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Lake Meke drought analysis between 2017-2021 with planet multispectral data

Hasan Bilgehan Makineci[*1]

[1]*Konya Technical University, Department of Geomatics Engineering, Türkiye, hbmakineci@ktun.edu.tr*

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Abstract

The city of Konya is experiencing intense drought stress and feels the threat of desertification most intensely. Due to the uncontrolled use of water resources and irregular precipitation regime, Karapınar and its surroundings faced the danger of desertification in a short time. Lake Meke, which has been facing drought for many years, has been the subject of remote sensing research in recent years, with the widespread use of high-resolution satellite data. In this study, the temporal variation of Lake Meke between 2017 and 2021 for March was determined using 3 m spatial resolution multispectral Planetscope data. Wetland changes were determined using the Normalized Difference Water Index (NDWI) for each year of wetland boundaries. As a result, it was determined that the wetlands, which were relatively more in 2017 and 2018, experienced almost complete drought in 2021. When the surface area of wetlands is calculated, it was determined that there was approximately 75% wetland loss between the most significant area and the smallest area between 2017 and 2021.

1. Introduction

Drought is driving itself sensed on our planet and shows its effect by increasing day by day [1, 2]. Most of the research on drought covers large-scale wetlands such as lakes and streams [3]. The temporal analysis of wetlands of this size with remote sensing data has been achieved more frequently in the last quarter-century [4].

Our country, which connects the continents of Europe and Asia, has become a transition country in terms of drought. Due to desertification and rapid consumption of water resources, different problems occur regarding usable water resources in other geographical regions [5]. Konya, located in the Central Anatolia Region and is the largest city in Turkey in terms of surface area, is also in the most dangerous position in periods of drought and desertification [6]. Especially in and around Karapınar District, water use has been a big problem for years [7]. Known as the "Evil Eye Bead of the World", Lake Meke is more than affected by the danger of drought [8, 9].

There are different studies on determining drought as the metric. PDSI (Palmer Drought Severity Index) values are estimated using machine learning methods to predict drought values after one, three and six months [10]. Primary indices such as The Standardized Rainfall Index (SPI) and the Normal Percentage Index (PNI) are also used in drought analyses on a monthly, annual and seasonal scale [11]. Konya Closed Basin (KCB) is one of the regions where the effects of drought are felt the most due to its semi-arid climate. In the research, which analyzed the KCB region between 1998 and 2015 in terms of severity, duration and impact area of drought, seven long dry periods took place, and the most severe and the highest average impact area was experienced in the period of 2006 December - 2007 October [12].

Meke Lake is a fantastic place visually and has an essential position as a wetland in the Konya Closed Basin. Due to biodiversity, Lake Meke, an essential lake, also has an important place for the Karapınar District. In the

region, where agricultural activities have significantly increased over the years, drought has increased, while water consumption has increased [13].

This research carried out a drought analysis of Lake Meke and its surroundings with temporal remote sensing data. The spatial water body was produced from Planetscope data using the Normalized Difference Water Index (NDWI). As a result, it has been determined that wetlands are gradually decreasing in 2019, 2020, and 2021 compared to 2017 and 2018.

2. Material and Method

In this study, data with the most appropriate visibility were determined and downloaded from the PlanetScope system with a spatial resolution of 3 m in March, the month when the wetlands were the widest. The obtained data were first processed as RGB images with appropriate band combinations. The suitable filter was searched for sharpening the data and enriching the details, and the RGB data were optimized with the Arithmetic Average Filter. In order to reveal the wetland areas, the data for each year was arranged with the NDWI index. Afterwards, necessary analyzes were made, and Change Detection was carried out. As a result of this, drought analysis was carried out depending on the wetland changes (Figure 1).

This study produced NDWI indices using Planetscope multispectral (MS) 3m spatial resolution data. In addition, the Arithmetic Mean Filter (3 × 3 pixels) was applied to NDWI images with five iterations to enrich and sharpen the wetlands in the images.

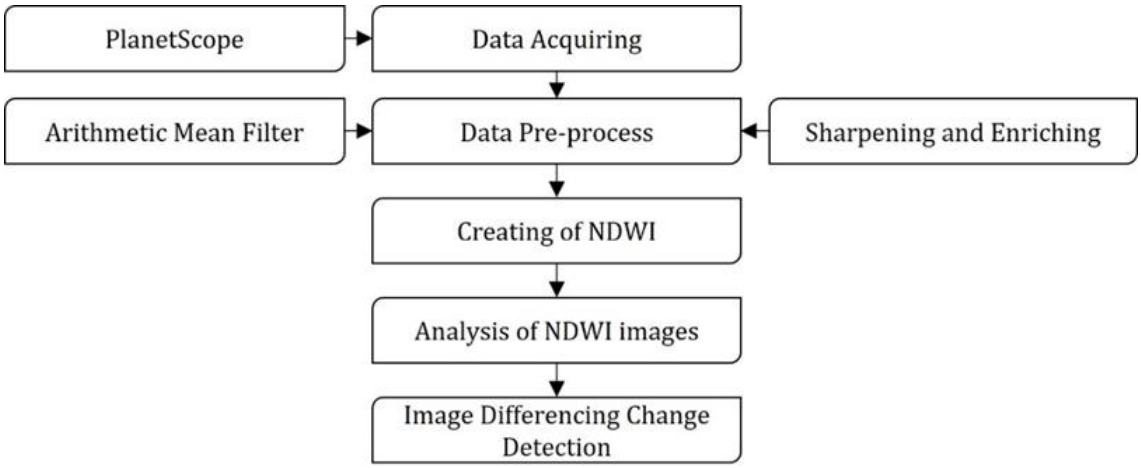

Figure 1. Workflow of the study

2.1. Study Area

Lake Meke, which is located at an altitude of approximately 980 m above sea level and is a volcanic structure, has been known as the "Evil Eye Bead of the World" for years because it looks like a black dot in the middle of its blue waters [9]. The red appearance formed by the shrinking wetlands is due to living microorganisms. It was included in the Ramsar Convention, an international convention aimed at protecting and sustaining wetlands, in 2005 [14, 15]. Lake Meke, which was selected for the study area of this research, is located in Turkiye, as presented in Figure 2.

2.2. Planetscope Remote Sensing Data

Planetscope constellation satellites consist of data from multiple launched satellite clusters, each in the form of cube satellites (DOVEs). The Sun-synchronous constellation system has the Ground Sampling Distance (GSD) in the nadir direction is 3.9 meters (Table 1). Multispectral data is presented in 4 bands (RGB+Near Infrared). Planetscope orthomosaic data is given to users with radiometric calibrated, and sensor corrections are applied, orthorectified, and converted into a UTM projection.

Since the overall area of Lake Meke's wetlands is not particularly large, using satellite data with a high spatial resolution is more helpful in finding actual wetlands. For this reason, analyzes were made using PlanetScope high-resolution MSI images.

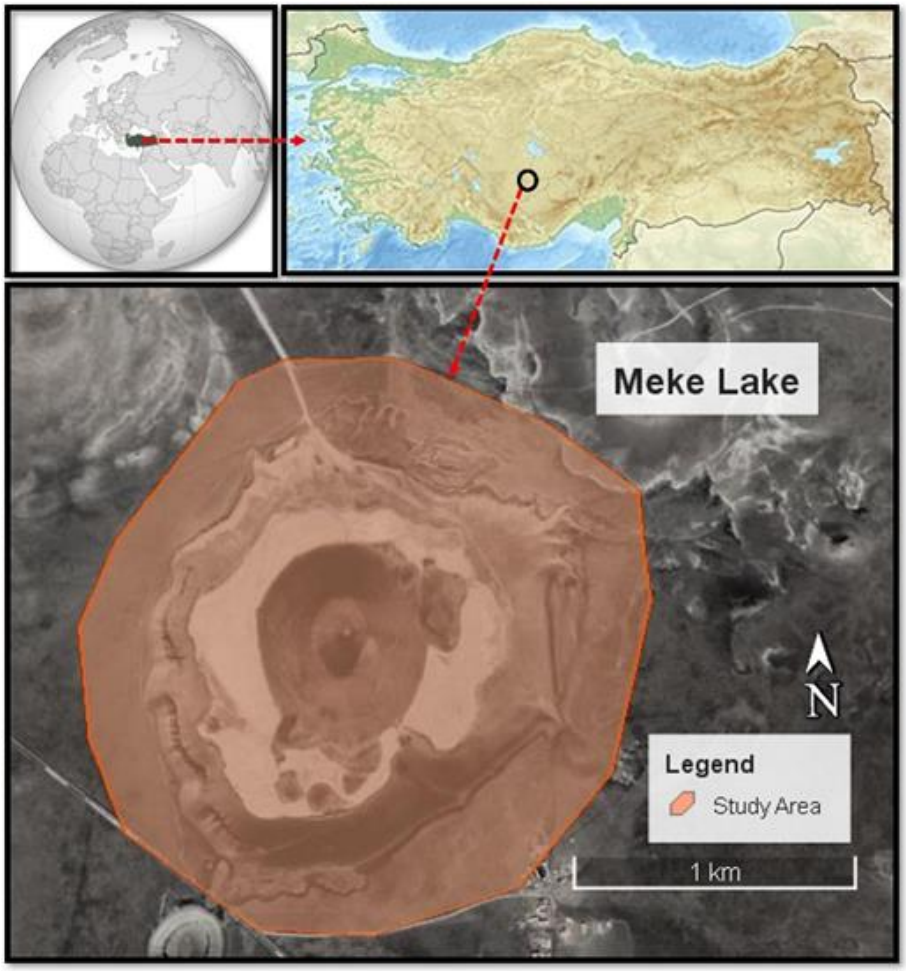

Figure 2. Study area

Table 1. Remote sensing data specs

Data Type	Date of Acquisition	Spatial Resolution	Bands
AnalyticMS-SR	03/22/2017	~3 m	RGB+NIR
AnalyticMS-SR	03/21/2018	~3 m	RGB+NIR
AnalyticMS-SR	03/23/2019	~3 m	RGB+NIR
AnalyticMS-SR	03/22/2020	~3 m	RGB+NIR
AnalyticMS-SR	03/19/2021	~3 m	RGB+NIR

2.3. NDWI

NDWI is used to reveal wetlands' temporal changes occurrences by remote sensing [16-18]. It is based on a different combination and normalization of the bands (Equation 1). If the reflectance values are more significant than 0.5 in the result obtained, these areas generally correspond to water bodies.

$$NDWI = \frac{Band\ 2\ (Green) - Band\ 4\ (NIR)}{Band\ 2\ (Green) + Band\ 4\ (NIR)} \quad (1)$$

2.4. Aritmetic Mean Filter

The filter, known as the arithmetic mean filter, is a preferred image processing for sharpening and enriching the details in images. Sharpening and enriching provide convenience in the study and eliminate some errors caused by image acquisition. The arithmetic mean filter, which has been tried on data and has shown successful

results, has been preferred because of its positive effects on evaluating results. When used as 3 × 3, it serves to rearrange the image using the arithmetic means of eight different neighbors of a pixel. The mean filter is a simple way to reduce noise in an image. If the size of the template matrix increases (like 5 × 5 or 9 × 9), the smoothing will increase even more.

2.5. Image Differencing Change Detection

The registered, normalized multi-temporal satellite images could be subjected to four of the most widely used change detection techniques. These techniques comprise post-classification, image differencing, image rationing, and principal components analysis (PCA).

The digital number (DN) value of a pixel for a specific band on one date is deducted from the DN value of the same pixel for the same band on another date to conduct the image differencing change detection approach [19, 20]. Three different images for the three bands, red, green, and blue, were produced via pixel-by-pixel subtraction of each band from image 2017 to 2021.

3. Results

As a result of the data evaluation for March of five different years belonging to Lake Meke, the surface area changes of the wetlands over the years (2017-2021) have been visually determined and presented in Figure 3. Change detection performed in this investigation is also presented in Figure 4. Relative accuracy can be mentioned when evaluating the findings. For this reason, no accuracy assessment was carried out in the research. Since the study area is not very large, it is assumed that the errors caused by the satellite data and the rough errors caused by the operator do not have a large percentage.

Table 2. Change detection of Meke Lake between 2017-2021

Data Type	Date of Analysis	Total of Wetland and Humid Lands (Ha)	Amount of Change (Ha)
AnalyticMS-SR	03/22/2017	~38.4	-
AnalyticMS-SR	03/21/2018	~45.5	~+7.1
AnalyticMS-SR	03/23/2019	~18.9	~-25.6
AnalyticMS-SR	03/22/2020	~14.1	~-4.8
AnalyticMS-SR	03/19/2021	~10.2	~-3.9

The evaluation was made on wetland, humid land, and dry land. When evaluated like this, the wetlands of Lake Meke, which had an increasing trend in 2017 and 2018, drought sharply in 2019, and in 2020 and 2021, the drought continued, and Meke Lake was almost wholly drought out (Table 2).

4. Discussion

Previous research has stated that Lake Meke and the Konya Closed Basin, where it is located, experience drought and will completely dry out in the coming years. Dogan, Berktay [8], in his drought analysis study covering the years between 1972 and 2009, revealed the drought threat for the Konya Closed Basin. Information has been provided that Lake Meke, located in the study area, is also under the threat of drought. Celebi [13] has stated that while there were 45,000 wells and 1,760,456 hectares of cultivated land in 2002, there were over 100,000 wells and 2,023,513 hectares of cultivated land in 2011 in the Konya Closed Basin. Some have entirely dried up, such as the Hotamış and Eşmekaya marshes, and also some wetlands like Ereğli marshes, Salt Lake, Beyşehir Lake, Meke Lake and Samsam Lake have decreased by about approximately 30-85%. Even though the research and findings that have been going on for years revealed the threat of drought, and it has been stated that agricultural activities accelerate the drought in the region, it is seen that no precautions are taken, and the region is left to fate. As a result, it is seen that the drought experienced in Lake Meke is a situation from the past. Although this study, which was carried out between 2017 and 2021, is not based on the data obtained from the field, it is essential to reveal the change in the surface area. It is possible to say that Lake Meke has been exposed to an irreversible drought.

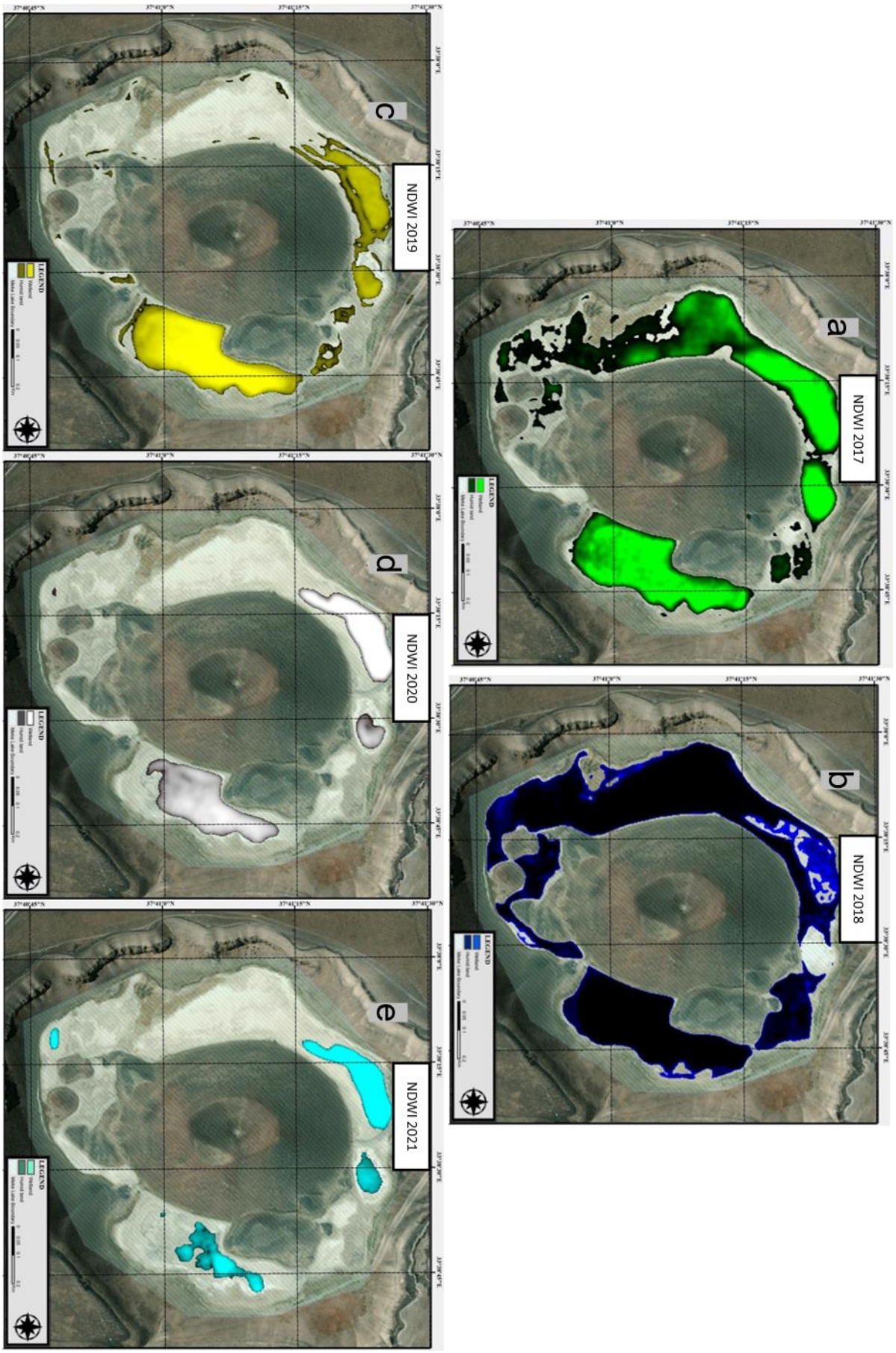

Figure 3. Wetland analysis from March data and change detection (a: the year 2017, b: the year 2018, c: the year 2019, d: the year 2020, e: the year 2021)

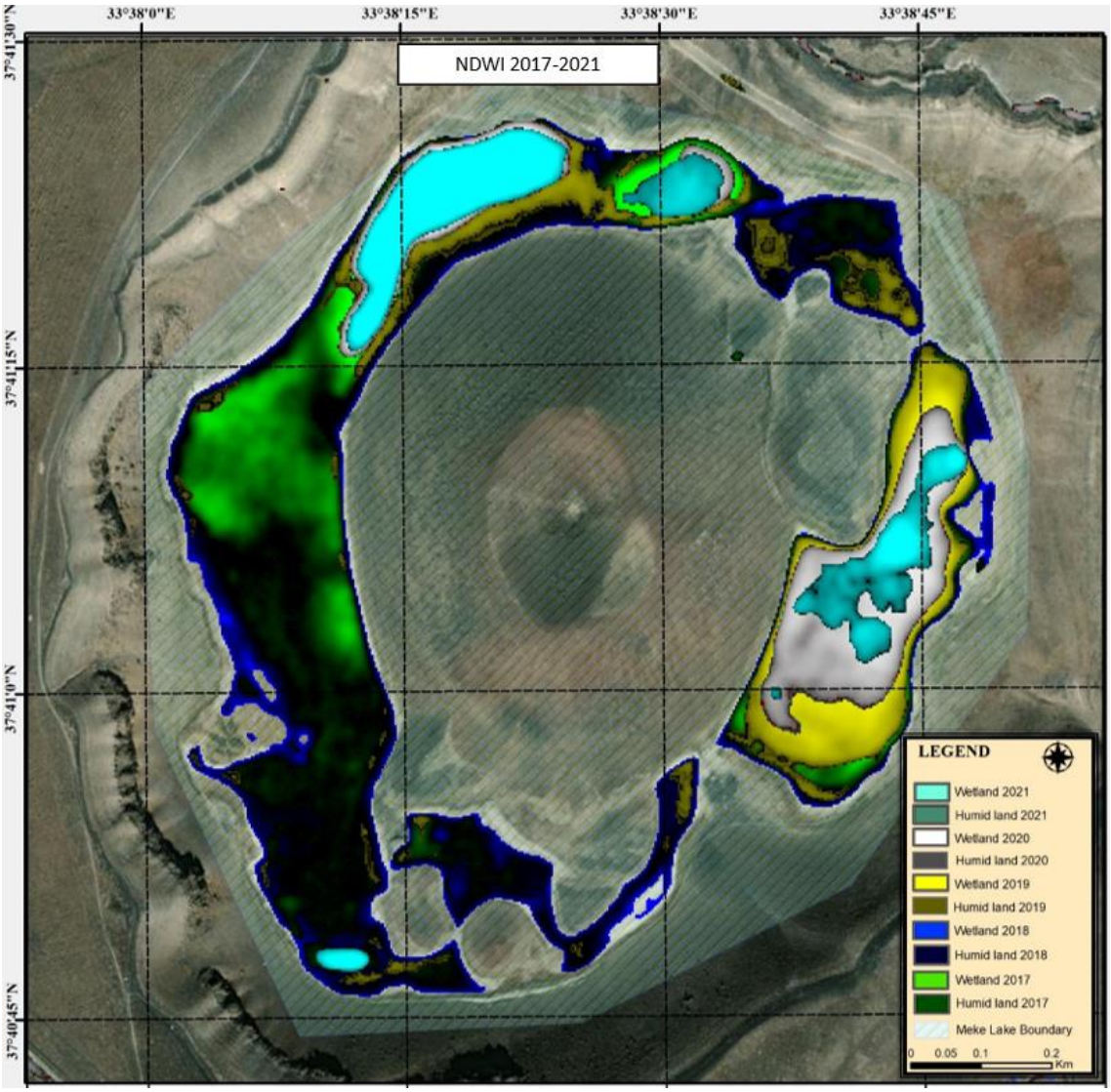

Figure 4. Change detection analysis from 2017-2021

5. Conclusion

This study successfully performed temporal drought analysis of Lake Meke in Karapınar District of Konya Province with Planetscope 4-band MS remote sensing data. From the March data for the years 2017-2021, new results of the NDWI indices were produced, wetlands and humid lands were determined, and change detection analyzes were obtained. It has been revealed the wetland area of Lake Meke, which was about 38 hectares in 2017, decreased to about 10 hectares in 2021. Using data sources such as PlanetScope constellations in monitoring studies of tiny wetlands, where the spatial resolution of the Landsat and Sentinel satellite data used by the researchers as free of charge satellite data is insufficient, can be said to be the most significant contribution to the literature of this study.

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Conflicts of interest

The authors declare no conflicts of interest.

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