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The determination of coastline changes using artificial neural networks in Yamula Dam Lake, Turkey

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***Abstract*—Yamula Dam Lake is an important area constructed for the purpose of producing hydroelectric energy and irrigation. In this study, the coastline boundary changes occurred in a part of Yamula Dam Lake in Kayseri province were examined using three multispectral Landsat 8 LDCM satellite images of March, August and November 2016. Firstly, image-to-image registration process was performed to conform the image coordinate systems of images to each other. The radiometric calibration process wasn't done, since there was not any process related to the reflectance and radiance values when determining the coastline boundary change. Then, each satellite image was classified into two information classes, namely water and other fields by using artificial neural network method. The change images were created for March-August and August-November pairs by using the obtained classification images. The changes in coastline boundary were determined by the post classification comparison method. Consequently, bi-directional changes from water to land and from land to water were detected in Yamula Dam Lake.**

Keywords—artificial neural networks; post classification comparison; change detection; satellite image; Landsat 8

I. INTRODUCTION (*HEADING 1*)

Remote sensing is a frequently preferred method because of its reliability in many disciplines. Compared to classical methods, it gives very quick results. It is also very safe. Remote sensing technique is being used as one of the most successful methods in landcover and landuse determination, mapping, planning, monitoring with different time intervals, determination of emerging deformations and management of natural resources.

Coastline except for situations such as water floods is an intersection with the land part of the sea, lake or river. It has also boundaries changing according to meteorological phenomena. Efforts to identify coastal boundary changes at different times have a major impact on the management, conservation and sustainability of coastal resources. In recent years, remote sensing has been widely used to monitor the changes in coastal area management, coastline or coastal use [1].

There are some studies met in literature about coastline change detection. Güney used images of Landsat MSS of 1975, Landsat TM of 1987 and Landsat ETM of 2000 to determine coastline changes. He detected changes by using post classification comparison technique, and he reached to result of approximately 153 hectares in land acquired by filling the sea [2]. Erener determined the water level decreased from 9.87% in 1987-2000 to 14.55% in 1987-2006 by using Landsat TM obtained in 1987, Landsat ETM+ obtained in 2000 and Landsat ETM+ obtained in 2006 [3]. Wang used satellite images, obtained on five different times and taken from three type satellites which are Landsat 5 TM, Landsat 7 ETM+ and HJ-1A, to study the effect of coastal change on erosion [4]. Shettya used Landsat 5 TM images obtained from IRS 1C / 1 D in 1991, from IRS P6 in 2001, 2005 and 2009, from Landsat 8 OLI in 2013 satellite images and determined that sand was carried by erosion during the 46-year period. [5].

The algorithms using in remote sensing studies to detect change can be separated in two types of method. First method is unsupervised change detection approach. This method is based on the principle of the determination in landuse and landcover changes obtained from satellite images taken in different dates and converting to single or multi-band image. Second method is supervised change detection approach. This approach needs training classes as

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supervised classification for the determination in landuse and landcover changes [6]. For this reason, this approach is more challenging. However, it allows us to achieve a more effective result in determining the direction of change.

In this study, it is aimed to determine the change of coast line in Landsat-8 LCDM satellite images Yamula Dam Lake obtained in March, June and November of 2016. In this context, artificial neural networks were used for classification of satellite images and post classification comparison method was used for determination of coastal boundary change. It also briefly describes the planning of the work and the steps before the change is determined.

II. MATERIAL AND METHODS

A. Study Area

Yamula Dam Lake is one of the most important dams for the purpose of hydroelectric energy generation and irrigation purposes in Central Anatolia Region. The dam located 25 kilometres in northwest of Kayseri lies on the Kızılırmak River. It started to hold water on December 27, 2003 [URL-1]. The Landsat-8 LDCM satellite images of the year 2016 used in this study were chosen to include the Yamula Dam Lake and the change of coastline of the lake. The satellite image of the study area is shown in Fig 1.



Fig. 1. Landsat 8 LDCM satellite image on March 5, 2016 of the study area

B. Materials

In the study, Landsat 8 LDCM March, August and November satellite images of the spring, summer and autumn seasons of Kayseri Yamula Dam Lake in 2016 were used. Due to the cloudy weather in December, January and February, none of the winter season satellite images were evaluated. Satellite images being acquired on March 5, 2016; August 26, 2016 and November 4, 2016 were used in the study. In Table 1, Landsat 8 bands and their properties are given in detail.

TABLE I. LANDSAT-8 LDCM OLI / TIRS SATELLITE IMAGE BANDS AND FEATURES [URL-2]

Band	Wavelength (micrometer)	resolution (meter)
Band-1 Coastal Aerosol	0.43-0.45	30
Band-2 Blue	0.45-0.51	30
Band-3 Green	0.53-0.59	30
Band-4 Red	0.64-0.67	30
Band-5 NIR	0.85-0.88	30
Band-6 SWIR-1	1.57-1.65	30
Band-7 SWIR-2	2.11-2.29	30
Band-8 Panchromatic	0.50-0.68	15
Band-9 Cirrus	1.36-1.38	30
Band-10 TIRS-1	10.60-11.19	100*30
Band-11 TIRS-2	11.50-12.51	100*30

III. METHODS

A. Artifical Neural Networks

In this study, artificial neural networks are used in the classification of satellite images.

Artificial Neural Networks are extremely simplified model of the brain. Artificial neural networks consist of simple linear or nonlinear computing elements called "neurons", which are interconnected in complex ways and are usually arranged in layers [7].

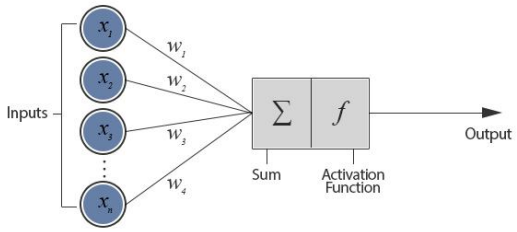


Fig. 2. Neurons structure [URL-3]

The structure of the neuron is shown in Figure 2, where $x_1,x_2,x_3.... x_n$, are inputs and $w_1,w_2,w_3.... w_n$, are the weights of these inputs. The weights determine the influence of inputs on the cell. The addition function calculates net data entering the cell. This can be mathematically identified as given in equation (1).

$$Net\ Input = \sum x_i w_i \quad (1)$$

The activation function can be identified as given in equation (2).

$$y = F(x) \quad (2)$$

All artificial nerve cells come together to form artificial neural networks. Artificial neural networks are composed of three layers: input layer, hidden layer and output layer.

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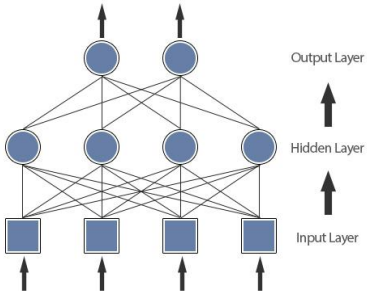


Fig. 3. Layers of the artificial neural networks [URL-3]

The input layer receives the data from the outside and transmits it to the hidden layer. The hidden layer multiplies incoming data with weights and weighted data are collected. The results of the transfer function transmits output layer. Then, the output layer sends the result to the outside.

B. Post Classification Comparision

In determining the change, multiple temporal data sets are used to determine features such as shoreline, land cover between displayed dates. In this study, post classification comparison method was used in change detection analysis.

In this approach, satellite images belonging to two different times are classified and recorded independently. Then, the images that are classified independently are compared with each other. Thus, the direction and amount of change are determined [8].

IV. Application And Results

The direct use of raw images obtained from satellites in change detection studies is an obstacle for producing meaningful results. Because, these images contain non-systematic errors due to changes in satellite height or position. The geometric / image registration process must be performed in order to correct these errors (geometric distortions) in the images. The process steps followed in the study are shown in Figure 4.

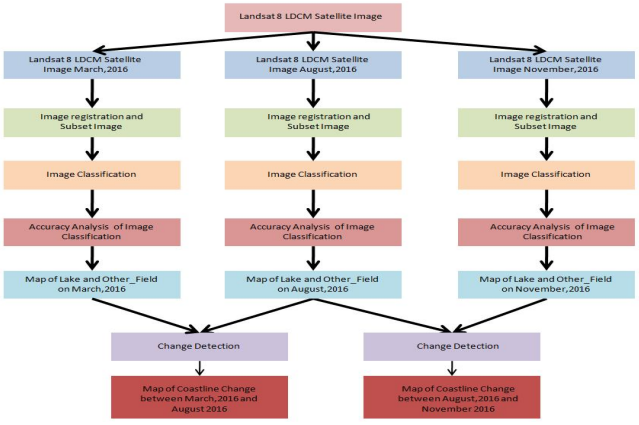


Fig. 4. Flow chart of methodogy

First of all, "Image to Image Registration" process is done for satellite images. March satellite image was selected as reference image and the other images were registered in that image. In the "Image Registration" process, image mapping is done by using ground control points (GCPs) which are known in the image. 30 well-distributed GCPs were used during implementation and it was noted that root mean square errors (RMSE) value was less than 0,5. Also, the images were cut based on the specified study area after registration. The registered images are shown in Fig 5.

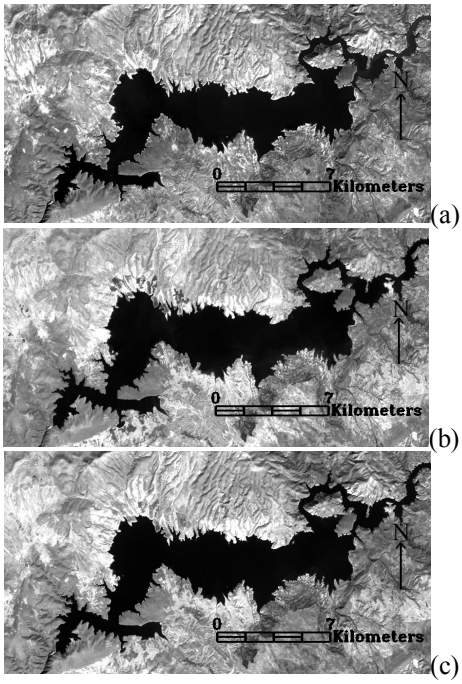
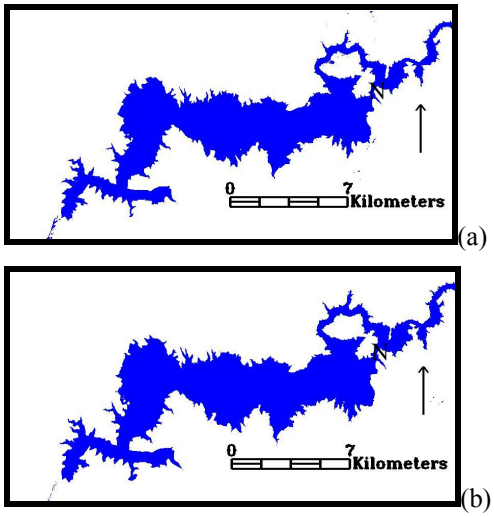
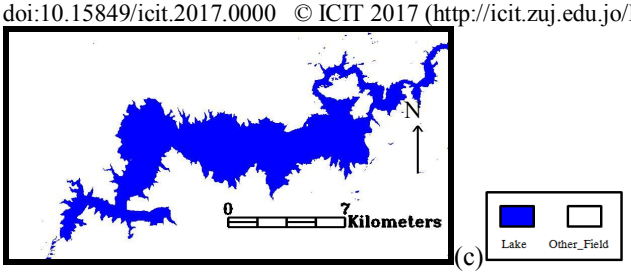


Fig. 5. (a) March, (b) August, (c) November registration images

In the second step, image classification is performed. Artificial neural network method is used for image classification. In this step, the multispectral images are divided into two classes namely "Lake" and "Other_Field". Classified images are shown in Fig 6.



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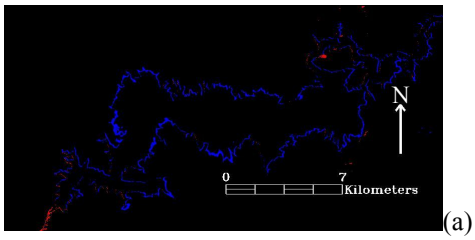


(c)

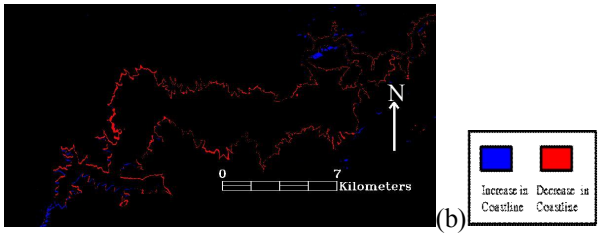
Fig. 6. (a) March, (b) August, (c) November classification images

In the third step, the image classification accuracies are calculated. It was observed 99.97% overall accuracy for March image, 99.90% overall accuracy for August image and 99.80% overall accuracy for November image.

In the fourth step, change detection was performed with the help of classified images. Change detection maps are shown in Fig. 7 and the graphic of changes from March to August and November in Yamula Dam Lake is shown in Fig. 8.



(a)



(b)

Fig. 7. (a) Map of changes from March to August (b) Map of changes from August to November

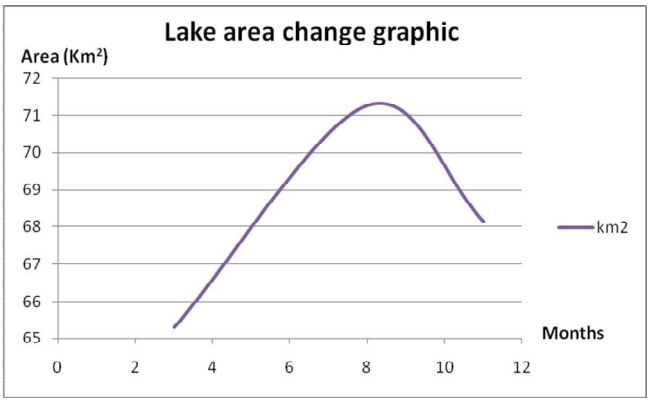


Fig. 8. The graphic of lake area from March to August and November in Yamula Dam Lake

According to the obtained findings, lake area has a 5,95 km^2 increase from 65,31 km^2 to 71,26 km^2 between march and august; a 3,12 km^2 decrease from 71,26 km^2 to 68,14 km^2 between august and november.

V. CONCLUSION

Coastline changes in the dam lake can be occurred as a result of climatic warming or agricultural irrigation. It is important to follow the coastline changes being necessary for environmental management.

In this study, image registrations, classification and change analysis were done. The seasonal change information was obtained by using post classification comparison method on the classified Landsat LDCM satellite images with artificial neural networks. It is seen that the method used in this study produced meaningful change results in satellite images of different months.

The study results show that there is both increase and decrease in Yamula Dam Lake. According to the researches, the increase of the water in the Yamula dam until August can be shown due to the increase in rainfall until that month whereas the decrease after August can be shown the reduction in rainfall and the high temperature of the air.

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