	ELEVATION LEVELS ( m )				
			0-100	101-200	201-300	301-400	401-500
Forest	to Olive	74.29	4.48	36.85	38.08	18.29	2.30
Barren or meadow		23.73	10.76	49.17	29.77	9.02	1.29
Agriculture		1.98	96.36	3.64	-	-	-
<b>Total</b>		<b>100.00</b>					

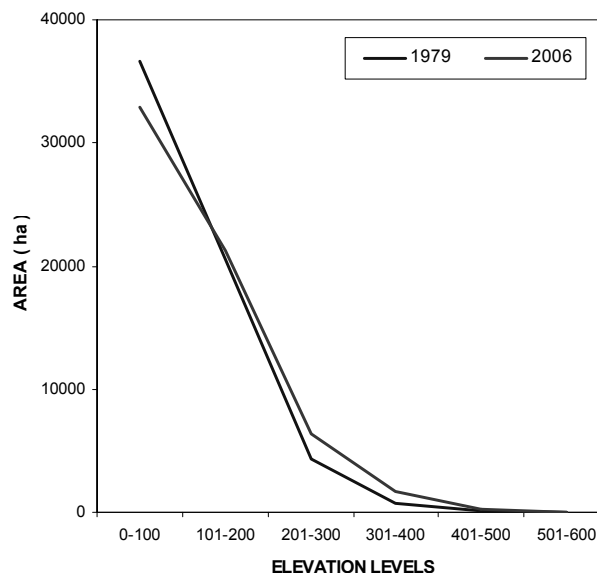


**FIGURE 7 - The distribution of landuse change from other landuse types to olive groves between "1979 – 2006" according to the Elevation Levels (ha).**

With its specialties, the vicinity of Edremit has an attribute to be a representative field for the interaction and competition between olive groves and other land-uses. Increase in population and secondary housings have caused negative effects on the crop which has been cultivated in natural environments. Between 1979–2006, because of land-use changes, 5610 hectares of olive groves in the coastal zone have been destroyed and transformed to other land-uses. In this time, the residential areas have increased by 3465 ha, from 4720 to 8185 ha (Table 1a), and 2482 ha were taken from olive grove areas (Table 1b).

On the other hand, between "1979 – 2006", it is seen that the olive groves had decreased from 62497 to 62450 ha, only by 47 ha (0.08 %). This situation shows that the olive trees removed to obtain barren to build residential and touristic facilities in the coastal zone between 0–100 m,

have been reestablished in regions away from the coast in elevations of 100–500 m (Table 5). It is seen that olive cultivation areas have been spread from the coastal zone through the slopes of the Kaz Mountain (Figure 8), unfortunately causing economical losses. Firstly, the growth of the olive tree is slow in elevations which are not suitable for growing conditions, and yield is low. Secondly, newly sowed seedlings need a long time to obtain full yield.



**FIGURE 8**  
**Distribution of olive groves on elevation levels in 1979–2006 (ha).**

## CONCLUSIONS

There are concerns that insensitive housing and tourism developments will lead to:

- establishment and expanding of new olive groves on the slopes of Kaz Mountains, on the marginal lands over 300 m, not suitable for olive cultivation;
- the further loss of native vegetation - the clearance of maquis and red pine forests;
- exacerbation of bushfire risks to housing and human life;
- increasing degradation of soil and water quality;
- increased loss of biodiversity;
- increasing poorly planned settlements,
- filling the natural drainage pattern for infrastructure, secondary houses and tourism developments.

In the vicinity of Edremit, olive plantations shifted to the marginal lands with severe limitations for productive use, soil limitations, high variation in the elevation of the terrain, and unfavorable ecological conditions. Edremit region is an important tourism and recreation area and has significant natural and cultural features. The agricultural pattern of the region has changed and will further change quite rapidly, in accordance to the demand for land and summer houses.

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**CORRESPONDING AUTHOR**

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**Recep Efe**  
Department of Geography  
Faculty of Arts and Sciences  
University of Balıkesir  
10145 Balıkesir  
TURKEY

Phone: +90 266 6121442  
Fax: +90 266 6121215  
E-mail: [refe@balikesir.edu.tr](mailto:refe@balikesir.edu.tr)