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Monitoring shoreline and areal change with UAV data

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Abstract

It is important to determine the spatiotemporal changes of wetlands for their sustainable management and effective use. In this study, the shoreline of Topçu Pond used for agricultural irrigation in Yozgat, Turkey in 2022 and 2023 was determined with the help of contour lines. In addition, the maximum capacity elevation of the pond was determined, and its maximum area was calculated. As a result of the study, the water level and pond area for the year 2022 were calculated as 1191.56 m and 99165.58 m^2, respectively, and the water level and pond area for the year 2023 were calculated as 1195.05 m and 142487.95 m^2, respectively. The maximum elevation and area of the pond were determined as 1200.65 m and 279019.94 m^2 respectively.

1. Introduction

Wetlands have vital importance in many areas such as freshwater supply, energy production and agricultural irrigation (Ünel et al. 2020). Wetlands have historically been a hub for a wide range of activities such as transportation, tourism, trade and industry (Duan et al. 2016; You et al. 2018; Zhang et al. 2020). As a result, population growth, destruction and uncontrolled development in coastal areas are occurring (Alptekin and Yakar, 2020). Countries that experience or anticipate the destructive consequences of this uncontrolled development attach importance to sustainable coastal change. However, when we look at the planning processes of coastal lands in Turkey, it is seen that traditional methods are mostly used and sustainable coastal monitoring policies are insufficient (Şahin et al. 2022). Remote sensing techniques have long been successfully used to determine coastlines (Wen et al. 2021). In particular, NASA's Landsat program has been monitoring the contraction and expansion of lakes for nearly 50 years (Jiang et al. 2020). In 2016, Sentinel satellite data, freely shared by ESA, also allowed us to track changes in the Earth's surface with higher spatial and temporal resolution. Many studies have been conducted in the literature using remote sensing data (Dewidar, 2004; Muttitanon and Tripathi, 2005). There are a limited number of studies determining the shoreline change in Turkey. Firatli et al. (2022) determined the 35-year areal change of 27 lakes larger than 2000 hectares in Turkey using Landsat and Sentinel-2 images with Google Earth Engine. Dervisoglu (2022) examined the short and long-term changes of lakes in Ramsar sites in Turkey using Landsat and Sentinel-2 data. Although medium spatial resolution satellite data such as Landsat are effective in determining the areal changes of large lakes or seas, they are not useful for small ponds or dams (Kaiser et al. 2021). UAV data give more successful results in determining small water areas (Kaya et al. 2019). In this study, very high resolution UAV data were used to examine the changes of Topçu pond in 2022 and 2023.

2. Method

2.1. Study area

UAV data obtained in September 2022 and UAV data obtained in September 2023 were used in the study. Flight was made with DJI Mavic 2 UAV in the study area (Figure 1). Information about the UAV flight is given in Table 1.

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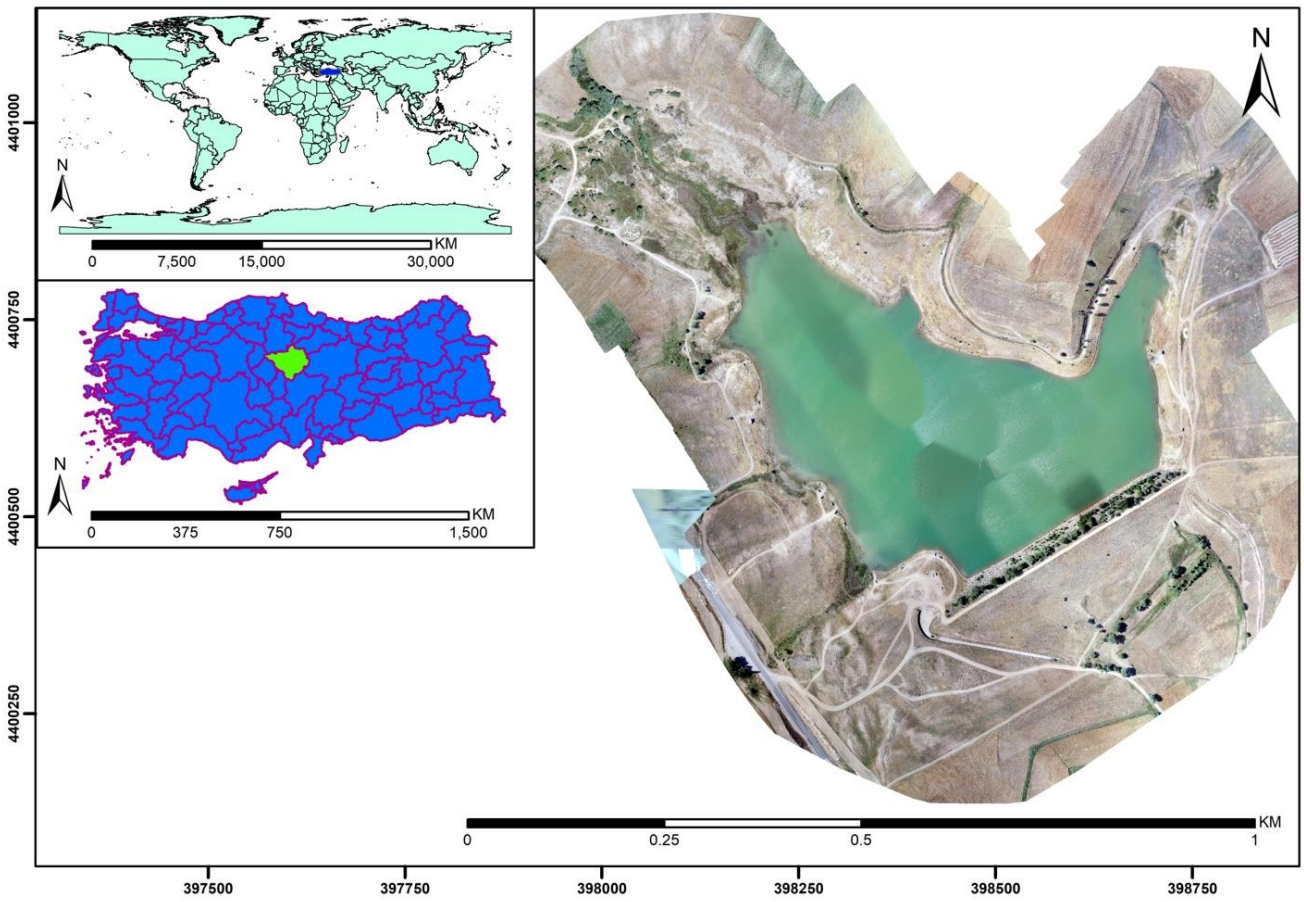

Figure 1. Study area

Table 1. Flight parameters

Parameter	Value (2022)	Value (2023)
Flight Date	10.09.2022	15.09.2023
Flight Time	55 mins	56 mins
Flight Area	656430m^2	702286m2
Overlap	80	80
Camera Angle	90^0	90^0
Planned Altitude	100m	100m
Average Altitude	102m	113m
Number of Photos Taken	490	480
Number of Photos Used	475	464
Planned GSD (cm/pixel)	2.68	2.68
GSD (cm/pixel)	2.95	2.76
DEM Resolution (cm/pixel)	2.54	2.36
Point density (points/m^2)	68	77
Point Cloud Number	7480774	7731599
Dense Point Cloud Number	44762241	50743096

2.2. Method

UAV technology has been used frequently in landslide (Kuşak et al. 2021), rockfall (Yakar et al. 2023) and cultural heritage studies (Yakar and Doğan, 2017; Alptekin and Yakar, 2021; Karataş et al. 2022; Kanun et al. 2022) in the last decade.

In the study, the coordinates of ground control points (GCPs) measured in the field with the photographs obtained from 8 UAV flights performed one year apart were evaluated in Agisoft Photoscan software. One of the most important steps of the photogrammetry method is the determination of camera calibrations. In this study, the photographs were calibrated by self-calibration method using the parameters in the software. The GCP coordinates measured in the field were matched with the points appearing in the software to coordinate the model. Since the quality of the DEM is affected by the dense point cloud produced, the dense point cloud was produced with high accuracy. Then, the orthomosaics and DEMs of the terrain were exported in high quality. The parameters and information used in orthomosaic and DEM generation are given in Table 1. Then, using the contour lines where the shoreline is located, the boundaries of the shoreline and the area covered by the maximum water capacity in the terrain were determined.

3. Results

The shorelines of Topçu pond in 2022 and 2023 were determined by photogrammetric method. Since it is assumed that the water level will be the same at every point of the water surface, contour lines were produced in the coastal areas. From these lines, the shoreline in two different years and the shoreline of the pond at maximum capacity were determined (Figure 2).

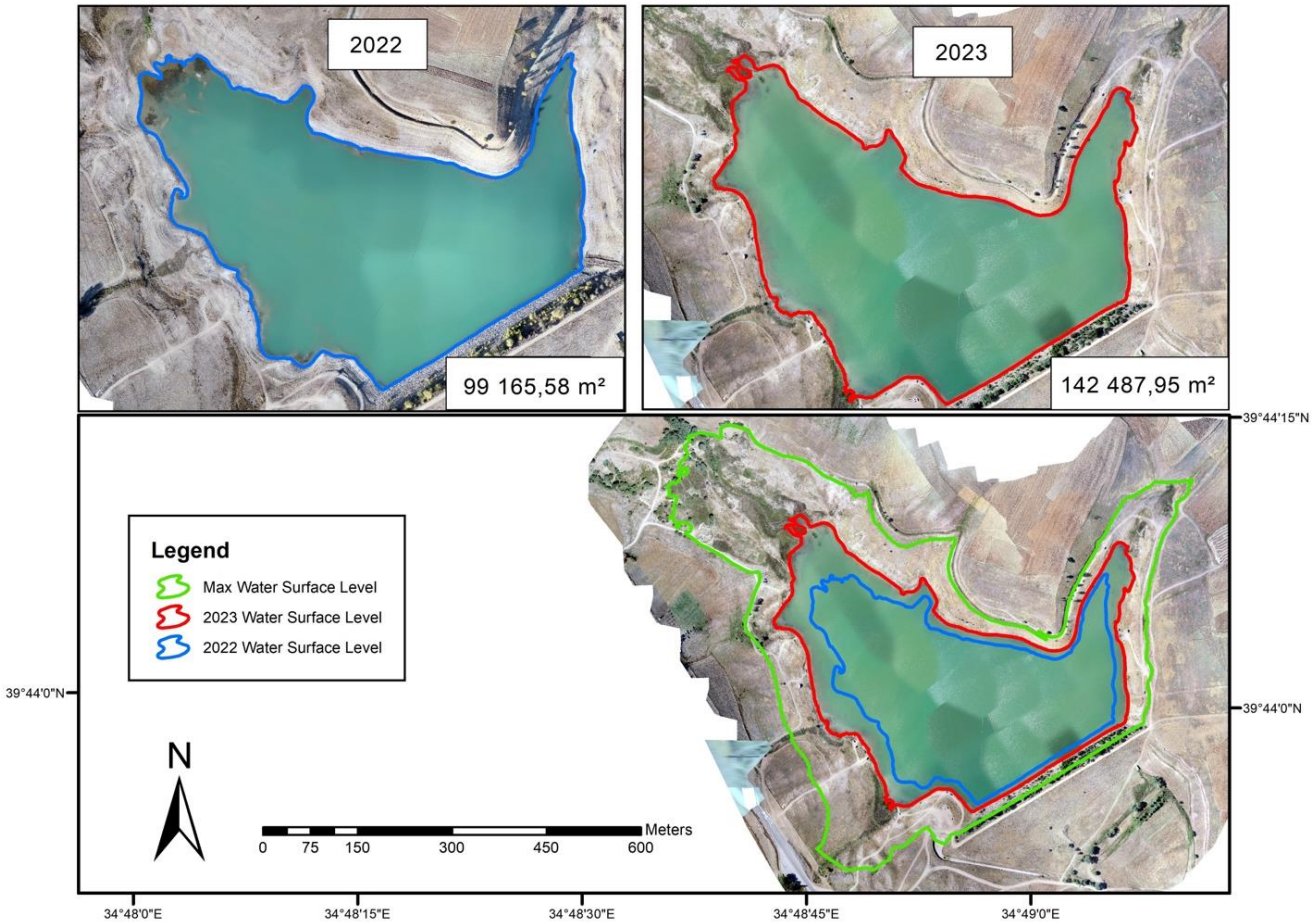

Figure 2. Shorelines in 2022, 2023 and maximum capacity

4. Conclusion

Shoreline monitoring is important for sustainable use of available water and planning for future use. While medium resolution data such as Landsat is effective for determining shoreline changes in large water areas, it is insufficient for determining changes in small water areas. For this reason, UAV technology, which has been used in many different fields in recent years, is also used to determine terrain topography. In this study, the shoreline of Topçu Pond, Yozgat, Turkey, which is used for agricultural irrigation, was determined by high-resolution UAV in 2022 and 2023. In addition, the areas that will be covered by water when the pond reaches its maximum capacity were also determined with UAV data and GCPs. The shoreline in two different years was determined by the average height of the water surface. The water covered areas were also determined with the help of the contour lines at the level of the discharge gate of the pond.

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