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Investigation of Land Use and Coastline Changes on the Kepez Delta Using Remote Sensing

Uzaktan Algılama Yöntemi ile Kepez Deltasında Arazi Kullanımı ve Kıyı Çizgisi Değişimlerinin İncelenmesi

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Abstract

This paper presents land use features and coastline changes on the Kepez Delta between 1962 and 2005 by using remote sensing, aerial photograph interpretations and field observations. Rapid increase of population of the Kepez town from 1935 to 2000 fits with a growth of 24 times, resulting in continual expansion (~23 times) of residential areas on fertile farming lands. The sprawling of summer houses in the Dardanos area to the south threatens agricultural lands and the coastal ecosystem on a large scale. Coastline changes occurred as result of natural morpho-dynamic processes and human involvement in the past 43 years. These changes are characterized by seaward progradation (sediment accumulation) of about 40 m and coastal retrogradation (marine erosion) of 20 m at various parts of the coastline.

Keywords: Land use, coastline change, Remote sensing, Kepez delta.

Introduction

Land use and land cover changes give rise to land degradation that results mainly from anthropogenic activities particularly in lesser-developed

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countries (Hudson and Alcántara-Ayala, 2006). It is mostly related to the accumulation of debris with various origin, type and amount as has been pointed out by numerous studies in a wide range of environments (Wade et al., 1991; Gabrilides et al., 1991; Golik and Gertner, 1992; Corbin and Singh, 1993; Willoughby et al, 1997; Ribic, 1998; Debrot et al., 1999; Silva-Iñiquez and Fisher, 2003; Claereboudt, 2004, Santos et al, 2005). The Mediterranean Region has been an important area where land degradation by misuse of land and pollution have threatened the human environment since foundation of the ancient civilizations (Tzatzanis et al., 2003). This threat on Mediterranean shores has been ascribed to pressure of more than half of the world's tourism potential (Barale and Folving, 1996).

As a Mediterranean country, the Turkey's coastal areas also have been heavily affected by these pressure driven by human activities, which resulted, for instance, in coastal pollution and related deterioration of water quality (Samsunlu and Akça, 1999) and coastline changes due to construction of dams (Cetin et al., 1999; Erginal et al., 2006) and harbours (Szmytkiewicz et al., 2000). The main problems in use, sustainable planning and appropriate management of the Turkey's coastal areas result from residential, commercial, tourism and recreational activities (Dogan and Erginoz, 1997). Numerous studies on this subject have dealt with the urgent need for conservation of various coastal environments of the coutry, such as Black Sea (Gazioğlu et al., 1997; Yilmaz and Yetim,2002; Seyhan et al.,2002; Başar et al., 2002); Mediterranean Sea (Özbek ve Dinç, 1984; Akova, 1997; Akkaya, 2004); Aegean Sea (Kocman, 2002; Ozkan, 1993; Emekli, 2002; Irtem and Karaman, 2004); and Sea of Marmara (Kaya et al., 2002; Gurbuz et al., 2004).

A typical example of rapidy degraded coastal areas in Turkey is discussed in this paper. The present paper aims (1) to explain changes in the position of coastline and (2) to determine land use and land cover features of the Kepez Delta coast based on interpretations of aerial photographs, satellite images and field data.

Methods

In order to explain coastline change and landuse characteristics of the delta, geographic information systems (GIS) and remote sensing (RS) methods were employed. The coastline change was studied based on interpretations of aerial photos of 1962 and 1997, and ASTER satellite image of 2005. The geometric correction of aerial photographs and satellite images were performed on ERDAS 8.5 software. Digital Elevation Model (DEM) of the area was produced by digitizing 10-m-interval of contours on 1/25000-scaled

topographic base maps. Slope classes were then identified. The whole calculations were carried out on ARC-GIS 8.3 software. Classification of various land use classes were conducted using ERDAS 8.5 software and were further controlled in field surveys using GPS data collection.

Geographical settings

The Kepez Delta, one of the several coastal plains that developed along the Strait of Canakkale (Dardanelles), is located between latitudes 40°6'37" to 40°4'34" north and longitudes 26°21'32" to 26°24'3" east. The delta was formed by accumulation of sediments carried by the Kepez Creek and its tributaries that discharge into the Strait of Canakkale.

On the contrary of restricted catchment area of the Kepez Creek, the rapidly development of the delta has been ascribed to the existence of erosion-prone geological formations of Miocene age in the drainage basin of the Kepez Creek (Atabey *et al*., 2004) and additional sediment transportation by longshore currents from the north (Erol, 1969; Erginal et al., 2002). The delta with an area of about 636.9 hectare constitutes a typical seaward protrusion of 1.5 km on the eastern side of the Strait of Canakkale (Figure1).

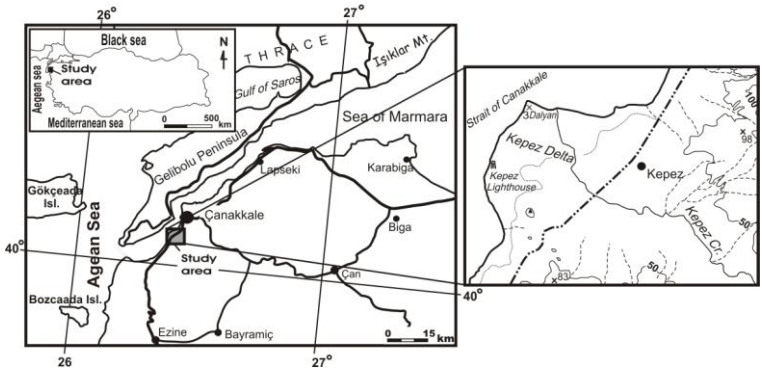

Figure 1. Location map of the study area.

According to the meteorological data from the Çanakkale Meteorology Station (DMI) which is 30 km south from the area, the annual average precipitation is 599.6 mm, 43 % of which falls during the winter season. The monthly mean temperatures show that the warmest and the coldest months of the year are July and January with the long-term averages of 25°C and 6.4°C, respectively. The NE and SW winds are prominent in the area.

72.3 % of the study area is characterized by slopes with inclination lesser than % 3. As a matter of fact, the areas where human activities are presently carried out have slopes ranging from 15 % to 1 % and occupy about 96.3 %

of the area. The degree of inclination in only 0.6 % of the area is more than 15 %. As known, deep alluvial soils of coastal strips are among the most fertile soil groups of Turkey because they have a texture between fine and average (Tanoğlu, 1964). The young alluvial soils of the Kepez delta constitute the main soil group in the area, which occupies 76.4 % of the total area.

The colluvial soils, brown forest soils and rendzina are of secondary importance due to their unsufficient mineral component and texture. According to data from KHGM (1999), class 1, 2 and 3 type of farming lands occupy 76.5 %, 1.8 % and 21.7 % of the area, respectively.

The last census in 2000 shows that the total population is 7.918 in Kepez town, which is the only permanent settlement nearby the area. Presently, the town appears to expand in more than one direction depending on rapid increase in population as will be discussed below.

Results

Relationships between population and land use

As stated previously, the study area has very suitable natural conditions for human life implementation of various ecocomic activities, such as agriculture, transportation, coastal tourism etc.

Is is commonly known that increasing pressure driven by high population is one of the chief agents affecting human activities, land use patterns and degradation on coastal environments of Turkey (Doğan and Erginöz, 1997; Döös, 2002). The most prominent cause of change in land use patterns is also widely associated with growth in population since, in particular, early 1970's.

Table 1. Change in population in the Kepez town.

	Years of Census							
	1935	**1945**	**1955**	**1965**	**1975**	**1985**	**1990**	**2000**
Population	322	597	582	725	1439	3404	4582	7918
Annual increase (%)	--	8.5	-0.3	2.5	9.8	13.7	6.9	7.3

As for the study area, change in amount of population was evaluated according to the census data from DIE for the period between 1935 and 2000 (Table 1). It is clear that a rapid and continual increase occurred in total population of Kepez town (Table 1). Thus, the amount of population of the year 2000 shows an augmentation of 24 times when compared with that of 1935.

In order to reveal relationships between population increase and horizontal growth in residential areas, the expansion ratio of the Kepez town for the years 1957, 1967 and 2005 was calculated. The results show that the total area of the Kepez town in these years has been 84864 m^2, 141930 m^2 and 1.979.337 m^2, respectively (Figure 2).

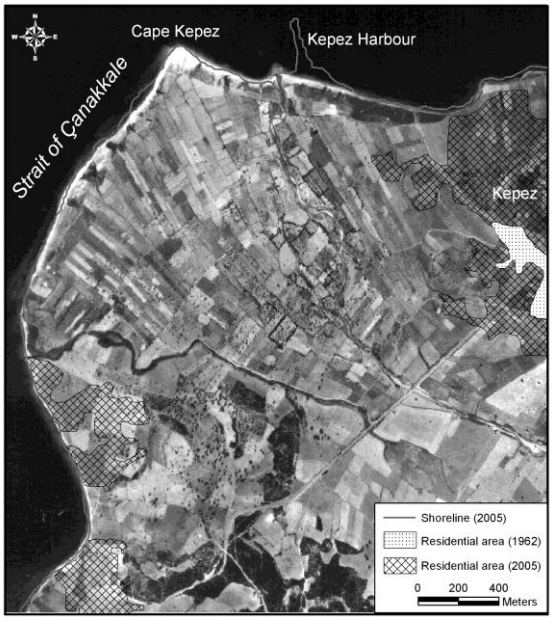

Figure 2. Expanding of settlement area in Kepez Delta between 1962 and 2005.

The rapid expansion of the town towards the delta plain took place associated with increase in population since early 1970's when industrial development has been commenced. Thus, an area of about 707.770 m^2 farming land on fertile soils of the delta was occupied due particularly to progress in food industry. This industrial growth inevitably necessitated more laborers, which in turn caused an accelerated migration from several parts of the country.

Classification and assessment of land use

Although industry is the prominent economic activitiy, agricultural production also plays a crucial role in emerging various landuse patterns and a polycultural farming structure in the delta plain. Indeed, a large part of the study area is used for cultivation owing to the convenience of climatic conditions and good irrigation facilities.

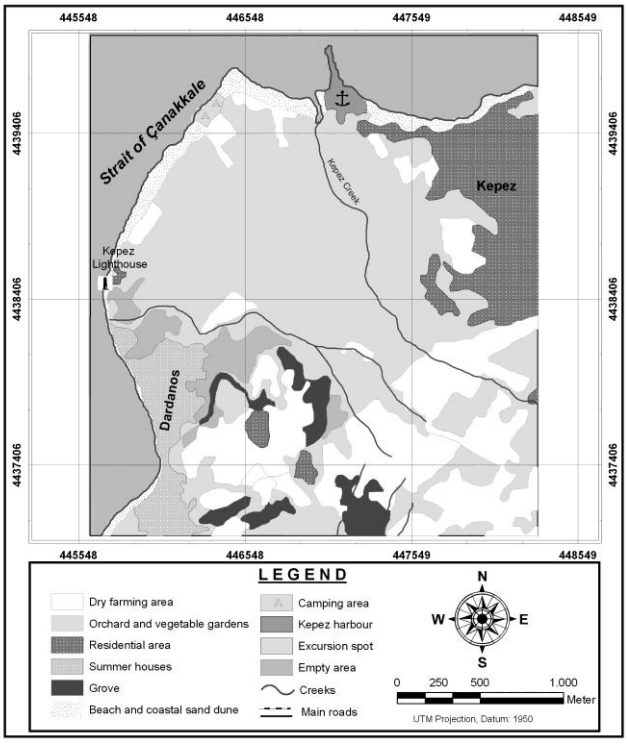

Figure 3. Land use features in Kepez Delta (2005)

Based on classification from ASTER satellite image of 2005, present land use features in the area is shown in Table 2 and Figure 3. As seen in Table 2, farming lands including orchard and vegetable gardens and dry farming areas with a total area of 451.6 ha constitutes about 70.9 % of the investigated area. In the beginning of 1960's, Orchard and vegetable gardens where various crops are cultivated, such as peach, olive, apple, apricot, grape, melon, tomato, watermelon, bean and broad bean, became the predominant land use class (48.1 %). Besides, less amount of wheat and barley cultivation are also carried out using dry faming method (Figure 4A). By means of the Atikhisar Dam built in 1975 to the northeast of the area, irrigated cultivation areas expanded and usage of intensive farming methods enabled to grow up various kinds of crops.

The residential areas consisting of permanent settlements and summer houses have an area of about 102.3 ha, occupying approximately 16 % of the delta. The only permanent settlement in the area is Kepez town, which has been initially located upon a low rigde to the north of the delta plain.

Table 2: Land use in the Kepez delta in (2005)

Land Use Type	*Area (acre)*	*Area in proportion to the whole area (%)*
Orchard and vegetable gardens	306.5	48.1
Dry farming areas	145.1	22.8
Residential area	70.8	11.1
Summer houses	31.5	4.9
Empty areas	25.9	4.1
Beach and coastal sand dune	24.6	3.9
Grove	22.3	3.5
Kepez Harbour	4.8	0.8
Camping area	1.9	0.3
Excursion spot	3.5	0.5
TOTAL	636.9	100

Today, the settlements involved rapidly extends both toward the city of Canakkale to the north and the Kepez delta to the west. Another factor that caused sprawl of residential areas is associated with increase in the number of summer houses in southern coast of the delta (Dardanos) since the early 1980's (Figure 4B).

Beach and coastal sand dune areas near the backshore occupy about 3.9 % of the area. Sandy beaches are generally gently (about 2-3°) inclined towards the sea and are composed mainly of quartz grains. Even though coastal sand dunes with elevation lower than 1 meter do not occupy a significant area, a large number of plant species were identified on them, such as *Phragmites australis, Hordeum marinum, Phleum cristatum, Ammophyla littoralis, Bromus rigidus, Glaucium flavum, Hypecoum pendulum, Convolvulus soldanella, Otanthus maritimus, Senecio vernalis, Eryngium maritimum, Medicago marina, Juncus sp. Salsola etc., (*Davis, 1965-1985; 1988; Seçmen, and Leblebici, 1978; 1996; Seçmen et al., 2000).

Since sandy beaches and adjacent low sand dunes are preferably demanded by recreasyonalists and summer house owners for coastal tourism activities, a growing pressure do exist in these areas. As seen in Figure 4C, coastal sand dune material are partly intervened to produce suitable areas for sportive and social activities. In addition, a great amount of dune sands are extracted possibly to obtain building material in or around the area (4D, E).

Figure 4. New residents prograding towards the delta plain in the east (A), summer houses in the south (B), campings in municipal beach (C), sand extraction from sand dunes (D-E), and coastal retreat in the southernmost part of the delta (F).

An intensive coastal pollution and degradational changes occur along the coastline due particularly to pressure driven by coastal tourism, residential waste, unconsciously use of medicine and fertilizers on farming lands. Abundant existence of several alg species living in polluted environments (Güven and Öztürk, 2005), such as *Ulva lactuca, Enteromorpha sp., Cladophora sp. Cystoseira barbata, Halopteris sp. Colpomenia sp., Callithamnion sp.,Polysiphonia variegata, Nemalione sp. Lomentaria sp.*

(Güven and Öztığ, 1971; Aysel and Güner, 1982; Coppejans, E., 1983) can be suggested as an explicit evidence for land-based pollution along the coastline.

Coastline change

Using aerial photos of 1962 and 1997, and ASTER satellite image of 2005, changes in the position of coastline over the past 43 years were determined. Human involvement and natural longshore dynamics were both found to be responsible for changes in coastline position (Figure 4F).

The maximum progradation with an amount of 91.4 m is related to the accumulation of filling material to construct the Kepez harbour to the north (Figure 5).

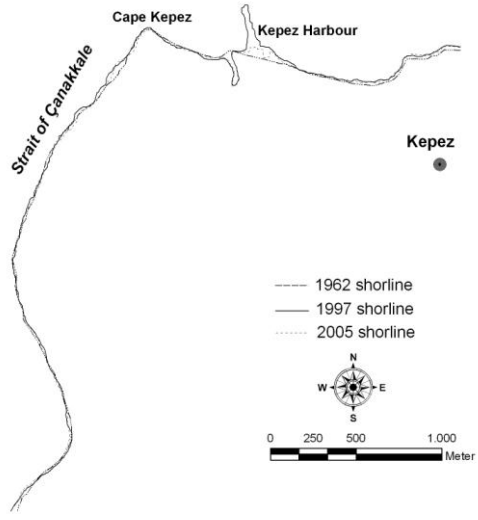

Figure 5. Coastline changes along Kepez delta coasts.

Another prograding part (about 42.1 m) of the coast is located at the 350 m southwest of Cape Kepez possibly associated with decrease of velocity of longshore current. The maximum coastal retreat of 204.2 m occurs in mouth of the Kepez Creek resulted from extraction of accumulated material in this part. Another coastal retreat (about 18.6 m) takes place at approximately 80 m west of mouth of the Kepez Creek and near the Dardanos area. Considerable changes were also determined in length of coastline during the same period. Our calculations point out that length of coastline was 5.3 km, 5.8 m and 6.2 m in 1962, 1997 and 2005, respectively.

Conclusion

On the basis of aerial photograph and satellite image interpretations and GPS measurements, land use features and coastline changes on the Kepez Delta coast was studied for the period between 1962 and 2005. With progress in industry in early 1970's, rapid increase of population of Kepez town from 1935 to 2000 which fits with a growth of 24 times resulted in continual expansion (~23 times) of settlement areas on fertile farming lands. Since the early 1980's, summer houses sprawled in the Dardanos area to the south, which threatens agricultural lands and coastal ecosystem on a large scale. Presently, marine and land-based beach litter on the Kepez delta coast suggests that delta has been excessively polluted by human interference. The predominant pressure by human activities appears to be on coastal sand dunes that occur limited areas. It is frequently encountered that dune materials are either partly deformed or wholly removed for different purposes, resulting in degeneration of restricted coastal plant ecosystem.

Coastline changes observed on different parts of the delta are associated with both natural morphodynamic processes along the coastal zone and human involvement in the past 43 years. Seaward progradation (sediment accumulation) of about 40 m and coastal retreat (marine erosion) of 20 m in separate parts of the coast were determined. The total length of the coastline also shows an increase of 110 m related to accumulation of sediment load by combining effects of Kepez Creek and longshore currents acting from the north to the south. Thus, coastline growth of 20 sq km in total area of the delta was determined in this period.

Özet

Bu çalışma, hava fotoğrafları ve uydu görüntüleri temel alınarak, 1962-2005 yılları arasındaki periyotta, Kepez Deltasındaki arazi kullanım özellikleri ve kıyı çizgisi değişimlerini ortaya koymaktadır. Kepez kasabasının nüfusu, 1935-2000 yılları arasında hızlı bir artışla 24 kat büyümüş, bunun sonucunda yerleşim alanları da verimli tarım arazileri üzerine doğru (yaklaşık 23 kat) genişlemiştir. Tarım alanlarını ve kıyı ekosistemini büyük ölçüde tehdit eden ikincil konutlar ise, sahanın güneyindeki Dardanos mevkiinde, 1980'li yıllardan itibaren yayılış göstermektedir.

Son 43 yıl içinde, kıyı zonundaki doğal morfodinamik süreçler ve beşeri etkenlerin etkisiyle kıyı çizgisi değişimleri meydana gelmiştir. Bu değişimler kıyının farklı kesimlerinde, yaklaşık 40 m'lik progradasyon (sediman birikimi) ve 20 m'lik kıyı gerilemesi (kıyı erozyonu) ile karakterize edilmektedir.

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References

Akkaya, S. (2004). Plansız Yapılaşmanın Mersin Kenti Üzerine Etkileri. Türkiyenin Kıyı ve Deniz Alanları V. Ulusal Konferansı (Ed. E. Özhan), Türkiye Kıyıları 04 Konferansı Bildiriler Kitabı. Cilt 1: 323-331, Adana.

Akova, S. (1997). Bir Kıyı Kasabası, Kocahasanlı'da Arazi Kullanımındaki Değişim. Türkiye Kıyı ve Deniz Alanları I. Ulusal Konferansı, Türkiye Kıyıları 97 Konferansı Bildiriler Kitabı (Ed. E. Özhan). Ankara., pp: 243-254.

Aysel, V., Güner, H. (1982). Ege ve Marmara Denizindeki Alg Toplulukları Üzerinde Kalitatif ve Kantitatif Çalışmalar. 6. Laurencia obtusa (Huds.) Lam. Var. obtusa (Rhodomelaceae, Ceramiales, Rhodophyta) Topluluğu, Doğa Bilim Dergisi. Temel Birimler 6: 97-103.

Coppejans, E. (1983). Iconographie d'Algues Mediterraneenes (Chlorophyta, Phaeophyta, Rhodophyta). Bibliotheca Phycologica Herausgegeben von J. Cramer Band 63.

Davis P.H. (1965-1985). Flora of Turkey and the East Aegean Islands. Vol. 1-9. Edinburgh: Edinburgh Univ. Press.

Davis PH et al. (1988). Flora of Turkey and the East Aegean Islands (Supplement). Vol. 10. Edinburgh: Edinburgh Univ. Press.

Doğan, E., Erginöz, M.A. (1997). Türkiye'de Kıyı Alanları Yönetimi ve Yapılaşması. Arion Kitabevi, p: 186, İstanbul.

Döös, B.R. (2002). Population Growth and Loss of Arable Land. *Global Environmental Change*12 : 303-311.

Erginal, A.E., Özcan, H., Öztürk, M.Z. (2006). Monitoring shoreline changes of the Kavak Delta (Saros Gulf-Nw Turkey) using GIS and RS. 2nd Göttingen GIS & Remote Sensing Days. Global Change Issues in Developing and Emerging Countries, 4-6 October 2006, Georg-August-University Göttingen, Book of Abstracts, pp: 24.

Gazioğlu, C., Yücel, Z.Y., Burak, S., Okuş, E., Alpar, B. (1997). Coastline changes and inadequate management between Kilyos and Karaburun shoreline. *Turkish J. Mar. Sci.* 3 : 111-122.

Güven, K.C., Öztığ, F. (1971). Über die marinen Algen an den Küsten der Türkei. Bot. Marina 14: 121-128.

Güven, K.C., Öztürk, B. (2005). Deniz Kirliliği, Temel Kirleticiler ve Analiz Yöntemleri. Türk Deniz Araştırmaları Vakfı Yay. No: 21, İstanbul.

Özbek, H., Dinç, U. (1984). Çukurova'da Verimli Toprakların Tarım Dışı Amaçlarda Kullanılmasının Sorunları. Tarım Topraklarının Amaç Dışı Kullanılmasının Önlenmesi Semineri,T.C. Başbakanlık Çevre Müsteşarlığı, Ankara.

Seçmen, Ö., Leblebici, E. (1978). Gökçeada ve Bozcaada Adalarının Vejetasyon ve Florası. Bitki 5 (2).

Seçmen, Ö., Leblebici, E. (1996). Türkiye Sulak Alan Bitkileri ve Bitki Örtüsü. Ege Üniversitesi Fen Fakültesi Yayınları No: 158.

Seçmen, Ö., Gemici, Y., Görk, G., Bekat, L., Leblebici, E. (2000). Tohumlu Bitkiler Sistematiği (Ders Kitabı). Ege Üniversitesi Fen Fakültesi Kitaplar Serisi No: 116.

Szmytkiewicz, M., Biegowski J.X., Kaczmarek L.M., Okroj T., Ostrowski R.X., Pruszak Z., Rozynsky G., Skaja M. (2000). Coastline changes nearby harbour structures: comparative analysis of one-line models versus field data. *Coastal Engineering* 40: 119-139.

Tanoğlu, A. (1964). Soil in Turkey. *Review of the Geog. Inst. of the Univ. of Istanbul*. 9-10: 38-57.

Yüksek,Ö., Önsoy, H., Birben., A.R., Özölçer, İ.H. (1995). Coastal erosion in Eastern Black Sea Region, Turkey, *Coastal Engineering* 26: 225-239.

Çetin, H., Bal, Y., Demirkol, C. (1999). Engineering and environmental effects of coastline changes in Turkey, northeastern Mediterranean. Environmental and Engineering Geoscience 5: 315-330.

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