THE USE OF MULTI-TEMPORAL AND MULTISPECTRAL LANDSAT DATA TO DETERMINE CHANGE DETECTION AROUND TUZ LAKE ON SEYHAN DELTA

Recep Efe [1] and Sermin Tagil [1]

[1]Departmen of Geography,
Faculty of Art and Sciences,
Balikesir University,
10145, Balikesir, Turkey

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SUMMARY

The Tuz Lake, Seyhan River mouth and related coastal area have been subject to important changes in the years 1972 and 2000. Three LANDSAT multispectral scanners (MSS), Thematic Mapper (TM) and enhanced Thematic Mapper (ETM), images, captured in 1972, 1987 and 2000 respectively, were used in this study. To delineate the interchange zone, land and water area, an unsupervised classification technique- ISODATA was applied. It was observed that there were important changes in the area of Lake Tuz, Seyhan river mouth, shoreline, coastal sand dunes, pastures, vegetation, barren land, swamps and agricultural areas. Landuse changes because of the intensifying agricultural activities. Two dams which were built on the river Seyhan and the coastal sea currents are the most important factors of this change. The changes involved concerning accretion and erosion processes which possibly impact directly with human alteration. Most of the changes occurred in the result of the transformation of different terrains such as pasture, sand dunes, bare lands, swamp, shrublands to agricultural areas.

Keywords: *Lake Tuz, land use, land use change, Seyhan Delta, shoreline, satellite images, change, detection*

INTRODUCTION

River mouth and coastal areas are special environments where water and land meet. Variation in inputs cause changes in the physical environment, for example, an increase in coastal currents may enhance coastal erosion, or a decrease in water discharge may limit the accretion [1].

Coastal sand dunes which have an extremely sensitive ecosystem create habitats for plants and animals. Coastal dunes are fragile systems where human activities destroy the vegetation and this results in the deterioration of the dune. Several simulation models of land use change [2-3] and management of coastal zone areas [4] were elaborated.

Turkey has the largest coastal sand dunes within the European countries with a total area of 290.000 da. However, 216.500 da of these sand dunes are along the Mediterranean coasts and 96.400 da of them is in the Adana province [5]. The best developed sand dunes occur in the Cukurova delta, where the rivers Seyhan and Ceyhan flow into the Mediterranean Sea. However, sand dunes located on the west of Cukurova between Seyhan River mouth and Tuz Lake have been subject to changes in last 20 years. The first studies about the deltas and their sediments in the Cukurova delta have been conducted by Erinc [6] in (1953).

Remote sensing (RS) and Geographical Information Systems (GIS) provide a means for locating, identifying and mapping certain coastal features and assessing of spatio-temporal changes and their environmental impact. A number of techniques have been reported in the literature for the derivation of the coastline management from satellite images [7-9].

The objective of this study is to detect the effect of humans on the biological and physical characteristics of a coastal area, and to determine changes of the shore line around Tuz lake and the Seyhan river mouth using Landsat imageries (MSS, TM and +ETM) from 1972 to 2000.

DESCRIPTION OF THE STUDY AREA

The study area is located nearly $34^{o}53'$-$35^{o}08'$ east and $36^{o}39'$-$36^{o}48'$ north coordinates between Seyhan delta and Tuz Lake, on the south of Turkey (Figure 1). The study area is approximately 228 km^2 and consists of various ecosystems such as lakes, lagoons, abandoned meanders, sand dunes, marshes. The area has various microenvironments, partly reflecting its, geomorphological, pedological, hydrological and bio-geographical diversity. Landforms largely consist of a series of sand dunes, abandoned meanders and river beds, alluvium plains which are suitable for either cultivation or habitation.

According to the data obtained from Adana meteorological station, mean annual temperature is 18.8 ºC. The coldest month is January and the mean temperature is 9.9 ºC. In summer months which are characterizing hot period, the mean temperature is 28.1 ºC in August. Annual average rainfall is 647.1 millimeters and the 50 % of precipitation occurs in winter which is parallel to the Mediterranean macroclimate character. The dominant wind direction is northerly in winter and southeasterly in summer and the mean wind speed is 2.2 m/sec. Although winds from the south-southwest dominate, other directions are observed with significant frequency. Winds shift direction in the year, but direction is much more variable during winter.

According to Thornthwaite [10] , the study area was classified as C2b2 s2b3, which is semihumid, second - degree mesothermal, under oceanic climate effect and has a strong water deficit during summer. According to Kocman [11] semi-humid Mediterranean climate prevails in the area.

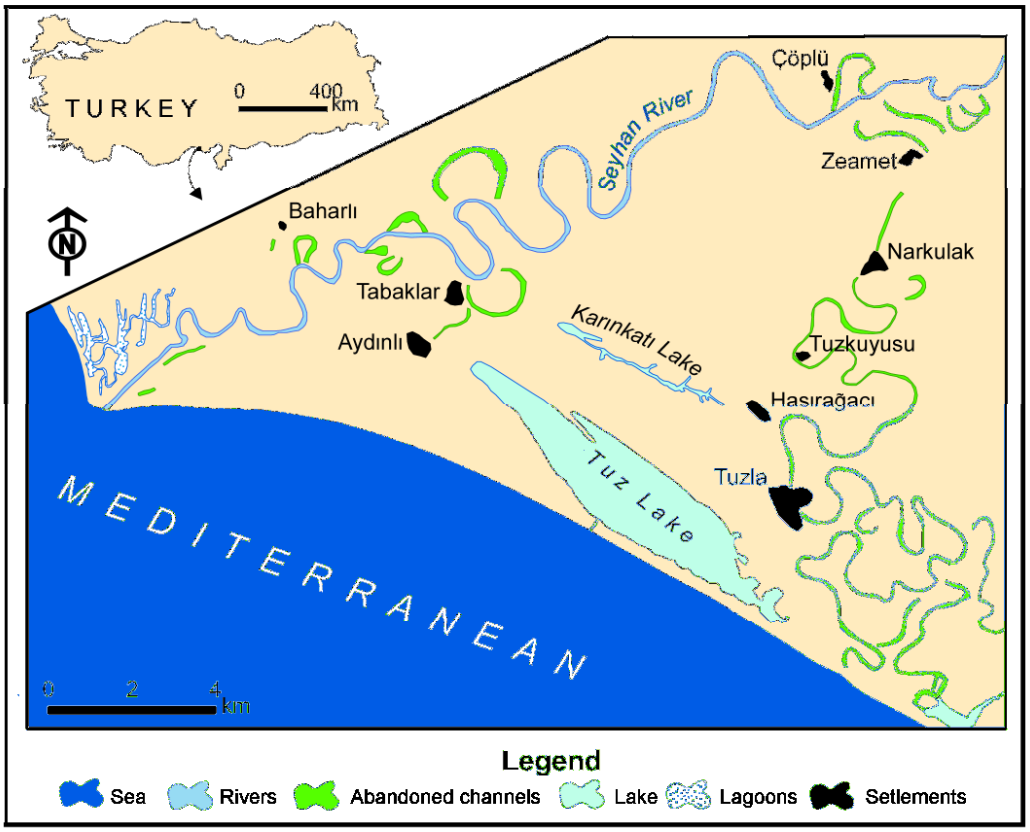

Figure 1: Location of the study area

Psammophitic, hydrophitic and halophytic plants and maquis species occur in the area which precludes the destruction of sand dunes. Vegetation has become sparse due to destruction of sand dunes which were covered with dense vegetation of shrub formations. *Cionura erecta*, which is a sign of extreme grazing occur on sand dunes which was exposed to destruction of vegetation. *Arthrocnemum fruticosum*, which naturally grows in salty swamps had been disappeared due to in deterioration of dunes. Nevertheless, lots of maquis species were destroyed in the area. For example, *Nerium oleander* is only seen in a limited area located on the west of Tuz Lake. *Nerium oleander* had been completely disappeared due to destruction in sand dunes on the north of Tuz Lake. Hydrophyte plants such as *Vitex agnus-castus, Juncus maritimus* are only seen around wetlands especially isolated areas in the west part of Tuz Lake.

Study area is also rich for the fauna and many of bird species live in and around the Delta area. *Larus fuscus, Larus cachinnans, Gelochelidon, nilotica, Sterna caspia, Sterna albifrons, Haematopus ostralegus, Charadrius hiaticula, Pluvialis squatarola, Arenaria interpres* are some species found in the study area. Coastal sand dunes are areas for breeding of sea turtles. *Caretta caretta, Chelonia mydas, Trionyx triunguis* lay eggs in April and May on the coastal sand dunes around Tuz lake.

The soils are generally entisols and inceptisols (taxonomy classification) and coarser textured and shallower. Sandy soils are found around Tuz lake between River Seyhan and Tuzla. Hygromorphic soils, which are flooded in winter and rich for organic matters, are common. Agriculture is carried out on the highly fertile inceptisols which have been developed on the alluviums. Irrigable agriculture is carried out in and around the abandoned bed of River Seyhan and lands located in the north of Karınkatı lake. Most people in the area engaged in agricultural activities and animal breeding. The remainder of the area is used for grazing with large numbers of cattle, sheep and goats being herded on the area, which is almost completely denuded of grass and with very little cover.

The most important residential area is Tuzla which summer and winter populations vary due to tourism activities. There are temporary settlements on the coastal area such as Altinkum Beach, Dalyan. Tuzkuyusu, Hasiragaci on the north and Tabaklar which are very close to the sand dunes.

MATERIAL AND METHODS

Multi-date satellite images from Landsat sensor were used to detect the changes of the northwestern of Seyhan Delta. Since the landscape is a result of the advance and retreat of shoreline in historical times, the present study is largely based on the analysis of recent multi-dates satellite images covering the years 1972, 1987 and 2000.

Digital image processing

Three satellite images from Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic Mapper Plus (ETM+), images taken in 1972, 1987 and 2000 were used in this study. All operations had been done by using tools of ERDAS IMAGINE Version 8.5. All images were geometrically corrected using a third order polynomial method was applied. More than 20 ground control points-GCPs (e.g., intersections of dykes, rivers and/or roads) were selected from the rectified topographical map. The calculated RMS error was acceptable. After all images were edge matched by a same spatial location and projection, there were masks or subset according to area of interest in this study. The process generates a same size of area and boundary position (Upper Left Conner and Lower Right Conner) to all images.

Unsupervised Classification

To delineate the interchange zone, land and water area, an unsupervised classification technique- ISODATA was applied [12-14]. The ISODATA algorithm is a modification of the k-means clustering algorithm, which includes merging clusters if their separation distance in multi-spectral feature space is below a user-specified threshold [15].

Postclassification operations

After classification the subclasses were merged and recoded to nine main classes. These classes are sea, river, lake and lagoons, agriculture, natural grassland, sparsely vegetated area, bare exposed soil and rocks, beaches, and marshy areas. In the result of classification, there were a lot of isolated pixels whose classification is different from that of their neighbors. These pixels create "a noise" for following interpretation of features in the resultant map composition. Therefore, these pixels were eliminated by using a 5×5-pixel majority filter built by the Model Maker of ERDAS IMAGINE. The filtering process smoothes the raster data and the resulting image is easier to read.

Accuracy assessment

In this case, to assess the accuracy of classification, 10 random points for each class of interest (only deposits) were generated on the resultant map composition and compare to visual inspection, comparison with existing database like 1: 25,000 scale topographic maps, land cover maps provided by the General Directorate of Rural Services and field studies. The classification accuracy of searching landuse landcover classes were more than 70%.

Shoreline Change Determination

GIS capability has been used to determine the changes of shoreline of the Lake Tuz and the delta which occur in the classified images. The boundaries created from unsupervised classification and IHS color composite were delineated through on-screen digitizing. Digitizing errors will always occur (undershoots, overshoots, triangles). However, on- screen digitizing is more accurate then using digitizing table and usually, according to Geographical Information System (GIS) and Remote Sensing software [16]. After digitizing process, the vector format was transferred to raster format. Through spatial analysis, the shape of the river mouth and sandy area (in hectare) were successfully detected and calculated. The changes of the Seyhan river mouth and the related shoreline from 1972 to 2000 were determined.

RESULTS

The changes of morphology at Seyhan river mouth and Tuz Lake between 1972 and 2000 were detected in this study by using RS and GIS. Not only shoreline change but also landuse-landcover change has been examined.

The most important change is seen in natural grasslands around Lake Tuz and close vicinity (Table 1, Figure 2). The area of natural pastures in 1972 decreased from 25% to 1% in 15 years and increased 2% in 2000. These natural pastures had been decreased almost completely in time. It is found that there is a major decrease of bare lands, beaches and marshlands and natural pastures. In contrast, a significant increase of agricultural areas was determined. Agricultural areas which did

not exist in 1972 have increased up to 44% in 28 years. This shows that not only pastures, but also scrublands and even bare lands and sand dunes are used for agricultural activities.

Table 1. Percentage of landuse-landcover classes

Area (%)	Years		
	1972	**1987**	**2000**
Sea	34	34	34
River	1	3	3
Lake And Lagoons	3	3	3
Agriculture	-	36	44
Natural Grassland	25	1	2
Sparsely Vegetated Area	25	14	9
Bare Exposed	5	6	2
Beaches	5	2	2
Marshy Places	2	1	0

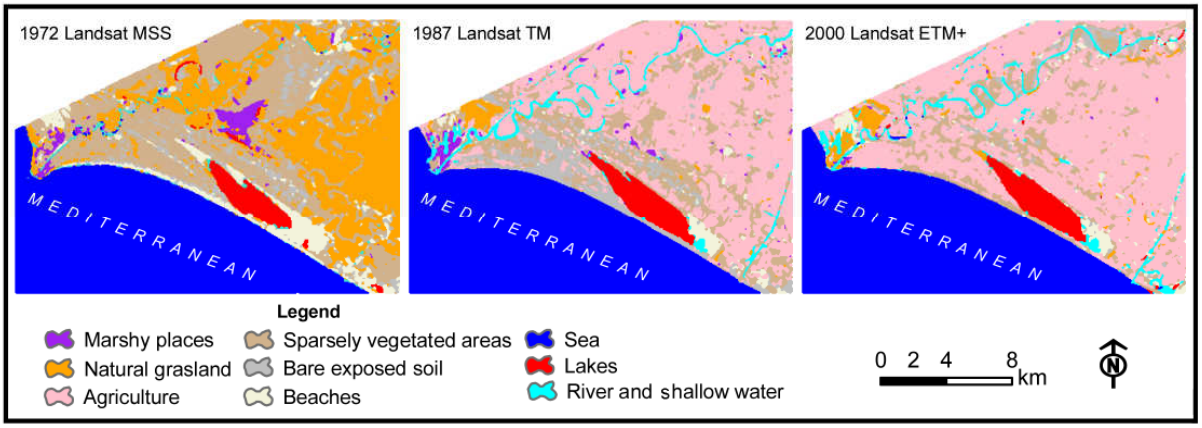

Figure 2. Landuse – landcover classes from satellite images covering the years 1972, 1987 and 2000.

This extreme human pressure on the delta area has caused important changes on the coastal area around Tuz Lake. The surface area of Tuz Lake reduced to 8 square kilometers from 14 km^2 in 1972. It was determined that, rehabilitation practices were performed in the lake in the following years. As the result of this rehabilitation and drainage changes, the surface area of the lake has reached to 10.7 km^2 in 1987 and 10.4 km^2 in 2000. Shortly, the surface area of the lake hasn't changed much in 1987 – 2000 (Table 2, Figure 3). Field studies and image evaluation methods confirmed the conclusion that the overuse of the area has caused the narrowing of the lake surface. In the satellite image taken in 1972, while a swamp area considered as the former bed of Lake Karınkatı is clearly seen, agricultural areas shifted to the swamp areas and swamps shifted to the Lake Karınkatı (Figure 2).

Table 2. Shoreline changes of the Lake Tuz in periods 1975-1987, 1987-2000 and 1975-2000 (ha).

Changing	Old lake bad-1972	1972-1987	1987-2000	1972-2000	Old lake-2000
Always lake	784	781	1032	779	1032
Lake to land	617	3	37	5	370
Land to lake	-	288	10	263	10

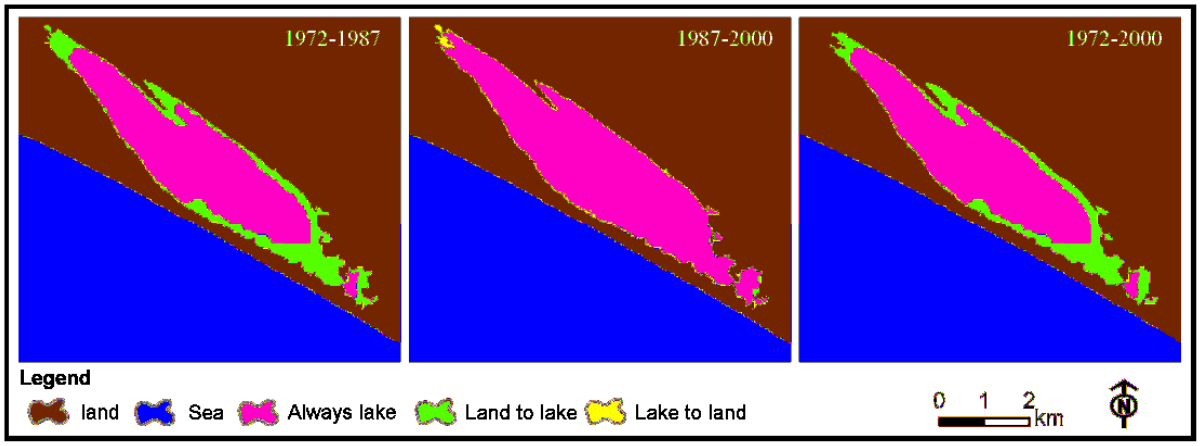

Figure 3. Shoreline delineation and change detection occurred from 1972 to 2002

Distinct changes have been determined on the coasts of delta where such landform changes occur. Change in the mouth of Seyhan River has been examined. According to this, it is found that there was a retreatment of 408 meters in 1972 – 1987, 359 m in 1987 – 2000 and 624 m in 1972 – 2000 in average (Figure 4). At the same time periods, maximum changes in the river mouth were ~486m, ~361m and ~823 m respectively. Changes of the area at the river mouth are related to retention of the water in two dams on the Seyhan River. As the result of this erosion, coast line retreated and an area of 94 ha has become sea while it was land, between 1972 – 1987 (Table 3; Figure 4). Erosion and advance of sea to the land had continued while it slowed down in 1987 – 2000.

Table 3. Change detection area occurred at the shoreline (ha).

Change detection	1972-1987	1987-2000	1972- 2000
Always sea	11561	11639	11575
Always land	22674	22762	22622
Erosion	94	82	145
Accretion	170	16	156

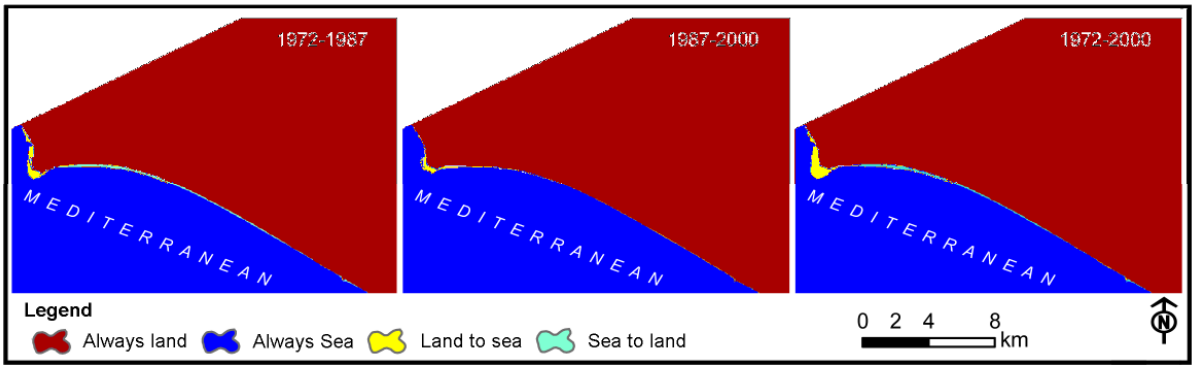

Figure 4. River mouth delineation and change detection occurred from 1972 to 2000

DISCUSSION AND CONCLUSION

The results indicate that landuse and landcover have undergone huge changes due to human activities allover the Seyhan delta zone. However, loss of sand dune and degradation continue rapidly, largely due to the escalating human activities and the associated conversion of natural habitats for human uses. The value that is placed on natural resources by local communities living in and around Seyhan delta and Tuz Lake is based upon the immediate benefit they derive in terms of income and livelihood. But this evaluation tends to be viewed from a short-term perspective with no thought being given to what will happen once the natural resources have been depleted. The local people are aware of the value and functions of the sand dunes, lagoons, wetlands, as well as the dangers of over-exploitation. The sand dunes are in the process of being irreversibly destroyed usually as a consequence of the unsustainable use by local people, demographic changes, increases in demand for agricultural land, for pasture. Agricultural activities are important pressure factor for the decrease of marshlands, swamps and pastures in the area. The presence of agricultural based economy and land reclamation in the region are the most important reasons of this unsustainable land use. Researches on sand dunes conducted in different locations in the Mediterranean coast have concluded with similar results [17-20]. Similar results were presented by Uslu and Bal (1993) for different periods (1947-1992). They determined that the length of the coastal dunes of Seyhan delta has been declined, the widest belt of coastal dunes moved backward, the area of the coastal dunes have been decreased, and during 45 years period, 25,1% of coastal dunes have been converted to the agricultural fields, orchards and greenhouses [21].

Coastal sand dunes which occur in the study area are losing their naturalness due to human pressure, misuse and unsustainable of land. Rapid growth of population and increasing agricultural activities in the research area has caused the rise of pressure over the natural areas in the Seyhan delta between Tuz lake and river mouth. Agricultural activities in sand dunes have accelerated by this effect. Agricultural areas are expanded by flatting the sand dunes.

Vegetables are grown very extensively to harvest in early spring on the coastal dunes in the area. Increase in mechanization has resulted in transforming the sand dunes rapidly to agricultural areas after 80's. Today, cereals, mostly peanuts and early vegetables and fruits are widely grown in the area (Photo 1). Wheat agriculture is preferred some years because of ability to grow above-average yields per acre for less cost. Secondary crops are grown for higher yield on sand dunes in research area. Field researches show that a peanut is grown after harvesting the wheat and water melon.

Photo 1. Peanuts and early vegetables and fruits (strawberry, melon, and watermelon) are widely grown in the area on the sandy soils which were formed by flattening of sand dunes.

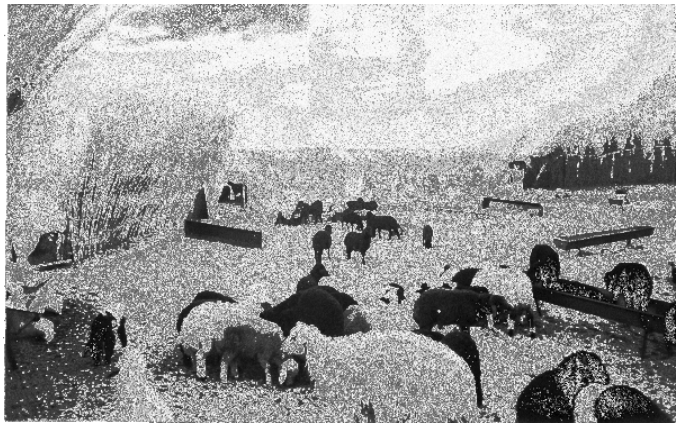

Photo 2. Stockbreeding activities are carried out in the decreasing number of pastures around coastal and inland sand dunes but as not efficient as agriculture.

Any form of deterioration of the natural potential of land that affects ecosystem integrity either in terms of reducing its sustainable ecological productivity or in terms of its native biological richness and maintenance of resilience. Agricultural activities that cause land degradation include shifting cultivation without adequate fallow periods, absence of soil conservation measures, and cultivation of fragile lands such as sand dunes in the study area. Population pressure also operates through other mechanisms.

Too many people with trying to raise too many animals lead to overgrazing. This removes grass cover and vegetation on the sand dunes and leads to high rates of wind and water erosion on

sand dunes around Tuz Lake. Overgrazing is made worse by the conversion of traditional rangelands to crop lands. Stockbreeding activities are carried out in the decreasing number of pastures around sand dunes and coastal dunes but as not efficient as agriculture (Photo 2).

Major land use on inland dunes and coastal dunes are mentioned below according to the results of field researches and analysis of satellite images: Reclamation of sand dunes for agriculture purpose and transformation of coastal and inland sand dunes to agricultural areas by stakeholders (1), Utilization as inert materials for constructions (2), transportation of sands to the yards of houses (3), usage as seedling medium (4), laying out sand over infertile fields for betterment (5), laying out over the roads (6), spreading out in barns (7), spreading out on the surface of greenhouses (8), spreading for the seedlings vegetable fields (9) and usage as filling material on sideway parquets(10).

Coastal currents and winds are the main factors that caused the significant changes like land accretion and erosion have been observed between 1972 and 2000 on the delta shoreline. Human interference with sediment supply also affected the coastline change. Seyhan and Catalan dams which were built on Seyhan River have blocked the materials brought by the river to the coast. Sediments on the mouth of the river were carried to the south east of the delta by the coastal sea currents and wind. In other words, due to arrival of little materials, the sand on the coast was transported to the south east by dominant north westerly winds. Also, short cut channels made for irrigation and drainage affected the nature of delta. Similar result observed in the Ceyhan delta which is situated on the east of Seyhan [22]. Man-made short-cut channel caused to stop the natural development on Ceyhan delta. Coastal erosion has been dominant and the eastern half of the former delta undergone a strong coastal erosion and destruction [22].

Overall, based on results from the various analyses and discussions that have been made, some conclusions can be drawn from this study. These are:

1. The results reported here highlight the disappearance of coastal sand dunes which are important habitats for both flora and fauna on the Seyhan Delta.
2. Converting Landsat imagery from the RBG to the IHS imagery is useful for detecting shoreline and sandy area.
3. Landsat imagery can be used for coastal changes detection analysis and the accuracy could be increased by using high spatial resolution imagery.
4. Integration of remote sensing and GIS on coastal analysis improve the quality of the information attain.
5. Stability of the Seyhan river mouth and the Tuz lake is not consistent, the sedimentation processes need to be monitored, especially for managing purposes.

REFERENCES

[1] HASLETT, S.K. (2000) Coastal Systems, Taylor & Francis Group. 218p.

[2] VELDKAMP, A. AND FRESCO, L.O. (1996) CLUE: A Conceptual Model to Study the Conversion of Land Use and Its Effects. Ecological Modeling, 85, 253-270.

[3] ENGELEN, G., WHITE, R. AND DE NIJS, T. (2003) Environment Explorer: Spatial Support System for the Integrated Assessment of Socio-Economic and Environmental Policies in the Netherlands. Integrated Assessment, 4, 97-105.

[4] DE KOK, J., ENGELEN, G., WHITE, R. AND WIND. H.G. (2001) Modeling land-use change in a decision-support system for coastal-zone management. Environmental Modeling and Assessment, 6, 123-132.

[5] USLU, T. (1989) Geographical Information on Turkish Coastal Dunes. European Union for Dune conservation and Coastal management publ. 60 pp. Leiden.

[6] ERINC, S. (1953) Alluvial morphology of Cukurova. Journal of Geographical Institute (University of Istanbul), 3-4, 149-159.

[7] SMITH, L.C. (1997) Satellite remote sensing of river inundation area, stage, and discharge: a review. Hydrological Processes, 11, 1409-1413.

[8] FRAZIER, P.S. AND PAGE, K.J. (2000) Water body detection and delineation with landsat TM data. Photogrammetric Engineering and Remote Sensing, 66 (12), 1467-1467.

[9] RYU, J., WON J. AND MIN, K. D. (2002) Waterline extraction from landsat TM data in a tidal flat. A case study in Gomso bay, Korea. Technical Report Series Department of Geography and Antropology Lousiana State University, 83, 442-456.

[10] THORNTHWAITE, C. W. (1948) An approach toward a rational classification of climate. Geographic Review 38, 55-94.

[11] KOCMAN, A. (1993) Climate of Turkey. Ege University Publications 72, Izmir.

[12] ERDAS, (2003) ERDAS Field Guide, Atlanta: Leica GeoSystems, 672p.

[13] REES, W.G., WILLIAMS, M. AND VITEBSKY, O. (2003) Mapping Land Cover Change in a Reindeer Herding Area of the Russian Arctic Using Landsat TM and ETM+ Imagery and Indigenous Knowledge. Remote Sensing of Environment, 85, 441-452.

[14] STOW, D., COULTER, L., KAISER, J., HOPE, A., SERVICE, D., SCHUTTE, K. AND WALTERS, A. (2003) Irrigated vegetating assessments for urban environments. Photogrammetric Engineering and Remote Sensing, 69(4), 381-390.

[15] SCHOWENGERDT, R.A. (1997) Remote Sensing: Models and Methods for Image Processing (2nd edition), Academic Press, San Diego, California.

[16] ZAKARIYA, R., ROSNAN, Y., SAIDIN, S.A. YAHAYA, M.H., KASAWANI, I. AND LOKMAN, H. (2006) Shoreline detection and changes for Terengganu river mouth from

satellite imagery (Landsat 5 and Landsat 7), Journal of Sustainability Science and Management, 1(1), 47-57.

[17] TSOAR, H. (1990) Trends in the development of sand dunes along the Southestern Mediterranean coasts. In: BAKKER, TH.W., JUNGERIUS, P.D. and KLIJN, J.A. (Eds.), Dunes of the European Coasts, Catena Supplement No. 18. Catena Verlag, Cremlingen, 51-61.

[18] KUTIEL, P. AND GEFFEN E. (1999) Coastal dune ecosystems: management for conservation objective: I. The impact of woody vegetation removal on annual plants. Journal of Mediterranean Ecology, 1, 101-108.

[19] DOYGUN, H., BERBEROGLU, S. AND ALPHAN, H. (2003) The Determination of Land Use Changes By Using Remote Sensing in Burnaz Coastal Dunes, Hatay. Ekoloji, 12 (48), 4-9.

[20] KUTIEL, P., COHEN, O., SHOSHANY, M. AND SHUB, M. (2004) Vegetation establishment on the southern Israeli coastal sand dunes between the years 1965 and 1999. Landscape and Urban Planning 67 (1-4), 141-156.

[21] USLU, T. AND BAL, Y. **(**1993) Coastal dune management of Seyhan delta. In : OZHAN, E. (Eds.). Proceeding of the First International Conference on the Mediterranean Coastal Environment, MEDCOAST 93: Vol. 1, 199-216. Antalya.

[22] EROL, O. (2003) Geomorphological evolution of the Ceyhan River Delta, Easter Mediterranean coast of Turkey. Aegean Geographical Journal, 12 (2), 59-81.