Temporal Analysis of Ramsar Sites via Remote Sensing Techniques – A Case Study of Meke Maar

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Abstract. Wetlands have globally significant social, economic and environmental benefits. Ramsar supports the conservation and conscious use of wetlands. Meke Maar is one of the Ramsar sites which located in Konya Closed Basin. Aim of the study is analysis of Meke Maar from 1984 to 2017, along with the reasons for the change. Remote sensing techniques were used for change detection from 1984 to 2017. Remote sensing has widely used in environmental analysis and change detection. Change analysis was conducted for 2 different month interval as spring (May-June) and autumn (August-September). For detecting water surface area, Normalized Difference Water Index (NDWI) and Classification and Regression Tree (CART) methods were used. These methods were implemented in the Google Earth Engine (GEE) platform. Obtained results evaluate with meteorological data and groundwater level measurements. Guflet Yayla well is the nearest well to study area. That is why, its observations were used in evaluation of change detection results. In conclusion, water surface area in the Meke Maar has decreased approximately 90%. As a result of the study, it was determined that the factors affecting the water change in Meke Maar were precipitation and groundwater level.

1. Introduction

Wetlands have an important place for human and natural life. Wetlands have many functions such as regulation, habitat provision, production and information provision for the sustainability of life on Earth [1, 2]. Wetlands according to the Ramsar Convention; “natural or man-made, permanent or temporary, continuous or seasonal, ditch or running, fresh, brackish or salt water, at a maximum of 6 m during low tide, mattering as habitats to especially aquatic birds and other life, all waters, swamps, marshes and peat moor and all areas ecologically swept by water from their coastline inwards” [3].

Approximately 7% of the earth's surface covers wetlands, while at the same time it hosts about 40% of all species in the world and 12% of all animal species [4]. However, wetlands and its vital activities have decreased significantly in the last 200 years. Besides drying for agricultural activities, the natural ecosystem of many wetlands has been deteriorated due to filling, draining, pollution and excessive consumption of resources [5,6]. Additionally, climate change has directly affected the wetlands. Due to these threats, wetlands are ecologically and economically important ecosystems that need to be monitored and managed.

Over the past 40 years, remote sensing has served as an important and powerful tool for mapping, monitoring and characterization of wetland ecosystems [7]. For this reason, remote sensing was used in many studies related to wetlands. Aksoy and Ozsoy (2002) determined that Ulubat Lake which is a Ramsar site has decreased approximately 13% [8]. There are a lot of methods in determination of wetlands such as spectral indices and classification. Campos et al. (2012) applied the Normalized
Differen
tce Water Index (NDWI) types in Sahara-Sahel transition zone. In order to determine the seasonal and continuous water areas, they applied these indices to Landsat 5 TM and 7 ETM + images [9]. Ekercin et al. (2013) examined the water and salt sources in Konya Closed Basin by using remote sensing techniques between 1984 and 2011 and found a reduction in these sources [10]. Kesikoglu et al. (2015) classified the 2012 ASTER satellite image to determine the land cover of the Sultan Sazligi National Park Ramsar site [11]. Yagmur et al. (2018) classified Landsat satellite images to determine the water area of the Meke Maar Ramsar site [12].

Google Earth Engine has widely used for remote sensing analysis. Pekel et al. (2016) globally mapped the seasonal and permanent water areas in the world between 1984 and 2015 using the millions of LANDSAT satellite images [13]. Farda (2017) compared the different classification algorithms in the Google Earth Engine environment with the analysis of temporal change in coastal wetlands, and stated that the classification and regression tree method showed the highest accuracy [14].

In this study, Meke Maar which is a Ramsar site was chosen as study area. The 35-years change of Meke Maar, which was drying, was evaluated. Arik (2010) stated that Meke Maar is in a critical condition [15]. Temporal change of Meke Maar was analysed with meteorological data and groundwater level measurements.

2. Study Area
Konya Closed Basin (KCB), one of the 25 river basins in Turkey, which is located in the Central Anatolia region of Turkey and covers the 7% surface area of Turkey. There are 14 Ramsar sites in Turkey and two of them are located in KCB. One of them is Meke Maar which is selected as study area. Meke Maar is located 2 km northwest of the Karapinar-Eregli highway, 8 km southeast of the Karapinar (Konya) district center and has 202 ha surface area. Meke Maar is a crater lake which is formed by the filling of a volcanic eruption pit with water that occurred 400 million years ago. Then, a second volcanic eruption occurred 9000 years ago and a second volcanic cone was formed in the middle of the lake. Meke Maar plays host many bird species. Meke Maar; it was declared the 1st Degree Natural Site in 1989, the Natural Monument in 1998 and the Ramsar Area in 2005 [16]. Study area is shown in the Figure 1.

![Figure 1. Study area.](image-url)
3. Data and Methodology

3.1. Data

In this study, Landsat Tier 1 satellite images were used to determine the water surface area. Landsat Tier 1 includes Level-1 Precision and Terrain (L1TP) corrected data that is calibrated radiometrically and geometrically. Landsat satellite images have been widely used for temporal analysis and have provided data since the 1970s. Characteristics of Landsat satellite images are given in Table 1.

**Table 1.** Landsat data used in the study.

| Satellite | Spectral Resolution (µm) | Spatial Resolution (m) | Radiometric Resolution | Temporal Resolution |
|-----------|-------------------------|------------------------|------------------------|---------------------|
| LANDSAT 5 TM | 7 Band (0.45-2.35) | B1,B2,B3,B4 B5,B7:30 | 8 bit | 16 days |
| LANDSAT 7 ETM+ | 8 Band (0.45-2.35) | B1,B2,B3,B4 B5,B7:30 | 8 bit | 16 days |
| LANDSAT 8 OLI | 9 Band (0.433-2.30) | B1,B2,B3,B4,B5,B7,B9:30 | 16 bit | 16 days |

Google Earth Engine (GEE) platform was used to analyse the satellite images. GEE is a cloud-based platform that makes it easy to access high-performance computing resources to handle very large geographic datasets without downloading satellite images. Additionally, temperature and precipitation values of Karapinar and Eregli Meteorological Stations and groundwater level measurements of Gulfet Yayla well were used for analysing reasons of water decrease. Location of the meteorological stations and well is shown in the Figure 2.

**Figure 2.** Location of the meteorological stations and Gulfet Yayla well.
3.2. Methodology
In this study, Normalized Difference Water Index (NDWI) and Classification and Regression Tree (CART) methods were used for detecting water area. Flowchart of the study is shown in the Figure 3.

![Flowchart of the study.](image)

NDWI is an improved method for detecting and measuring water presence on remote sensing images. NDWI utilizes near infrared and visible green bands to improve the presence of water features while eliminating the presence of soil and terrestrial vegetation characteristics [17]. NDWI results vary between -1 and 1. NDWI values which are bigger than 1 shows the water surface area. CART includes the identification and construction of a binary decision tree using a set of training data, with the correct classes known, as in other controlled classification methods [18]. There is only one feature in each decision stage and a simple threshold rule is used in this decision. As other supervised classification methods, it uses marked training data to form the tree. After creating a tree, it used to mark the unseen data [19].

4. Results

4.1. Evaluation of Meteorological Data

There are 12 meteorological stations in KCB. According to meteorological parameters of stations, precipitation, evaporation and temperature distribution maps are created with Inverse Distance Weight (IDW) method. IDW which is an interpolation method estimates the value of the unsampled area as the weighted average of the adjacent points inversely proportional to the distance [21]. According to Figure 4, Meke Maar is located in low precipitation, high evaporation and high temperature zone.
Figure 4. Precipitation, evaporation and temperature distribution maps, respectively.

Eregli and Karapinar Meteorological Stations are the closest stations to Meke Maar. Considering the proximity of these stations to Meke Maar, the weighted average of precipitation, temperature and evaporation values were taken into consideration. From 1984 to 2017, weighted precipitation and temperature distribution is shown in Figure 5. Additionally, average of the 12 stations is shown in the figure. According to results, precipitation has mostly stayed below the average precipitation of 12 stations; but, temperature has increased and passed the average temperature value recent years.

Figure 5. Precipitation and temperature distribution of Eregli and Karapinar Meteorological Stations between 1984 and 2017.

4.2. Time Series Analysis

Change detection analysis was done for two different season: May-June and August-September. Firstly, NDWI and CART methods were applied to satellite images in May-June season between 1984 and 2017. For 5-years interval, NDWI and CART results are shown in the Figure 6 and their areal results are compared in the Figure 7. According to results, these two methods showed the same trend and have minimum differences. CART method was chosen for August-September season. In 2016, water surface area decreased to 0 because of the increase of temperature.
Figure 6. (a) Time series of NDWI between 1984 and 2017, (b) Time series of CART between 1984 and 2017.

CART was applied to two season and water surface areas of the two season were close to each other. That is why, average of these two season were calculated for analysing reasons of decrease. Average water surface area is shown in Figure 8. There are only two classes as water and other. Therefore, accuracy assessment of classification results were obtained as greater than 90%.

Figure 7. Comparison of water surface area for NDWI and CART.
Figure 8. The average water surface area of May - June and August - September seasons determined with CART in the range of 1984-2017.

4.3. Relationship Between Agriculture and Groundwater Level

Agriculture is significant in Central Anatolia. 1.245.782 ha of land in Karapinar is used for agricultural purposes. 78.6% of this area is cereals and herbal products, 1% is vegetable, 0.6% is fruit, beverage and spring crops and while 19.8% is left as fallow fields [20]. However, water consumption values of the plants that are irrigated in the region are more than the rainfall values. Since the plants cannot meet the water demand with rainfall, this need provides with irrigation. The need for water, which is met by irrigation, is called net water demand. The net water demand varies type of the plant. Considering the plants needing the most water needs, the water requirement for growing sugar beet is 705 mm, 630 mm for corn and 500 mm for sunflower.

Another issue that needs to be taken into consideration together with the net water requirement is the amount of agricultural land covered by these plants. The cultivation of sugar beet in Karapinar was carried out in 1991 in an area of 29,630 daa. This value increased to 103,809 daa in 2009 and showed an increase of 250%. In 2017, sugar beet cultivation was made in the area of 43,777 daa. Corn cultivation in Karapinar was planted in 880 daa in 1999. While this value reached 47,910 daa in 2004, it reached 214,360 daa in 2017. Like corn, sunflower was first planted in 2004 and had only 70 daa of land. While it had an area of 20,343 daa in 2009, this value increased significantly to 96,000 daa in 2017.

The main reason for this increase in corn and sunflower is that it is preferred by farmers because of its high income. Likewise, the increase in sugar beet cultivation triggered the problem of water shortage. For this reason, leakage wells were started to be opened and groundwater has been consumed significantly. Figure 9 shows the groundwater level measurements of Gülfer Yayla well in range of 1984 and 2009. Meke Maar which was declared as Ramsar site in 2005, groundwater level of Gülfer Yayla well was reduced by 8 meters after 2005. This situation explains why the water area in the Meke Maar did not increase despite the precipitation.
5. Conclusion
In this study, change analysis of the Meke Maar, which is a Ramsar area, was evaluated between 1984 and 2017. LANDSAT satellite imagery was used for this purpose and analysis were done with Google Earth Engine. NDWI and CART methods were used for determining water surface area and it is observed that both of the methods are usable for water related analysis. Water surface area were determined for two different seasons, which are May-June and August-September. Results of two season were close each other and average of the seasons were taken. According to results, Meke Maar has lost 90% water surface area. For analysing reasons of the decrease, meteorological parameters and groundwater level measurements were evaluated in the same interval. Water surface area and precipitation parameter have same trend until 2005. After this date, although the precipitation has increased, water surface area has decreased continually. According to groundwater level measurements, groundwater level has decreased approximately 8 meters. Reason of that can be shown as agricultural mistakes. Farmers should be directed to cultivate the plants, which have low net water requirement. GEE offers a significant contribution to the temporal change analysis studies. It provides objective evaluation of generated numerical results. Precautions must be taken to recover an important RAMSAR area.

6. References
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