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Examining the Effects of a Flood Event in the Lower Ceyhan Basin in 1980 Using Historical Satellite Data

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Abstract

Analysis of past flood events contributes forecasting of effects of future flood events. Flood maps have been created in order to assess flood hazards in planning projects and to identify flood-inundated regions with flood damage following flood occurrences. Flood mapping in the context of flood monitoring enables development of flood management strategies to protect life and property. Although conventional terrestrial observations and measurements in flood control have been constrained by topographical and meteorological circumstances, remote sensing provides decision support with quick analysis capability. The flood event that occurred in the Lower Ceyhan Basin of Turkey in 1980 was examined in this work utilizing satellite-based remote sensing techniques, and flood inundation areas were calculated using NDWI (Normalized Difference Water Index). As a result, it was determined that 3493.45 ha in the north of Karataş in the Lower Ceyhan Plain, 7799.42 ha between Bahçe, Akdeniz, and Yumurtalık, 7404.9 ha around Çatalpınar and Yakapınar in the Lower Ceyhan Plain, and approximately 24890 ha in the Upper Ceyhan were affected by the flood event in 1980.

Keywords: Ceyhan River floods, Historical satellite data, Landsat-3, NDWI

1980 Yılında Aşağı Ceyhan Havzasında Gerçekleşen Taşkın Olayının Tarihsel Uydu Verisi Kullanılarak İncelenmesi

Öz

Geçmişteki taşkın olaylarının analizi, gelecekteki taşkın etkilerinin tahmin edilmesine yardımcı olur. Taşkın haritaları, taşkın tehlikelerini planlama sürecinde değerlendirmek ve taşkın sonrası hasarı olan bölgeleri belirlemek için hazırlanmaktadır. Taşkın haritalarının yapılması, taşkınların izlenmesi kapsamında, can ve malları korumak için taşkın yönetim stratejilerinin geliştirilmesini sağlamaktadır. Taşkın kontrol çalışmalarında, geleneksel karasal ölçümler ve gözlemler, topografik ve meteorolojik

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koşullar tarafından sınırlandırılmış olsa da, uzaktan algılama tekniği, hızlı analiz yeteneği ile karar desteği sağlamaktadır. Bu çalışmada 1980 yılında Türkiye'nin Aşağı Ceyhan Havzasında meydana gelen taşkın olayı uydu tabanlı uzaktan algılama teknikleri kullanılarak incelenmiş ve NDWI (Normalize Edilmiş Su İndeksi) kullanılarak taşkın alanları hesaplanmıştır. Sonuç olarak, Aşağı Ceyhan Ovası'nda, Karataş kuzeyinde 3493,45 ha, Bahçe, Akdeniz ve Yumurtalık arasında 7799,42 ha, Çatalpınar ve Yakapınar çevresinde 7404,9 ha ve Yukarı Ceyhan Ovası'nda yaklaşık 24890 ha alanın 1980 yılındaki Aşağı Ceyhan Havzasında gerçekleşen taşkın olayından etkilendiği tespit edilmiştir.

Anahtar Kelimeler: Ceyhan Nehri taşkınları, Tarihsel uydu verisi, Landsat-3, NDWI

1. INTRODUCTION

Floods are natural catastrophes that occur often in many areas across the world and have disastrous impacts on people, nature, society, and the economy. Over many years, structural and non-structural solutions have been implemented to avoid loss of life and property and to mitigate the harmful consequences of flood disasters. Historical records, observations, studies, publications, and images of previous flood occurrences give knowledge on flood-affected places; hence, flood risk assessments are supported by the use of these materials in future flood management activities. In this context, investigating previous flood incidents will help to forecast future flood management techniques. Historical floods have been investigated in many previous studies [1-14].

One advantage of employing remote sensing techniques to detect flood spreading regions is that it provides data from flood extent locations that are physically difficult or impossible to access. The GIS strategy, as an effective tool for data storage, analysis, and administration, supports decision-making while also saving time and cost. In comparison to previous years, tremendous progress has been achieved in flood risk assessments, flood monitoring operations, flood mapping, and flood damage assessment utilizing remote sensing (RS) and geographic information systems (GIS).

Many studies and articles on the use of RS and/or GIS methods in flood mapping have been published in the literature [15-28]. Knowing the geographical extent of submerged regions during flood occurrences is crucial for organizing relief studies as well as detecting faults with flood control facilities [29]. Because of the ability to acquire data in uncharted areas, remote sensing data has become an alternative to in-person observations as technology advances [29]. It was expressed by Dash and Sar (2020) that spatial mapping of historical floods using spaceborne data are getting popularity based on the advancements in sensors and repetitive coverage [30].

Flooding occurred in agricultural regions and some villages in the plain as a result of the flood event that occurred in the Seyhan and Ceyhan rivers in the Çukurova Plain in 1980. According to the official flood report issued by State Hydraulic Works, the 1980 flood event in Lower Ceyhan Plain caused damage in four neighborhoods and 26 villages in Ceyhan, nine villages in Kadirli, thirteen villages in Kozan, one neighborhood in Osmaniye, and one village in Yumurtalık [31].

In this study, maps of flood-inundated regions from the 1980 flood event in the Lower Ceyhan plain were created for the first time using satellite-based remote sensing data. The purpose of this research is to assess the value of using past satellite data in the creation of flood control plans for future projects in order to assist decision-makers. In this study, it is also evaluated if flood control infrastructure or devices require restoration or redesign.

2. MATERIAL AND METHOD

2.1. Material

The study area was chosen to be the Lower Ceyhan Plain, which was flooded in 1980. The study area is in Turkey's southern Mediterranean Region, with the Ceyhan River as its major water supply. Figure 1 depicts flood-inundated regions in the Lower Ceyhan Basin on April 1, 1980, as well as their location in Turkey. The development of projects in the Lower Ceyhan Basin and the basin development process were thoroughly reviewed in an IECO study issued in 1966. The Seyhan basin lies west and north of the Lower Ceyhan basin, the Middle Ceyhan basin lies east, and a coastal basin runs south along the Iskenderun Bay. The key agricultural plains in the research region, Kirmit, Kozan, and Kadirli, are on the right coast, Misis, Ceyhan, Kösreli, and Osmaniye are on the left coast, and Andırın and Haruniye are on the east. Furthermore, although being outside the drainage region, the water resources in the Lower Ceyhan basin have a significant impact on the Yumurtalık and Erzin-Dörtyol-Payas plains, which are part of the development process [32].

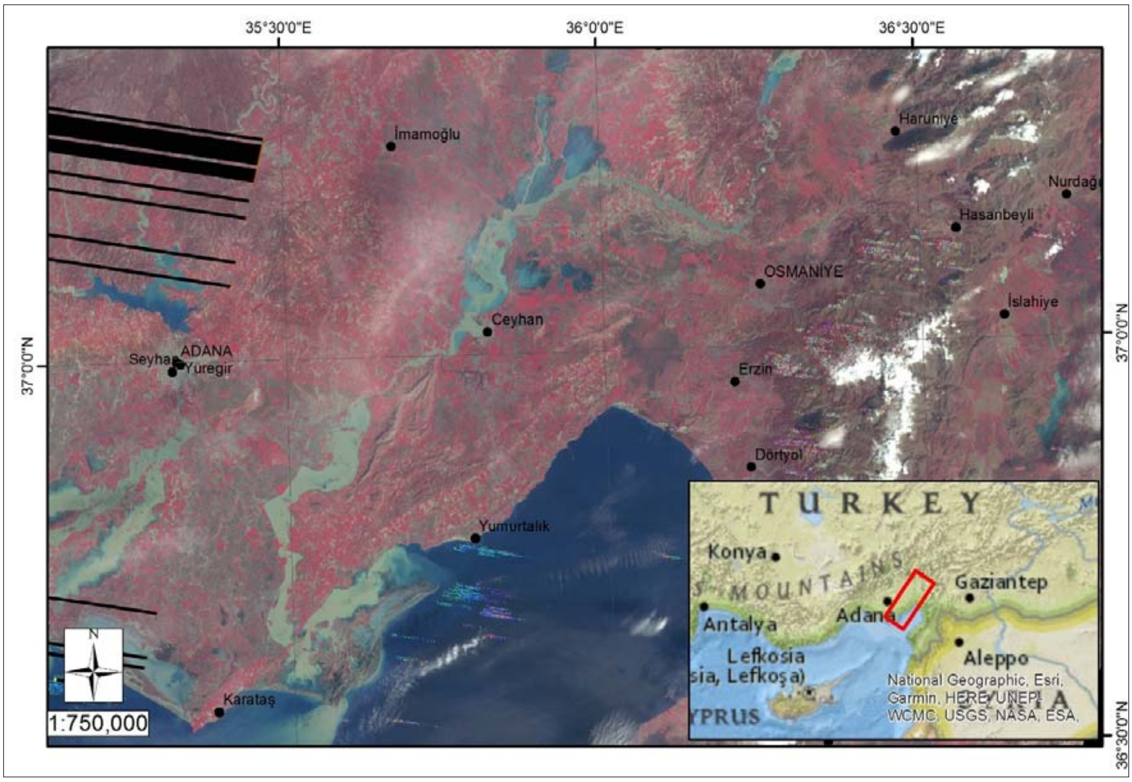

Figure 1. The flood inundated areas in Lower Ceyhan Basin on 1 April 1980 (Landsat 3 image of the study area)

Apart from the irrigation and energy production functions of the Ceyhan Aslantaş Dam, it was reported that one of the goal of the project was to protect 53,270 hectares of land from floods using this dam [32]. In the report prepared by IECO (1966), it was stated that the floods in the Lower Ceyhan basin generally occur in winter and spring, while the floods occur in agricultural areas along the Ceyhan river and in the flat areas next to the river tributary.

Landsat 3 satellite images were checked for cloudiness in the selection of satellite images used in this study, and it was determined that the satellite image dated 01.04.1980 was appropriate (Table 1).

After Landsat 1 and Landsat 2, the Landsat 3 satellite was launched into space in 1978 to acquire images of the Earth from space [33]. The USGS made Landsat satellite data freely available in 2008 through a decision [34]. Table 2 shows the band characteristics of the Landsat 3 satellite.

Table 1. Name and date of the image used in the study

Date	Name of the image
01.04.1980	LM03_L1TP_188034_19800401_20210714_02_T2
01.04.1980	LM03_L1TP_188035_19800401_20210714_02_T2

Table 2. Band Specifications of Landsat 3 satellite [33]

Band Number	Band name	Bandwidth (nm)	Resolution (m)
4	Green	0.5-0.6	60
5	Red	0.6-0.7	60
6	Near Infrared-NIR	0.7-0.8	60
7	Near Infrared-NIR	0.8-1.1	60

2.2. Method

Radiometric calibration and atmospheric adjustments were performed during the preparation of Landsat 3 images. The Normalized Difference Water Index (NDWI) approach uses the NIR and green bands to delineate and monitor content changes in surface water. The NDWI index is frequently utilized to determine water inundation areas in flood management studies using remote sensing images. Several research throughout the world have employed the NDWI metric to designate floodplains [25, 29-30, 35-39]. In this study, NDWI was used to identify the flood inundated regions in the flood event. (1) gives the NDWI formula **[40]**. This formula was used to generate the NDWI image. Figure 2 depicts the NDWI picture for April 1, 1980.

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

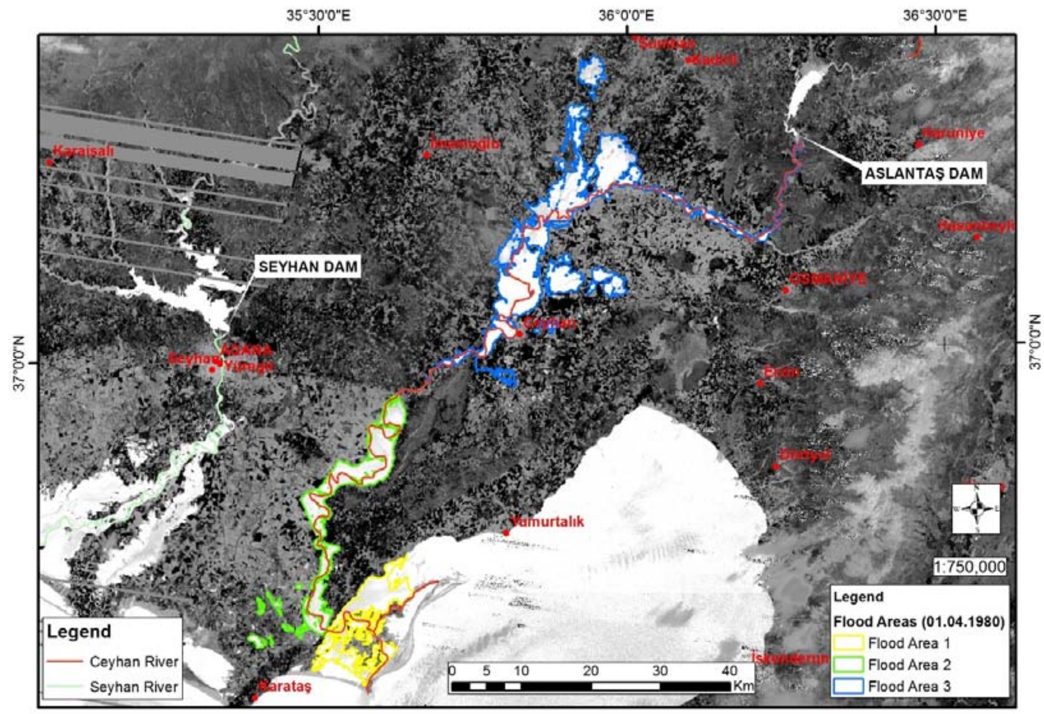

Figure 2. The NDWI image of the flood area on 01.04.1980

3. RESULTS AND DISCUSSION

The technique used in this work is a reassessment of past flood occurrences and flood spreading areas utilizing historical satellite data in places where flood effects were assessed by ground measurements based on the circumstances at the time.

When the first Landsat satellite was launched in 1972 and became freely available in 2008 as a result of a USGS decision [34], this study might have been conducted as early as 2008. The region was first seen by satellite during one of the worst floods in April 1980.

The image of Ceyhan River flood inundated areas on 01.04.1980 is given in Figure 3. Flood regions were divided into three sub-areas: Flood area 1, Flood area 2, and Flood area 3.

The coastline region was thought to be mainly inundated in the Flood area 1 (Figure 3.a) around the point where the Ceyhan River drains into the Mediterranean Sea. The flood inundated area was determined in a GIS environment to be 3493.45 ha in the north of Karataş in the Lower Ceyhan Plain, 7799.42 ha in the area between Bahçe, Akdeniz, and Yumurtalık, 7404.9 ha in the area around Çatalpnar and Yakapınar in the Lower Ceyhan Plain, and approximately 24890 ha in the Upper Ceyhan.

In the 1980 flood disaster, Kozan Dam and Mehmetli Dam were existing water storage systems that contained upstream flood waters in their reservoirs. Kozan Dam and Mehmetli Dam were built on the Kilgen and Kesiksuyu streams, respectively, and were completed in 1972. Because the Meletmez and Savrun Dams were not built at this time, the flow in Sumbas Stream and Savrun Stream, which are tributaries of the Ceyhan River, caused several communities and agricultural regions in the Flood area 2 (Figure 3.b) to be flooded (Figure 4).

The construction of the Aslantaş Dam on the Ceyhan River started in 1975, and the dam was put into operation in 1984. During the flood on the Ceyhan River on April 1, 1980, the Aslantaş Dam was in the construction stage.

The flood water were accumulated in the upstream cofferdam of Aslantaş Dam and the reservoir area as seen in Figure 3. Kalecik Dam on Horu Stream was put into operation after the 1980 flood event. Flood inundated areas were spreaded to flat areas next to the river in the Flood area 3 (Figure 3.c).

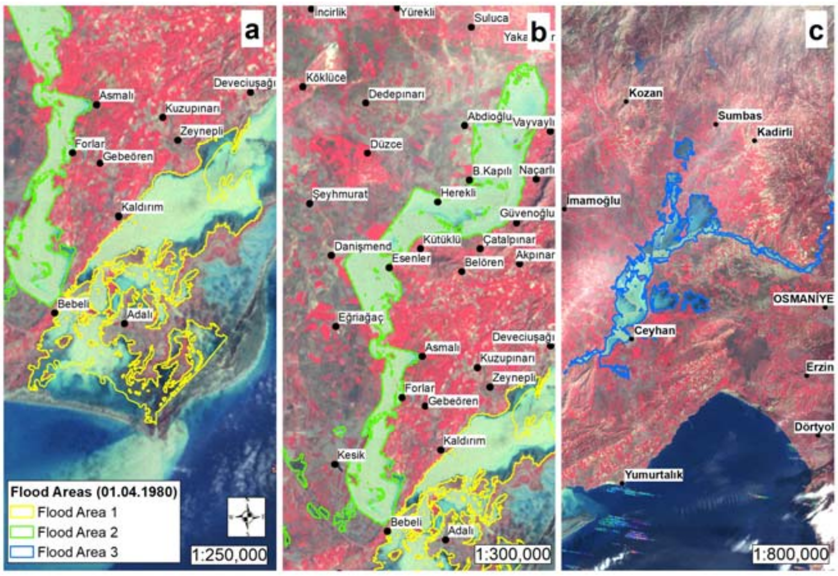

Figure 3. Ceyhan River flood inundated areas on 01.04.1980 (Landsat 3)

The results on determining flood inundated areas found in this study are consistent with the flood risk areas defined in the previous official reports. Figure 5 shows an image of the Ceyhan flooded region in 1980.

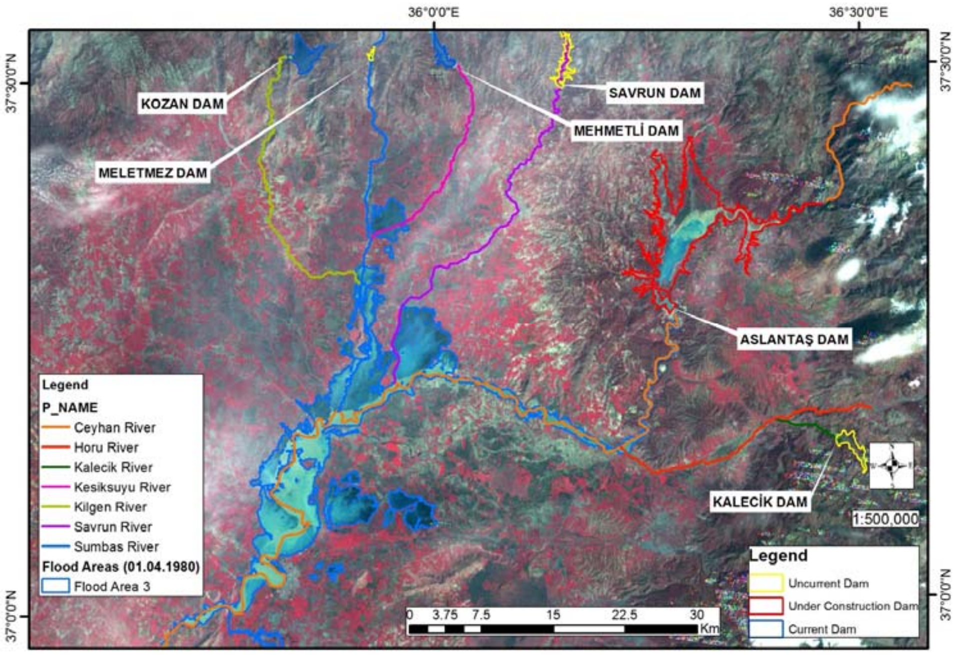

Figure 4. Ceyhan River flood inundated areas and location of dams in Lower Ceyhan River Basin on 1 April 1980

Figure 5. Ceyhan River flood inundated areas in 1980 (from Metin Ozturk's photograph archive)

4. CONCLUSION

The flood-inundated sites in the Lower Ceyhan Basin on April 1, 1980, were studied using archival satellite data. Flood areas were analyzed in this study in three sub-areas: Flood area 1, Flood area 2, and Flood area 3. The flood-inundated regions were analyzed in a GIS context and calculated as areal values.

The satellite-based remote sensing data have been widely used in flood monitoring, flood mapping and post-flood damage assessment tasks. It is feasible to detect flood inundated regions that cannot be accessed owing to bad physical circumstances, and that cannot be monitored by ground observations and surveys by employing satellite-based remote sensing data. To update and renew flood control operations, a study of all prior flood reports utilizing historical satellite data is necessary.

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