© 2012 Triveni Enterprises
Vikas Nagar, Lucknow, INDIA
editor@jeb.co.in
Full paper available on: www.jeb.co.in

J. Environ. Biol.
33, 487-492 (2012)
ISSN: 0254-8704
CODEN: JEBIDP

Investigation of Lagoon lakes in Kocacay delta by using remote sensing method

Author Details

Emel Irtem (*Corresponding author*)
Department of Civil Engineering, Balikesir University, Cagis, 10145, Balikesir, Turkey
e-mail: mirtem@balikesir.edu.tr

Yener Sacin
SACIN Construction Project Company, 06460, Ankara, Turkey

Publication Data

Paper received:
25 October 2010

Revised received:
02 July 2011

Accepted:
20 July 2011

Abstract

Coasts are areas that are under the influence of the interaction of the air, water and land and attract attention with the abundance of their natural resources and therefore are subjected to excessive usage. This excessive usage may disturb the sensitive balance of the coast ecosystem. In this study, the changes in Arapçiftligi, Poyraz, Dalyan lakes area found in Kocacay delta located in the south coast of Marmara sea was evaluated between the periods of 2000 to 2007 with remote sensing method. These lakes, located on the shores, have a very sensitive naturally dynamic balance and very importance in terms of natural surroundings and the coastal zones management plan. It must be known the change of the lakes mentioned above area according to years. Research and applications have demonstrated the advantages of remote sensing and geographic information system techiques on river,delta, lake, lagoon lake, sensitivite areas in a lakeshore, coastal erosion *etc.* monitoring and management. In the study, we benefited from Erdas and Intergraph-Geomedia 6.1 image processing and GIS, and also from AutoCAD 2007 and NetCAD 4.0 computer-aided design (CAD) software. For 2000, 2001, 2005 and 2007 years (4 number) Landsat-5 TM satellite images belonging to the region were used. As a result of the study, Arapçiftligi, Dalyan and Poyraz lake areas, number of islets that are seen in the lakes were given in respect to years. Arapçiftligi lake shrank 29.5% in size in the years 2000 and 2007. The fact that the lake continued to get smaller in size even in periods of high precipitation may be due to the sediment flowing from the agricultural fields established close to the lake area. Dalyan and Poyraz lakes lost 60% in terms of their surface area in the years 2000 and 2007. In 2000-2001 periods, Dalyan and Poyraz lakes increased in size by 3.2%. The reason for this could be the excessive precipitation and the fact that the seawater from Marmara sea seeps into the lake. Protection of the natural balance of the lagoons can be possible by using a monitoring programme to be set in connection with a healthy, systematic and manageable data system.

Key words

Lagoon lake, Kocacay delta, Remote sensing, Poyraz lake, Dalyan lake, Arapciftligi lake

Introduction

The coastal areas have become densely populated due to the increase in population, and the activities in the fields of tourism, fishery and industry. Furthermore, the subject matter areas are also affected from storm waves, tsunami, tides and changes in sea levels. The ecological sustainability of these areas carries great importance.

Particularly the lagoons that make up 13% of the world's coastal areas, are special eco-systems which are ecologically very significant. The coastal lagoons are shallow masses of water that are separated from the sea by some kind of barrier while still being linked to it through one or more channels. The coastal lagoons are areas that are left between the continental land, and sea and therefore they are very sensitive to any impact exerted by either sea or land. The lagoons are under the influence of many parameters associated with land and sea as well as being seasonally effected from factors of nature such as fresh water inflows, precipitation, evaporation and wind. The changes caused by such factors, in time, may lead to changes in the lagoon. (Bickici and Balas, 2010).

Research and applications have demonstrated the advantages of remote sensing and geographic information system techiques on river,delta, lake, lagoon lake, sensitivite areas in a lakeshore, coastal erosion etc. monitoring and management (Seker

et al., 2003; Göksel *et al*., 2003; Göksel *et al*., 2004; Seker *et al*., 2005; Maktav *et al*., 1999; Kaya *et al*., 2008; Efe *et al*., 2008).

There are various studies carried out on deltas and lagoon lakes in the world and in our country as well. In the recent years, especially the studies that utilize remote sensing and geographic information system techniques have been observed frequently. Some of these studies are summarized below.

Maktav *et al*. (1994) carried out some lake systems (including rivers, mouths, coasts and wetlands) in Turkey by using remote sensing technology coupled with hydraulic techniques. The water level change in the lakes, discharge capacity and discharge rate of rivers incl. sediment load, hydrodynamic conditions of the coast around the river mouth were investigated by using hydrologic and hydraulic methods.

In the study conducted by Eryigit Urfali (2006) it has been aspired to determine the natural and cultural resource potential of Bakirçay delta and its vicinity by remote sensing technique followed by their classification according Commision of European Environment (CORINE) system. Within the boundaries of the area under study, earth elements on the basis of 5 main groups and 13 segmented series have been determined according to the CORINE classification system. The segmented boundaries of these are determined on the basis of the colour changes on satellite images and in this process pixel reflection data constituted the basis as supplementary data and the study area has been classified based on a reflection element for each class.

Kaya *et al*. (2006) carried out on a river to demonstrate the utility of remote sensing (RS) technology for studying fundamental theoretical properties of turbulent mixtures. They studied Filyos river mouth located on the Black sea coast of Turkey. Flow properties,

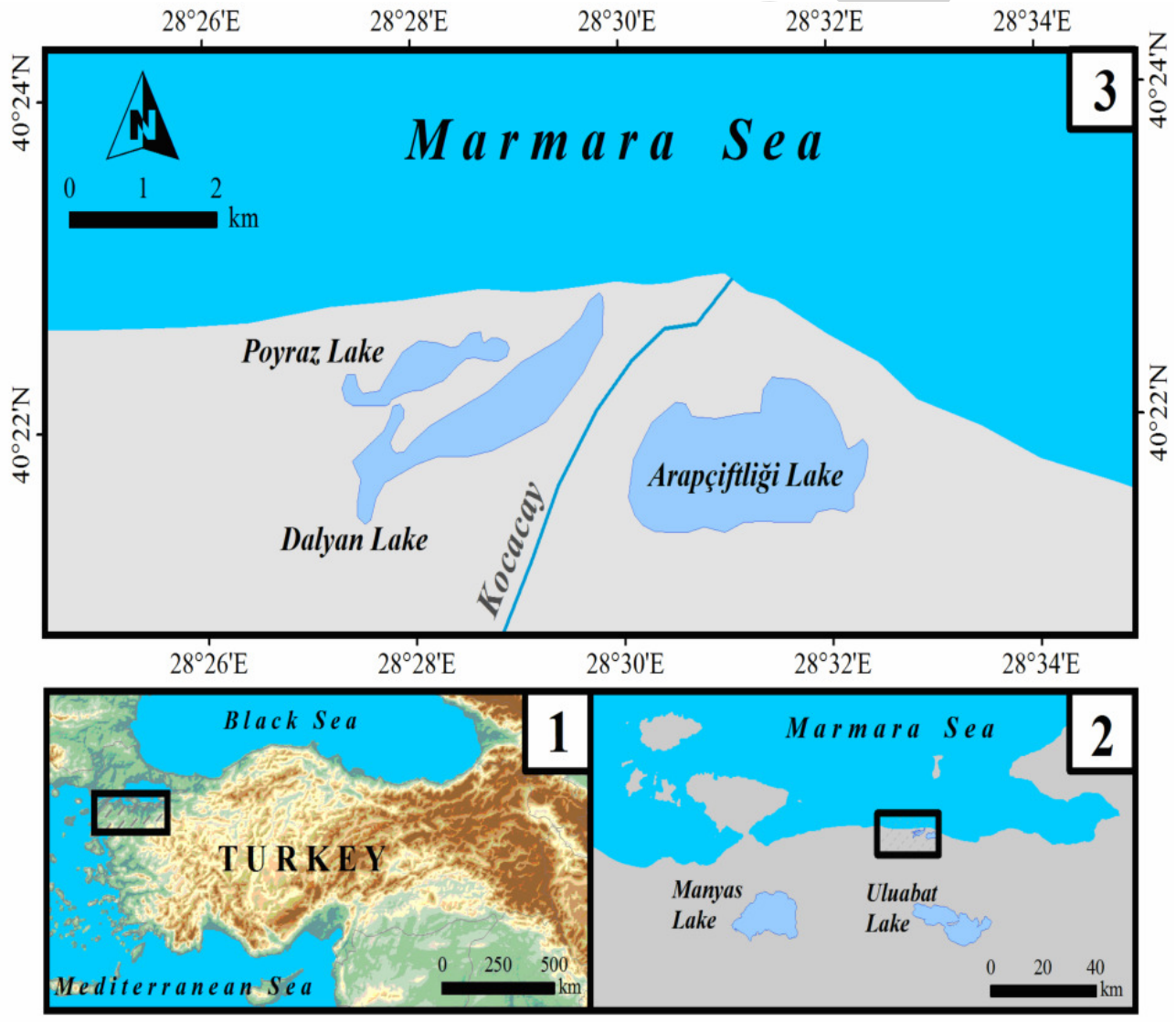

Fig. 1: Location of study area

such as the horizontal dispersion coefficient, have been calculated (using Landsat TM sensor images taken on two different dates). The effects of the plume on the morphology of neighbouring beaches are also examined. The related study shows the utility of RS technology for generating quantitative data and better defining the hydraulic behaviour of a river with high turbidity.

Sertel *et al.* (2008) investigated the spatial and temporal characteristics of the Kizilirmak delta. It is a major wetland complex on the Black sea coast, which has a very rich biodiversity and critical habitat for globally endangered bird species, and was announced as an RAMSAR protection site in Turkey. The obtained results delineated that the Kizilirmak delta has been considerably changed as a result of human activities between 1987 and 2004. Analysis of satellite images and other data sources in the GIS environment introduced the changes in the delta and their impacts on the environment.

In this study, Arapçiftligi, Poyraz, Dalyan lakes were selected as study area, founded in Kocaçay delta located in the south coast of Marmara sea, Turkey. The aim of this study was to identify the area changes of Arapçiftligi, Poyraz,Dalyan Lakes.Because these lakes, located on the shores, have a very sensitive naturally dynamic balance and very importance in terms of natural surroundings and the coastal zones management plan. It must be known the change of the lakes mentioned above area according to years. For this reason, the area of these Lakes were evaluated between the periods of 2000 to 2007 by using remote sensing method. Shrinking values that are seen in the lakes are expressed as percentage values, the reasons were discussed.

Materials and Methods

Study area: Kocacay (or Kocasu) delta was selected as a study area that takes place in the province of Bursa, on the southern shores of Marmara sea, Turkey (Fig. 1). On the western half of the delta, Dalyan and Poyraz lakes with a total area of 194 ha, 600 ha of reed covered fields and 730 ha of forested area can be found. On the east side of the delta there is the Arapciftligi lake (391 ha), as well as agricultural fields, sand dunes, reeds and wide plains of mud.

Kocacay delta is 21 km long. It reaches 3.5 km at its widest part and its geometry is such that it narrows moving from west towards east. Kocasu flows in a narrow channel curled towards right on the delta and as such it divides the delta into two. The channel length of Kocasu on delta is 4.5 km. The part of delta on the west separated by the channel is bigger than the one on the east. On both sides of the river estuary, there are two lagoons with irregular geometries. The location of these two lagoons may alter in time. The places that are elevated to a height of half to one meter on the delta plains take up the most area. (Kazanci *et al.*,1999). Dalyan lake is separated from the sea by means of a sand cordon. During winter months, the sea water seeps into the lake and as such the level of the lake water rises and covers an expanded area. Its elevation from sea level is 2 m at a depth of 75 cm. In spring, the lake water spills into the sea water until a balance is reached. Poyraz lake is located further into the west and extends into the forest. Arapciftligi lake is an alluvium lake by specification. Its maximum depth is 170 cm (average depth 55 cm). The saltiness of this lake that in fact contains brackish water, changes from season to season. The beach of the area is used by the residents for tourism related purposes.

In the study, remote sensing data was used to obtain almost any information that is typically obtained from maps. In many regions of the world landsat data may be the only source of good cartographic information. Drainage basin area and the drainage network are easily obtained from good imagery. In this study, a GIS system has been developed to monitor the changes in the study area. GIS is one of the important tools which provides scientific data integrates spatial and non-spatial information.

There have also been a number of studies to extract quantitative geomorphic information from landsat imagery. Once basic measurements have been taken from the imagery, the usual physiographic descriptors can be calculated such as basin shape, area, etc.We benefited from Erdas and Intergraph-Geomedia 6.1 image processing and GIS, and also from AutoCAD 2007 and NetCAD 4.0 computer-aided design (CAD) software. The satellite images used in the study was provided by Istanbul Technical University, Geomatic Engineering Department.

For the year 2000, 2001, 2005 and 2007 Landsat-5 TM satellite images (infrared band) belonging to the region were used as shown in Table 1.

The data on flows in the years 2000, 2001, 2005 and 2007 recorded at the 317 numbered Akçadere –Susurluk flow observation station has been obtained from General Directorate of Electricity Preliminary Studies Administration (EIE) and the precipitation values belonging to the same years have been obtained from General Directorate of State Hydraulic Works (DSI). Satellite images are given in Fig. 2 according to years.

Results and Discussion

The lake area values and shoreline lengths of Arapciftligi, Dalyan and Poyraz lakes were evaluated by means of remote sensing methods, are provided in Table 2 and 3.

Results related to Arapçiftligi lake:

-- The lake was lost 467374 m² (10.45%) in size between the years 2000 and 2001. In the year 2007, the area of Arapçiftligi lake has become 1326746 m² (29.55%) smaller compared to the year 2000.
-- The shoreline length of Arapçiftligi lake between the years 2000 and 2001 increased by 1436 m (7.2%). The reason for the difference is the increase in the indents as the area of the lake got smaller.
-- In the year 2000 while there were 7 islands in Arapçiftligi lake, where areas changed from 13023 m² to 1943 m², in the year

2001 only a single lake with an area of 6289 m² was observed. A new island in the size of 10580 m² was within the lake boundaries in the year 2000 but separated from it in the year 2001 due to the decrease in lake's size. In the year 2005, there were 3 islands in the lake in possession of the following respective surface areas; 13195, 11872 and 3932 m². It was determined that one of the three was in existence in the years 2000 and 2001, however the other two were formed due to the decrease in the volume of the

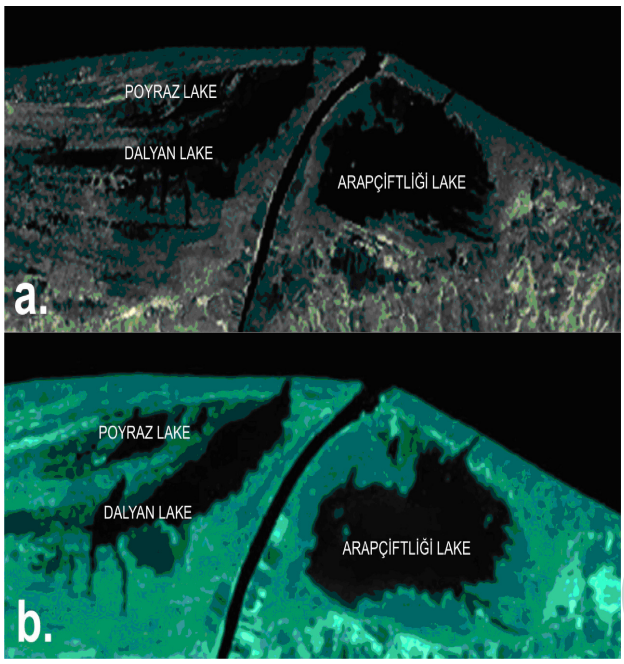

Fig. 2: Comparison of satellite images belonging to Lake Arapciftligi, Lake Dalyan, Lake Poyraz at scale1:125 000 (a) year 2000 (b) year 2007.

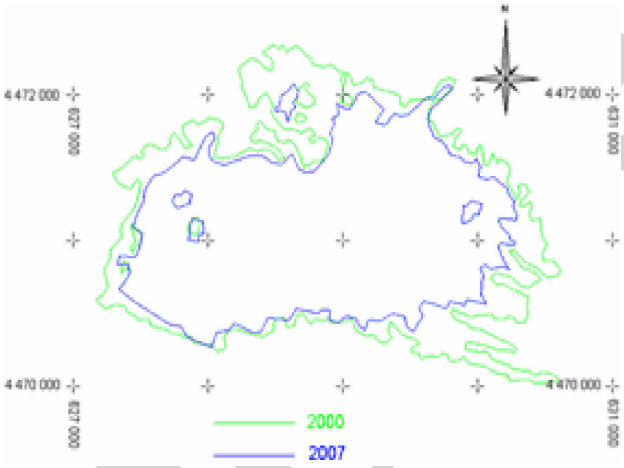

Fig. 3: Comparison of Arapciftligi lake area in 2000 and 2007 years

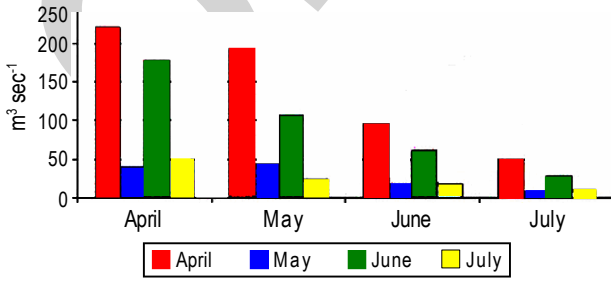

Fig. 4: Changes in flow values on the basis of years and months

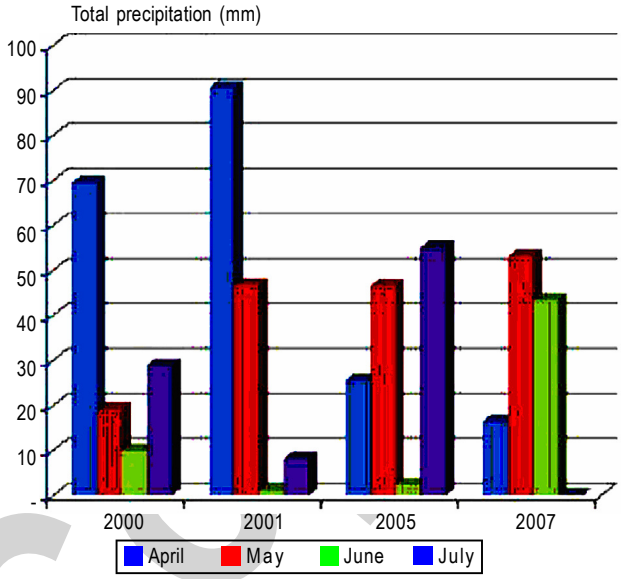

Fig. 5: Changes in precipitation values on the basis of years and months

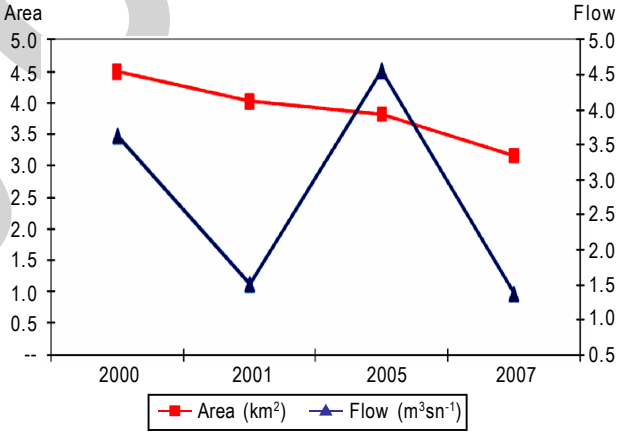

Fig. 6: Variation of Arapciftligi lake area with flow values

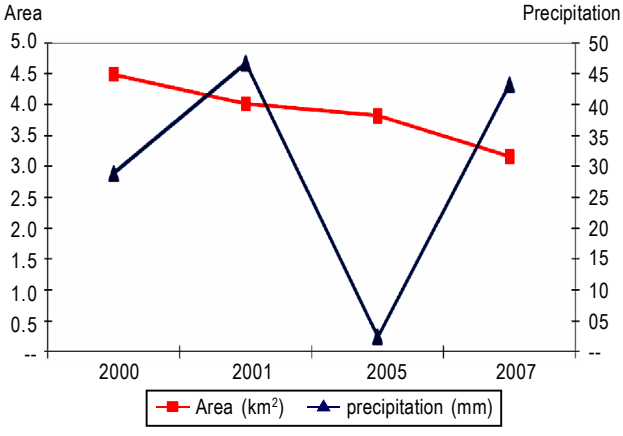

Fig. 7: Variation of Arapciftligi lake area with precipitation values

Table - 1: The satellite images used in the study

Satellite	Date	Resolution (m)	Band No.
Landsat -5 TM	02/072000	30	7
Landsat -5 TM	02/05/2001	30	7
Landsat -5 TM	06/06/2005	30	7
Landsat -5 TM	28/06/2007	30	7

Table - 2: The surface area of the lakes as evaluated by means of UA on the basis of years

Lakes/areas	Year 2000 (m^2)	Year 2001 (m^2)	Year 2005 (m^2)	Year 2007 (m^2)
Arapciftligi	4 490 048	4 022 674	3 824 362	3 163 302
Dalyan and Poyraz	4 088 600	4 220 094	1 909 343	1 677 538

Table - 3: Shore lengths of the lakes on the basis of years

Lakes/Areas	Year 2000 (m)	Year 2001 (m)	Year 2005 (m)	Year 2007 (m)
Arapciftligi	19 920	21 356	18 938	11 593
Dalyan and Poyraz	28 775	33 374	15 279	13 464

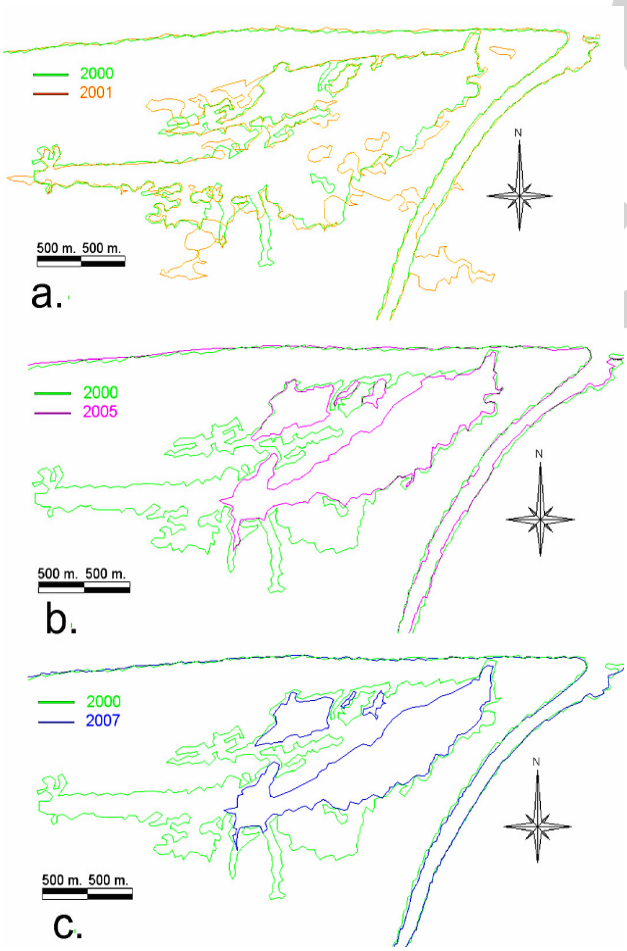

Fig. 8: Comparison of Dalyan and Poyraz lake areas areas (a) in 2000-2001 years (b) in 2000 and 2005 years (c) in 2000 and 2007.

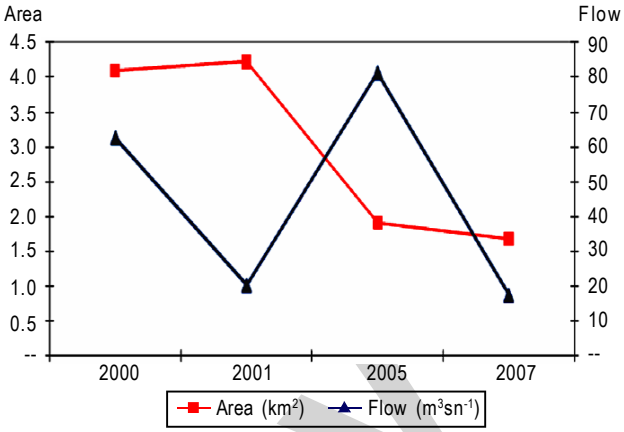

Fig. 9: Variation of Dalyan and Poyraz lake areas with flow values

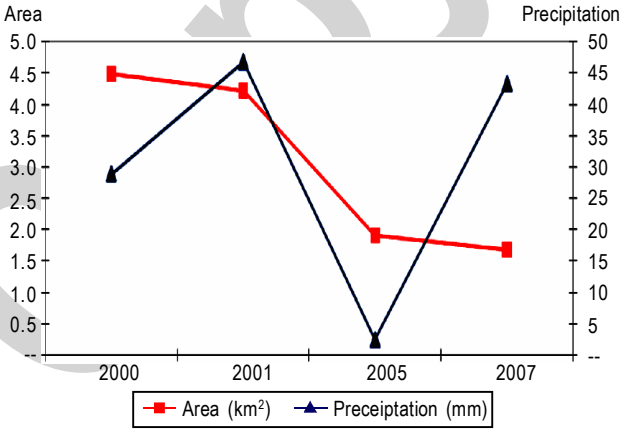

Fig. 10: Variation of Dalyan and Poyraz lake areas with precipitation values

water. On the other hand, it has been observed that the lake that was 19226 m^2 in size and close to the Kocasu mouth was a part of Arapciftligi lake in the year 2000 but separated from it in the year 2007 (Fig. 3).

Furthermore, the monthly and yearly changes in the flow data in the years 2000, 2001, 2005 and 2007 recorded at the 317 numbered Akçadere –Susurluk flow observation station and obtained from DSI and EIE are given in Fig. 4; and the monthly and yearly changes in precipitation values belonging to the same years and obtained from EIE were provided in Fig. 5.

When Table 2 and Fig. 5, 6, 7 were compared, it was found that there was no relationship between the flow, precipitation values and the decrease in size of Arapciftligi lake area. To give an example, although the precipitation in the year 2007 was more compared to the precipitation in June 2005, the area of the lake in the year 2007 was smaller than what it was in the year 2005.

Results related to Dalyan and Poyraz lake:

-- In the years 2000 and 2001, the Dalyan and Poyraz lakes merged and became one. In the year 2001, the lake increased 131494 m^2 in size (3.2%). However, in the year 2005, the lake

shrank 2179257 m² in size in comparison to the year 2000 (53.3%). In the year 2007, the lake continued to get smaller. The shrinkage in size was 2411062 m² in comparison to the year 2000 (60%).

-- In the year 2000, 3 islands in respective sizes of 108019 m², 56139 m² and 20780 m² were determined in the lake. On the other hand in the year 2001, the number of islands increased to 5, ranging in size from 128380 m² to 30045 m². The increase in the number of islands was due to the increase in the size of the lake (Fig. 8).

-- In the year 2001, it was observed that a new lake in the size of 18391 m² has formed close to the place where Kocaçay spills into the Marmara sea. It can be observed from Fig. 8 that in the year 2001, the subject matter lake had a connection with Marmara sea and Kocacay. This may be due to the excessive precipation in April, 2001 and May, 2001 in which the image was obtained as well as any infiltration of sea water due to the northeast winds. It can be seen from Fig. 9 that the connection of Dalyan and Poyraz lakes was cut off in the year 2005. At the same year, the connection of the lakes with Marmara sea and Kocacay was cut off. The reason for this could be the dry climate and negligible amount of precipitation in June, 2005 when the image was obtained as seen in Fig. 4.

-- In the year 2005, it was observed that two pieces in the sizes of 34490 and 15556 m² were separated from Poyraz lake. It can be determined from Fig. 8 that the 5 islands that formed in the year 2001, merged with shoreline of the lake in the year 2005. It was calculated that the surface areas of the two newly established lakes that were separated from Poyraz lake in the year 2005, were reduced from 15556 to 7157 m^2 and 34490 to 23344 m^2 respectively in the year 2007 (Fig. 8).

When Table 2 and Fig. 4, 5, 9, 10 were compared, it can be said that there was no relationship between the flow, precipitation values and the decrease in size of Dalyan and Poyraz lake area.

As a result of the evaluation process the following determinations have been made: Arapciftligi Lake shrank 29.5% in size in the years 2000 and 2007. The fact that the lake continued to get smaller in size even in periods of high precipitation may be due to the sediment flowing from the agricultural fields established close to the lake area. Dalyan and Poyraz lakes lost 60% in terms of their surface area in the years 2000 and 2007. In 2000-2001 periods Dalyan and Poyraz lakes increased in size by 3.2%. The reason for this could be the excessive precipitation, winds and the fact that the seawater from Marmara sea seeps into the lake.

In this study, a net correlation could not be seen between the change in lake areas and flow, precipitation values. A reliable evaluation will be possible with synchronized satellite images and measurements. Conserving this type of water systems is only possible with considering these systems as a whole and with control programs which are supported with common monitoring systems including remote detection technology.

References

Biçkici B. and L. Balas: .: Hydrodynamic of Coastal Lagoon (in Turkish). Turkey Coasts 10, VIII. National Congress of Coastal and Sea Zones of Turkey, Trabzon, **3**, 1267-1276, (2010).

Goksel, C., D.Z. Seker and S. Kabdasli: Prediction of lagoon's natural conditions using satellite data and GIS. *J. Environ. Sci. Hlth.*, **38**, 1669-1681 (2003).

Goksel, C., D.E. Mercan, S. Kabdasli, F. Bektas and D.Z. Seker: Definition of sensitive areas in a lakeshore by using remote sensing and GIS. *Fresenius Environ. Bull.*, **13**, 860-864 (2004).

Kaya, S., D.Z. Seker, S. Kabdasli, N. Musaoglu, A. Yuasa and M.B. Shrestha: Monitoring turbid freshwater plume characteristics by means of remotely sensed data. *Hydrol. Proc.,* **20**, 2429-2440 (2006).

Kaya, S., E. Sertel, D.Z. Seker and A. Tanik: Multi-temporal analysis and mapping of coastal erosion caused by open mining areas. *Environ. Forensics*, **9**, 271-276 (2008).

Kazanci, N., O. Emre, T. Erkal, O. Ýleri, M. Ergin and N. Görür: Kocasu ve Gönen Çayi Deltalarinin (Marmara Denizi Kuzey Kiyilari) Güncel Morfolojileri ve Tortul Fasiyesleri (Recent morphologies and sedimentary facies of Kocasu and Gönen delta (South coast of Marmara sea). *MTA Dergisi*, **121**, 33-50 (1999).

Maktav, D., S. Kapdasli and E. Irtem: The monitoring of complex water resources systems by remote sensing technology: A case study, 1st international airborne remote sensing conference and exhibition, strasbourg, France (1994).

Maktav, D., F. Sunar, S. Kapdasli, N. Musaoglu and T. Mutlu: Use of remote sensing to monitor the Koycegiz lagoon and its environment in Turkey. *Earth Observ. Rem. Sens.*, **15**, 321-331, (1999).

Seker, D.Z., C. Goksel, S. Kabdasli, N. Musaoglu and S. Kaya: Investigation of coastal morphological changes due to river basin characteristics by means of remote sensing and GIS techniques. *Wat. Sci. Tech.*, **8**, 135-14 (2003).

Seker, D.Z., S. Kaya, S. Kabdasli, N. Musaoglu, A. Yuasa and Z. Duran: Investigation of meandering in Filyos river by means of satellite sensor data. *Hydrol. Process*, **19**, 1497-1508 (2005).

Sertel, E., N. Findik, S. Kaya, D.Z. Seker and A. Samsunlu: Assessment of landscape changes in the Kizilirmak delta, Turkey using remotely sensed data and GIS. *Environ. Engg. Sci.,* **25**, 353-362 (2008).