OBJECT BASED ANALYSIS OF FOREST FIRES USING HIGH RESOLUTION SATELLITE IMAGES

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ABSTRACT: On 24st of June, 2016, a forest fire occurred in Kumluca, Cumhuriyet, Beşikçi, Belen and Erentepe districts of Antalya followed by the Adrasan forest fire on 27th of June 2016 causing damages on forest canopies of the region. The spatial extent of forest fire within the study area was determined by using a Spot 6 image obtained on 1st of July, 2016 just after the forest fire. Firstly, post-fire image was orthorectified to remove geometric distortions and to integrate obtained results to Geographic Information System environment for spatial analysis. Then, object based classification approach was utilized on orthorectified imagery to accurately identify the boundaries of burned areas. Lastly, classified post-fire image was integrated with the forest management map of the region to identify different forest types that were severely affected by the forest fire which could be an important information source for National Forest Directorate to be used for their operational activities to adequately handle response and recovery processes after the forest fire. Our results showed that a total of 1.738,49 ha area was affected as the result of the forest fire and according to forest management map mostly affected tree types are pine trees.

1. INTRODUCTION

Determination of the forest fire patterns has been important task for decades as they have critical relationship with ecosystem functioning, wildlife life and potential future climate impacts (Webber and Flannigan 1997; Dale et al. 2001). Forest fires have also great social impacts by destroying natural resources and human infrastructures (Radeloff et al. 2005).

All among the world, the Mediterranean region is especially vulnerable to forest fires caused by human-induced behaviors or natural conditions. In addition to five European countries Spain, Portugal, Greece, Italy and France suffering from forest fires most severely, respectively; western and southwestern parts of Turkey is being threatened by forest fires as well (Schmuck et al. 2011, Sertel and Alganci 2016). According to the statistics of National Forest Directorate of Turkey, 58 125 forest fires occurred in with a total burned area of 298 699 ha between 1988 and 2015.

Detection of burned areas is a very significant task to demonstrate the extent and effects of fire on environment and to manage further actions for recovery and/or impact reduction (Arnett et al. 2015). Mapping the burned area also provides spatial reference data for future planning actions (Polychronaki and Gitas 2012). Satellite images are commonly used for burned area mapping since it is easy to obtain images of large areas rapidly and differences in spectral response of vegetation and burned surfaces provide impressive information on the conditions of vegetation (Quintano et al. 2011, Sertel and Alganci, 2016). Forest fire monitoring applications were performed either using microwave (Coppo et al. 1991; Luzi et al. 1995) or optical (Giglio and Kendall 2001; Wooster et al. 2012) satellite images.

Several methods have been applied to optical satellite images for burned area detection and generally these methods focused on either vegetation index based analysis or classification of the spectral information (Jakubauskas et al. 1990; Chuvieco et al. 2002; Pu and Gong, 2004). The initial and basic approach was to determine the changes in spectral characteristics of the surface using before and after dated images together (Roy et al. 2005; De Santis et al. 2009; Somashekar et al. 2009; Alganci et al. 2010). Studies showed that empirical index based analysis using the SWIR channel were mostly efficient than the others (Hudak et al. 2007) and the indexes without SWIR channels like NDVI required pre and post fire images to be analyzed together (Sertel and Alganci, 2016).

Previous studies mostly used low – medium spatial resolution satellite images from platforms such as MODIS and Landsat. On the other hand, Gitas et al. (2012) pointed about the need for higher spatial resolution for appropriate analysis accuracy and higher temporal resolution for quicker response after fire phenomenon. Current high resolution (HR) satellites fulfill these needs with higher spatial resolution and urgent programming capabilities. However, most of them does not include SWIR channels, thus require pre – post fire image set for index based analysis. Second option for HR image based analysis is image classification especially when only post fire image is available, where object based classification (OBC) methods asserted to be more efficient (Sertel and Alganci, 2016).

Main objective of this study is to present a practical object based classification method applied to post fire Spot 6 HR satellite image in order to detect burned areas after two forest fires occurred in Antalya district of Tukey. Decision tree based rule set was developed and applied to 1.5m resolution Spot 6 image of the region in order to differentiate the burned areas from other land use / cover (LULC) types of the region. Burn mask obtained from classification results was spatially related to forest management map in GIS environment to determine the burned forest types in the region. Secondary objective is to demonstrate performance of Spot 6 satellite in emergency situations with its urgent mode acquisition capability in addition to its high resolution and comparatively large coverage.

2. STUDY AREA AND DATA USED

Two regions affected by forest fire are located at the south - western part of the Antalya province (latitudes 36º 20' 19" N to 36º 25' 20" N and longitudes 30º 18' 21" E to 30º 28' 22" E) and inside the first degree fire risk zone. A major portion of the area is covered with dense forests and dominant type is Pinus Brutia according to forest management map. The first region surrounded by Kumluca, Cumhuriyet, Beşikçi, Belen and Erentepe districts has a hilly topography with an average elevation around 200m and the second region nearby Adrasan district again showing hilly characteristics with an average elevation around 150m. The location of the study area with burn scars was given in Figure 1 (first region – left circle, second region right circle).

The forest fire affected area is actually a touristic location with natural green lands and closer location to beaches. Therefore, area contains touristic entities, local housings and agricultural lands either greenhouse type or natural in addition to forest areas. The date first fire started was one of the hottest days during the month with 42 ºC which is almost 10 ºC above the statistical mean of previous years (Accuweather, 2016).

Figure 1. Location and satellite view of the study area (background image ©2016 Google, burned area image Spot 6 ©AIRBUS DS, 2016).

The forest fire started on first region (Kumluca) on 24.06.2016 continued by the second region (Adrasan) on 27.06.2016. After the second fire Spot 6&7 satellites were programmed at priority mode and image of the area was acquired by Spot 6 satellite on 01.07.2016 at 08:28 (UTC). Spot 6 satellite provides images with 1.5m high spatial resolution and 60km swath width. Spot 6&7 twin satellites together can provide images from any part of the world with their agile structure and flexible tasking capability which is updated in 4 hours interval (AIRBUS, 2014). Second data source used in this study is forest management map provided by General Directorate of Forest as vector data. This data was prepared according to field work and the version used in this study was updated on 2012. This data includes attributes such as forest type, stand age and crown closure. Also several photographs that were taken during the forest fires were achieved from web sources and press (Figure 2).

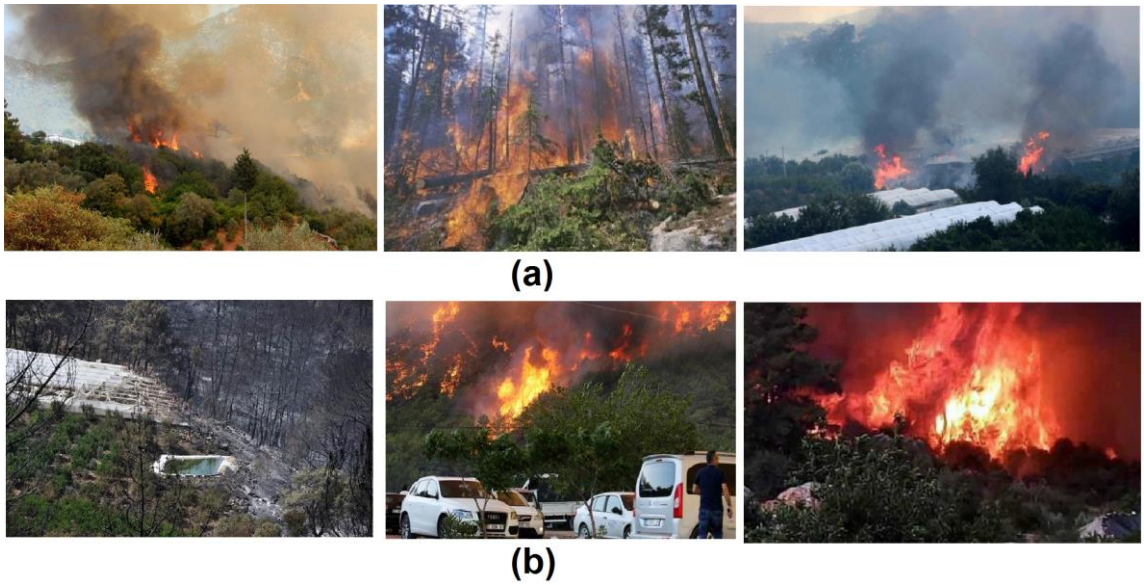

Figure 2. Photographs from fire a) Kumluca and b) Adrsan regions.

3. METHODOLOGY USED

Spot 6 satellite image was obtained as pansharpened and orthorectified product in UTM coordinate system and WGS 84 datum. Image was subset according to burn scar extend which was determined by visual interpretation. Forest management map was also converted to same coordinate system and datum in GIS environment.

Object based classification (OBC) is an efficient method for deriving thematic information especially from HR and VHR images. In this method, segmentation process is applied to images according to parameters such as scale, shape and color in order to produce objects from pixel groups.

Firstly, multiresolution segmentation algorithm was applied to Spot 6 image by using eCognition Developer© v.9.0 software. Image bands were weighted as “0.7, 0.7, 0.7, 1” respectively for “Red, Green, Blue, NIR” proportional to their standard deviation values. Other parameters were defined experimentally to obtain the best fit segments for fire scars. Scale parameter as “100”, color parameter as “0.8”, shape parameter as “0.2” and compactness as “0.5” were selected to reach optimized segments. Actually segmentation process can be assumed as first level thematic information extraction (Figure 3).

Figure 3. Spot 6 image before – after segmentation process; a) pixel view, b) segment view.

Created image objects were classified to determine the burned regions in the second step. For this purpose, a rule set based on decision tree was designed for burned area class. Class descriptions were structured according to membership functions that were defined according to image spectral properties. Thresholds were determined experimentally with use of Red and NIR mean brightness values of segments. For the current study, "260 – 440" and "280 – 540" respectively for Red and NIR bands were selected as appropriate thresholds to detect burn scars. Spot 6 image of the study area and OBC classification result is given in Figure 4.

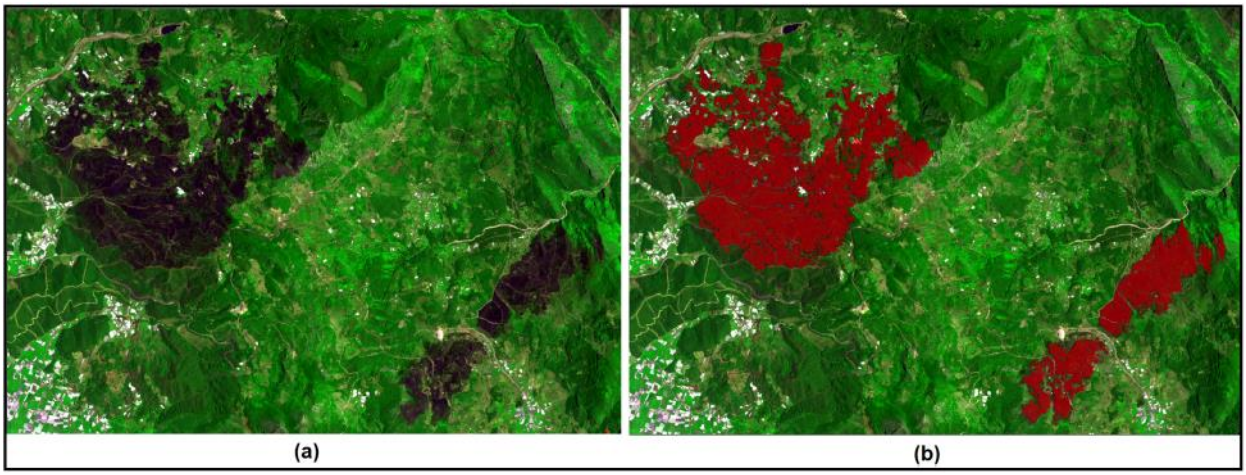

Figure 4. Spot 6 image (Red/NIR/Blue) of the study area and OBC classification result.

A burn mask was created from classification result by converting the thematic raster class data to vector form. Then, burn mask was intersected with forest management map in GIS environment to determine the forest types affected from fire. Resulting burned area forest type map was given in Figure 5. After the intersection analysis, spatial statistics of burn patches were extracted from burned forest type data and areal information of burned forest types were determined (Table 1).

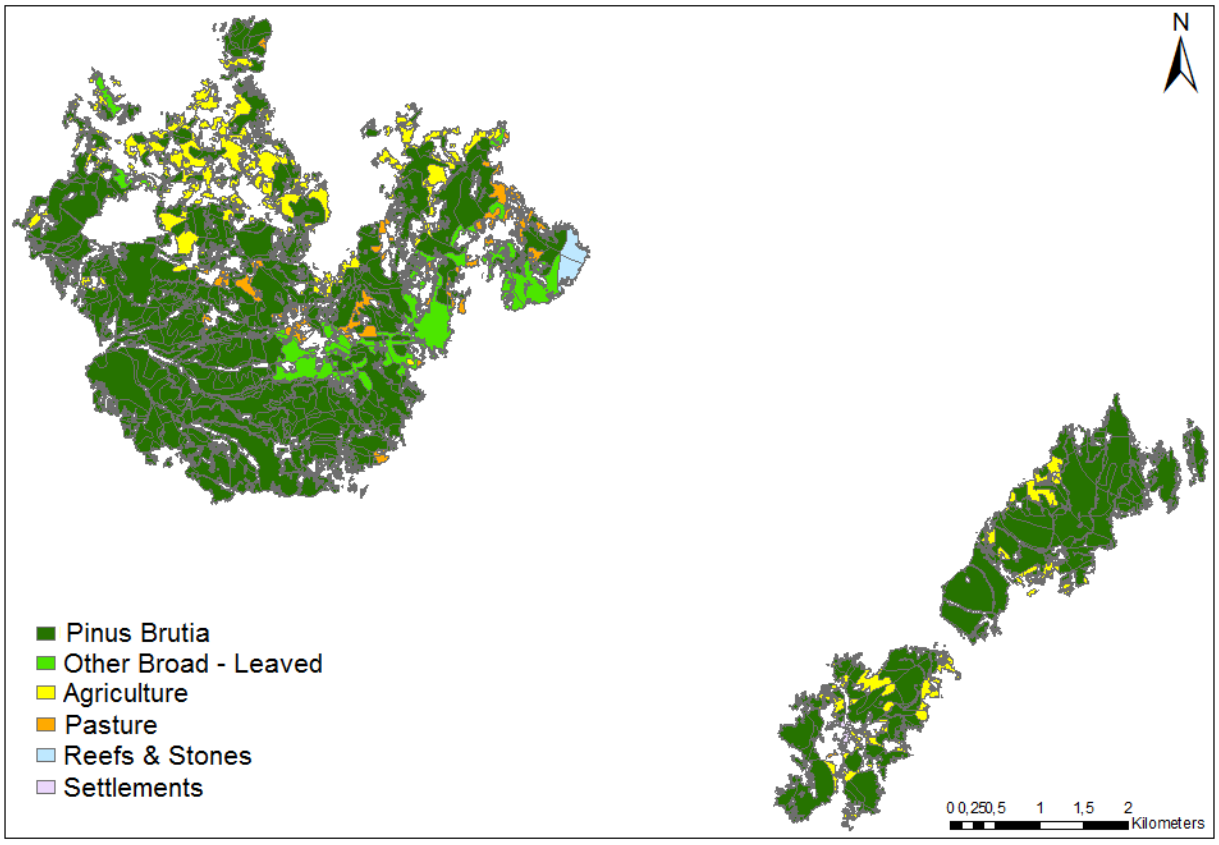

Figure 5. Burned area LULC map derived from forest management map.

Table 1. Areal information of burned forest types.

Forest Type	Area (ha)
Pinus Brutia	1,352.57
Agriculture	198.33
Other Broad - leaved	119.92
Pasture	51.76
Reefs and Stones	12.93
Settlements	2.98
Total	1,738.49

4. RESULTS AND CONCLUSIONS

Producing highly accurate and timely information of burned areas is an important task as this information can help response, recovery and mitigation processes. Produced information can also be used in future planning of the area by policy makers.

A decision tree based OBC classification to map the burned areas and their spatial distribution with HR Spot 6 post fire satellite image was introduced in this study. The simple rule set based on brightness value thresholding provided acceptable results for identification of the burned areas. According to results of the study, a total of 1,738.49 ha land was affected from these fires while forest areas and agricultural lands were the most affected LULC types.

Spot 6 satellite “priority” and “urgent” mode tasking in addition to its high spatial resolution provided an emergency mode post fire monitoring at appropriate scale and accuracy that policy makers can benefit. Introduced methodology is quite suitable for situations only post fire HR and VHR imagery of the affected region is available and there is lack of SWIR channel to produce burn ratio indices.

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