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Determining Areas Burned in Forest Fires from Satellite Images: 2019 August Gallipoli Forest Fire (Çanakkale / Turkey)

Halime Yılman[1] and Erdem Gündoğdu[2*]
[1]*Lapseki Emergency Health Services Station No:2 Çanakkale, Turkey*
[2]*Department of Mining and Mineral Extraction, Çan Vocational School, Çanakkale Onsekiz Mart University, Çanakkale, Turkey*
[*]*Corresponding Author: Erdem Gündoğdu (erdem@comu.edu.tr)*

Abstract
In this study, the areas affected by the forest fire that occurred in Çanakkale province, Gelibolu peninsula (between Behramlı and Alçıtepe) in August 2019 were tried to be determined by visual interpretation from satellite images and compared with the results obtained by different methods in the literature. At first, all area boundaries where the fire was effective were determined and calculated as 269 ha. Within the area affected by the fire, wooded areas and agricultural lands that were not affected by the fire were excluded from the scope and were considered as "non-destructed areas". A total of 16 areas that were not affected by the fire were determined within this area, and the total area of these areas was calculated as approximately 46 ha. Thus, the area of the completely destroyed region was found to be approximately 223 ha (269 ha - 46 ha). In addition, as a result of various band combinations applied to the LANDSAT8 OLI image covering the study area, it was seen that the band combination that best reflects these burning areas was obtained with the RGB: 762 combination. These results obtained through visual interpretation in this study; It is largely compatible with the results stated both in the records and in the literature with different index area calculations at different spatial resolutions.

Keywords: *Gallipoli, forest fire, satellite imagery, remote sensing*

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I. INTRODUCTION

Disaster is defined as ecological events that disrupt the normal life order of societies, cause losses and are so large that local resources cannot cope with them [1].

These events may require outside assistance, with the community's capacity to adapt and respond inadequate. For an event to be considered a disaster, there must be loss of life and property [2].

Today, the investigation of events that cause many types of disasters (such as earthquakes, floods, fires) is carried out through on-site observations and field studies. In some cases where it is not possible to conduct field studies (type of disaster, size of the area affected by the disaster, distance of the disaster area), alternative methods are used. The most important of these methods is remote sensing studies. In our country located in the Mediterranean climate zone; Depending on the meteorological, vegetation and topographic characteristics of this climate zone, there is always a risk of fire.

The Marmara Region, Aegean Region and Mediterranean Region are of first degree importance in forest fires and most of the forest fires occur in the summer months [3]. Today, there are approximately 4 billion hectares of forests in the world. However, between 1950 and 1990, half of these forests were destroyed for various reasons. In Turkey, approximately 12,000 hectares of forest were destroyed by fires between 1995 and 2005 [4].

The number of forest fires recorded in Turkey between 1937 and 2020 is approximately 114,941. A significant increase in the number of fires was observed especially in 2020, 2013 and 1994 [5]. When the causes of forest fires between 2001 and 2020 are examined, the cause of approximately 40% of the fires is unknown.

In this study, in the large-scale forest fire that occurred in the Gallipoli Peninsula (Çanakkale) in August 2019 (Figure 1), the damaged areas were determined by visual interpretation and remote sensing method and the results obtained were compared with the data in the literature.

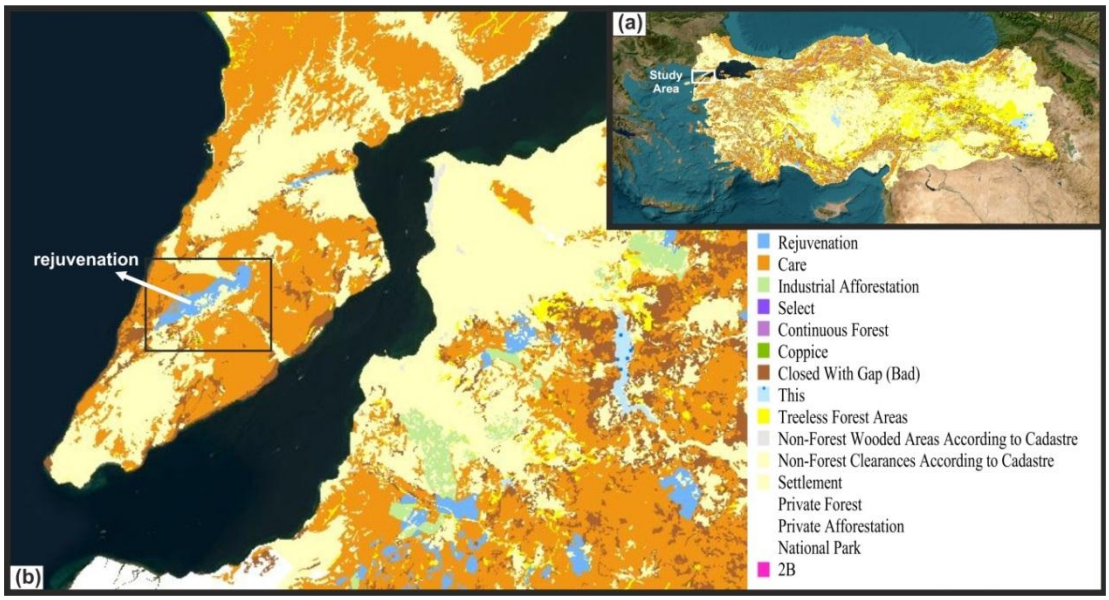

Figure 1. (a) Location of the study area (b) Area affected by forest fire within the study area (the area where rejuvenation works are carried out is shown in blue)

The image of the area within the study area affected by the forest fire that occurred in August 2019 is shown in Figure 2. The image before the fire, from May 2019, is shown in Figure 2a, the images after the fire are shown in Figure 2b and Figure 2c, and the area affected by the fire is shown in Figure 2d.

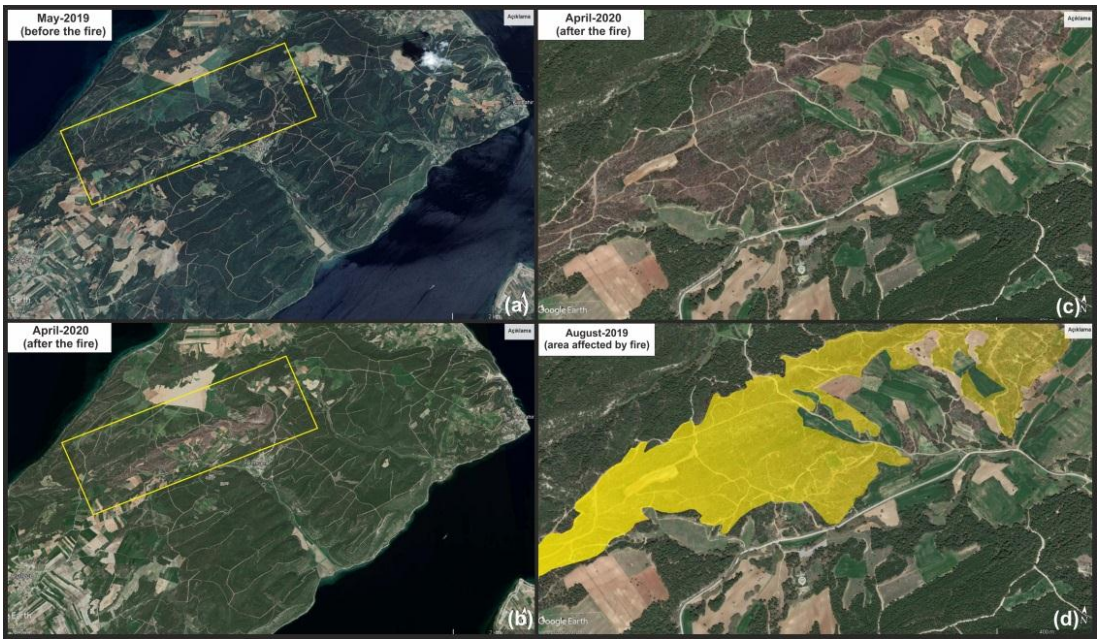

Figure 2. (a) Image before the fire, from May 2019 (b-c) images after the fire (d) area affected by the fire (obtained from Google earth image)

II. MATERIALS AND METHODS

Firstly, images of both before the fire (May 2019) and after the fire (April 2020) in the areas where the fire occurred were obtained separately on the Google Earth image. With the "World Imagery" data of the Global Mapper software, the boundaries of the region covered by the fire were determined and its area was calculated. A total of 16 areas within this area, but not destroyed by fire, were determined and the areas of these areas were calculated. The total area of the regions not affected by the fire was subtracted from the entire area covered by the fire, and the area of the region completely destroyed by the fire was calculated within the entire area covered by the fire.

Later, at 22:30 on 10 August 2019, in the fire that occurred in Behramlı village of Eceabat district, located on the Gelibolu Peninsula of Çanakkale province, 2 different LANDSAT satellite images were taken

before and after the fire in order to detect the destroyed areas (Figure 3). has been used. These images are satellite images belonging to the LANDSAT 8-9 OLI / TIRS C2 L1 category. To determine the condition of the field before the fire, the satellite image LC08_L1TP_181032_20180703_20200831_02_T1 dated 03/07/2018 was used. To determine the post-fire situation, the image LC09_L1TP_181032_20220722_20220722_02_T1 dated 27/07/2021 was used. Various band combinations were applied to the LANDSAT8 OLI satellite image with ENVI software. Thus, the band combination and sharpening type that best reflected the results obtained by visual interpretation were determined (Figure 3).

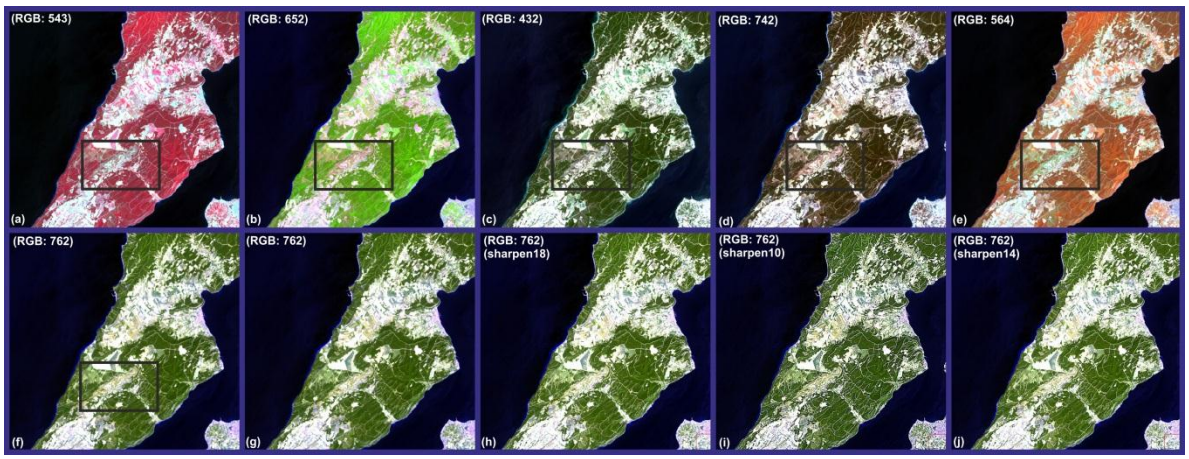

Figure 3. (a-f) Satellite images with various band combinations (g) Preferred RGB:762 combination (h-j) Image refinement processes applied to RGB:762 band combination

III. RESULTS

Using the Global Mapper software, with the "World Imagery" data, the areas covered by the 2019 Gallipoli Forest fire and the completely burned areas within this area were determined (Figure 4). Initially, the area of the entire region covered by the fire was calculated as 268.9 ha. Later, the areas not affected by the fire were determined within this area and were found to be 45.6084 ha. The difference of these two values gives us the surface area of the completely burned areas within the area covered by the fire. As a result, the surface area of the completely burned areas was calculated as 223.2916 ha (268.9 ha - 45.6084) (Figure 5 and Table 1).

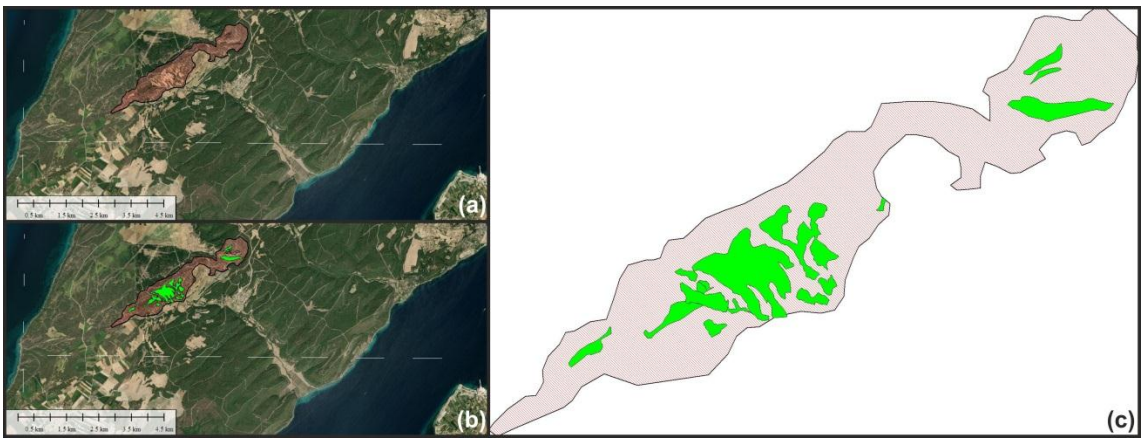

Figure 4. (a) The moment when the fire took effect (b-c) The areas that were not destroyed in the area where the fire was effective (shown in green color)

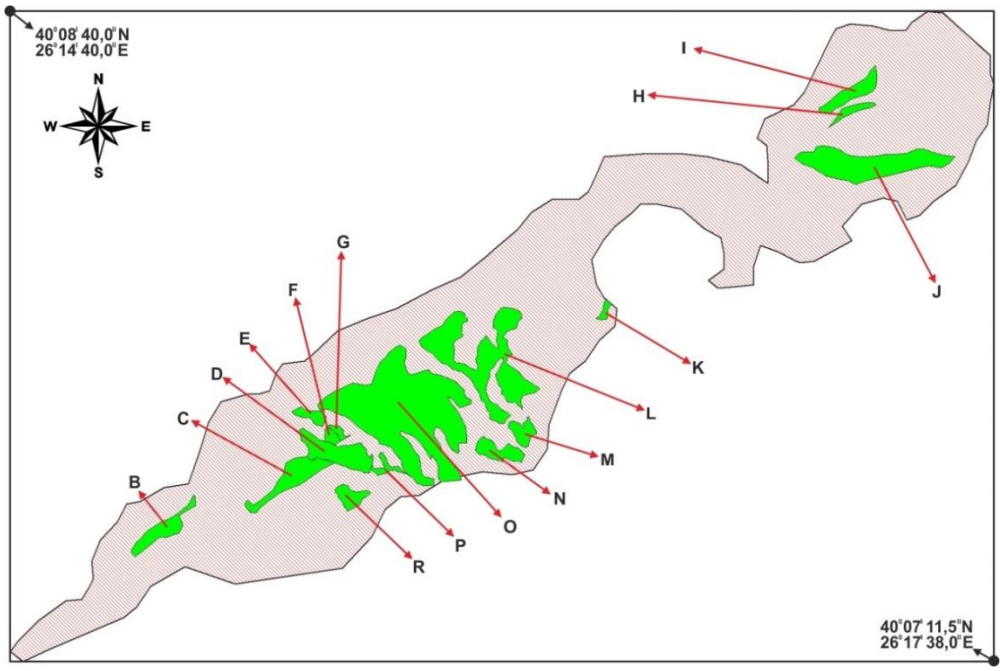

Figure 5. Unburnt/unaffected areas within the entire area affected by the Gallipoli forest fire (A total of 16 areas were identified and shown in green)

Table 1: Within the entire area affected by the Gallipoli forest fire, surface area of unburned/unaffected areas

		Field *(km²)*	**Field *(ha)***	***Field***	***Perimeter (m)***
Total field affected by fire	A	**2,689000**	**268,9**		*12607*
Unburned wooded fields within affected fields (km²)	B	0,016130	1,6130		*840,23*
	C	0,023730	2,3730		*1003*
	D	0,026940	2,6940		*904,23*
	E	0,005770	0,5770		*368,19*
	F	0,003232	0,3232		*226,09*
	G	0,002372	0,2372		*279,38*
	H	0,005200	0,5200		*478,53*
	I	0,014720	1,4720	**0,456084 km² = 45,6084 ha**	*695,5*
	J	0,058800	5,8800		*1485*
	K	0,002340	0,2340		*244,91*
	L	0,083800	8,3800		*2980*
	M	0,008430	0,8430		*447,96*
	N	0,012320	1,2320		*585,51*
	O	0,179100	17,9100		*3204*
	P	0,004290	0,4290		*507,52*
	R	0,008910	0,8910		*422,03*
Burnt fields		**268,9 ha - 45,6084 ha = 223,2916 ha**			

Burnt areas detected with Google Earth images and "World Imagery" data on Global Mapper software; An attempt was made to determine the type of image that reflects well from LANDSAT satellite images. The result obtained with sharpen-14 image sharpening applied on the RGB: 762 band combination that gives the best results is presented in Figure 6.

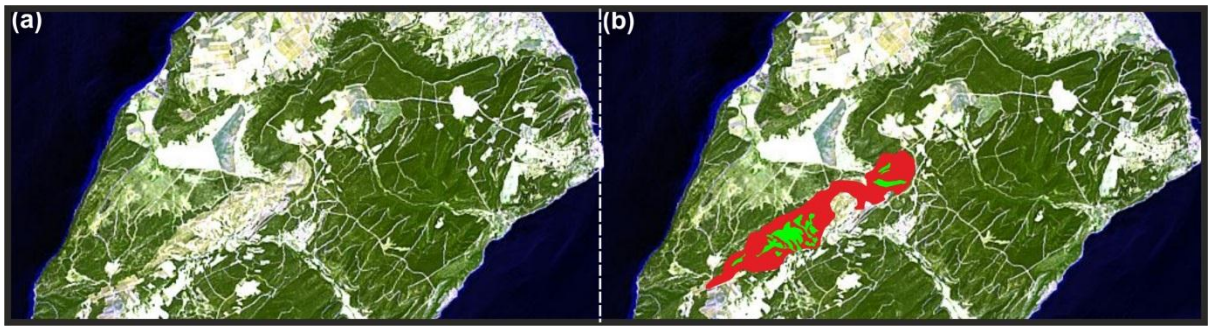

Figure 6. (a) Sharpen 14 sharpening performed on the LANDSAT image of the study area with RGB: 762 band combination applied. (b) Areas affected by fire on the image with this band combination applied.

IV. DISCUSSION AND CONCLUSION

Forest fires have an important place among disasters today, and Türkiye is exposed to many forest fires today. Due to the large areas covered by forest fires, remote sensing methods, as well as field observations, are frequently used today to detect burned areas and provide successful results.

Remote sensing studies are carried out together with field studies and facilitate the identification of large-scale structural elements. These studies are generally based on the principle of processing satellite images using various methods. Additionally, many algorithms have been developed to reduce the noise (interference) present on these images [6-10].

LANDSAT and ASTER satellite images; It is frequently preferred today because it is available free of charge, has multispectral images, has a suitable spatial resolution for medium-scale studies, and meets the needs in cases where the study areas cover large areas [11].

[12], investigated various change analysis methods used in remote sensing and comparatively applied these methods to forest fires affecting the Gallipoli Historical National Park using 1987, 2000, 2001 and 2007 LANDSAT TM/ETM satellite images.

Each of these applied band combinations differs depending on the purpose of operation. For example, (RGB 432: natural colors, RGB 543: infrared colors, RGB 764: short infrared waves, RGB 652: agricultural areas, RGB 762: geological features, RGB 564: Water/land features [13].

[14], stated that Çanakkale province is in a "very high risk and high risk" position in terms of forest fire risk in general, and "medium risk" at a local level.

[15], in his study in Muğla province, he created burning intensity maps and identified areas affected by fire by applying various difference indices to Sentinel-2 and Landsat-8 satellite images.

[16], Index area calculations of the burnt areas were carried out separately on the OLI image with images at 15 m and 30 m spatial resolution. With NDVI / EVI / SAVI / SAVI / NDMI / NBR / NBR2 / GEMI index area calculations, the burned areas on the image with a resolution of 15 meters were calculated as 177-158-172-187-189-188-190-184 ha, respectively. The burned areas on the image with a resolution of 30 meters were calculated as 197-114-186-186-187-188-190-186 ha, respectively.

In this study, the burned areas detected with Google Earth images and "World Imagery" data on the Global Mapper software; An attempt was made to determine the type of image that reflects well from LANDSAT satellite images. By calculating the area using this method, the total size of the area covered by the fire was calculated as 268.9 ha. Within this area, 16 areas that were not affected by the fire were identified and the total area was found to be 45,6084 ha [17]. The difference between the total area covered by the fire and the areas not affected by the fire gives the completely burned areas, and this value was found to be 223.2916 ha. This result found through visual interpretation is relatively compatible with studies in the literature. These results can be considered as visual interpretation, but to give more detailed results, index area calculations at different spatial resolutions may need to be calculated separately, as in the study of [16].

It was concluded that the LANDSAT satellite image that best reflects the values calculated from the areas covered by the fire in the study area and Google Earth images is the sharpen-14 image refinement applied to the RGB:762 combination.

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