AUTOMATED DETECTION OF THE BANANA FIELDS FROM SAR IMAGES

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KEY WORDS: Agriculture, Banana detection, SAR, Sentinel, Remote Sensing

ABSTRACT: Detection and monitoring of agricultural fields uses is important in terms of minimizing the problems arising from wrong field use. In our study, the banana fields in Antalya-Gazipaşa are investigated with the use of Sentinel-1 SAR and also Sentinel-2 optical datasets for comparison purpose. The aim of the study is separation of the banana fields from the other areas. Two methods are applied to separate the banana fields including forests. In the first method, the study area was classified on the optical image with the Enhanced Vegetation Index (EVI), which is sensitive to the structural variations of the vegetation. Since radar systems provide data acquisition in all weather conditions whether on day or night. The performance of radar sensing is affected by transmitter power, and antenna size, weather, atmospheric effects and other signal sources. In the second method, in order to minimize these negative effects, the difference in average values of images of the lowest and highest volumetric density of banana trees were calculated. Finally, the minimum and maximum threshold values were determined with histogram the threshold values obtained from Sentinel-1 and Sentinel-2 images were used to separate the banana areas from other areas. The final results show that results obtained with the Sentinel-1 SAR dataset are more accurate compared to the results from optical images.

1. INTRODUCTION

The urban population in the world increases with the need for natural resources in cities and the pressure on existing resources. The agricultural areas require to meet the food needs, and it can only be obtained by destroying natural environments (Şahin and Kendirli, 2012). In this case, it is possible to increase agricultural production by obtaining more products from specific area. Monitoring of the agricultural fields is important forest establishment of the policies and the decision-makers. Because sustainable and effective use of agricultural land is of great importance in the development of countries.

To monitor the agricultural fields, remote sensing technology is useful to achieve results in a short time with low cost. Optical and radar sensors have been used frequently for agricultural studies. Optical sensors have a rich spectral resolution but have limitations in terms of data acquisition time and weather conditions. On the other hand, radar sensor has advantages with their capability to acquire image data in all weather conditions and 7/24 hours since they are passive sensors, do not need solar radiation to derive the images and sensors are sensitive to the object geometry, and soil moisture which is important for the agricultural fields.

Satellite data are a valuable resource for land use and land cover mapping. Especially, it provides great convenience in solving problems of different scales in studies related to crop yield (Duchemin et al, 2015; Baup et al, 2015). The optical dataset has been widely used in recent years for the mapping of agricultural areas and the classification of crops (Wardlow et al 2008; Arvor et al.2011; Azzari et al.2017). However, the use of optical data is limited to affect by weather conditions. Radar systems penetrate the cloud cover and are not dependent on sunlight. More importantly, it is sensitive to various parameters such as moisture content, size, and shape of the plant (Bush et al. 1978; Wang et al. 1987).

In this study, two different methods were applied using Sentinel-1 SAR and also Sentinel-2 optical data sets to separate banana fields in the Antalya-Gazipaşa region. The aim is the separation of the banana fields from the forest area. The banana fields are open areas and also greenhouses. In the first method, the Sentinel-2 optical dataset was classified with the Enhanced Vegetation Index

(EVI). In the second method, in order to minimize the adverse effects on SAR images, the difference in average values of images of the lowest and highest volumetric density of banana trees were taken. Finally, the minimum and maximum threshold values were determined with histogram The threshold values obtained from Sentinel-1 and Sentinel-2 images were used to separate the banana areas from other areas. The results obtained from both methods were compared with the results obtained manually from Google Earth.

2. MATERIALS AND METHODS

2.1 Study Area and Used Data

This study was applied in the Antalya-Gazipaşa region in Türkiye. The banana fields are open areas and also greenhouses. While the open-field banana production can be harvested once a year, the banana harvest is made twice a year thanks to the underground banana production (Tarım ve Orman Dergisi, 2019). The maintenance of banana trees in the region starts in February and continues until the end of March. The study area is shown in Figure 1.

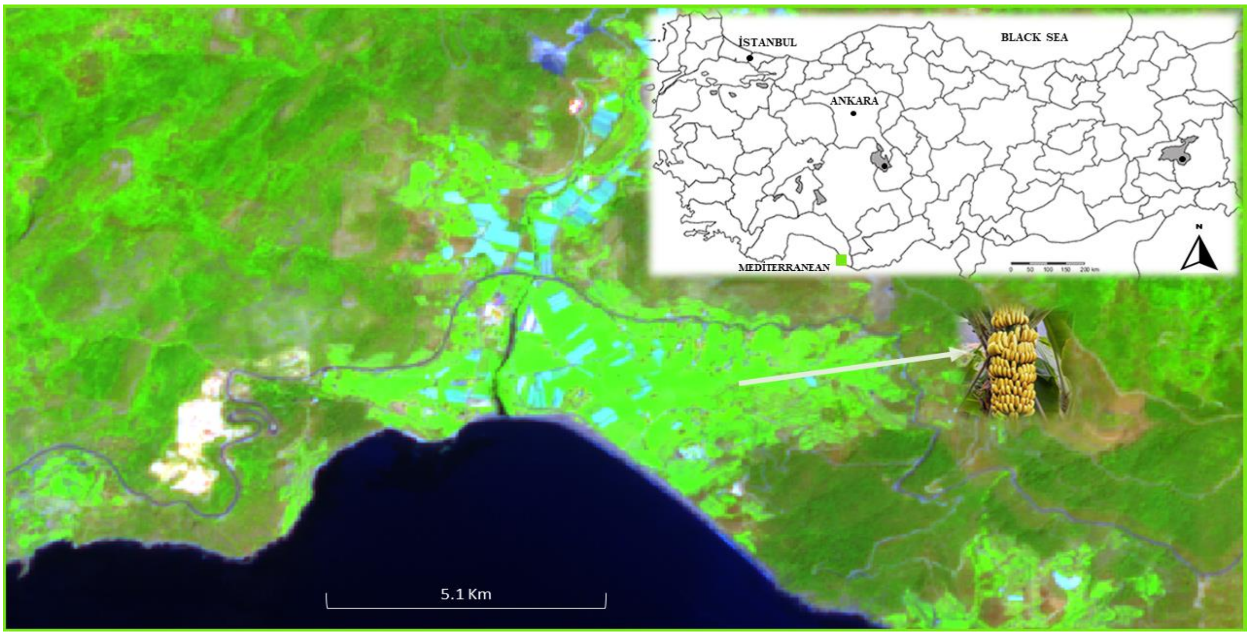

Figure 1: .The study area

In this study, Interferometric Wide Swath (IW) mode Sentinel-1 C Band SAR and Sentinel-2 optical images are used as the main data. The properties of Sentinel-1 and Sentinel-2 data are given in Tables 1 and 2. Sentinel-1, VV, and VH have double polarization bands. The results obtained from both bands were evaluated. Higher accuracy was obtained with VV polarization.

Table 1: Properties of the S1 level-1 product GRD

Satellite	Sentinel-1B
Orbit Mode	Ascending
Operational Mode	IW Swath Mode
Instrument	SAR-C
Polarization	VV
Revisit Time	6 days
Range and Azimuth Spacing	10 m
Azimuth and Range Looks	Single

Table 2: Properties of the S-2 optical data

Satellite	Sentinel-2
Spectral Bands	13 Bands (VIS, NIR, SWIR)
Spatial Resolution	10, 20 and 60 m
Orbit Mode	Ascending
Revisit Time	5 days
Swath Width	290 km

The banana fields are open areas and also greenhouses. Growth stages, maintenance, and planting periods of banana fields were investigated. As agricultural cycle, the banana trees volume decreases by February till March, this is also time period of maintenance of the banana greenhouses. After this period, the volume of the banana trees increases, which are the indicators for their separation from the other trees. Radar images are useful to identify these changes as we have used. SAR and optical images were provided from Copernicus Open Access Hub with free of charge. The dates of the selected images are given in detail in Tables 3,and 4.

Table 3:The Sentinel-1 SAR dataset

	Date of Lowest Tree Density	**Date of Highest Tree Density**
Date	6 March 2019	16 July 2019
	12 March 2019	28 July 2019
	18 March 2019	9 August 2019
	24 March 2019	21 August 2019

Table 4:The Sentinel-2 optical data

	Date of Highest Tree Density
Date	12 August 2019

2.2 Methodology

In this study, two different methods were applied using Sentinel-1 SAR and Sentinel-2 optical satellite images. The process steps consist of 4 stages. These steps: i) SAR and optical dataset pre-processing, ii) SAR image enhanced, iii) change detection with enhanced SAR images, iv) the optical data classification with EVI.

Satellite images contain systematic or unsystematic errors. To fix these errors, some pre-processing steps are needed to apply. First, the orbit file is updated for each SAR scene. The radiometric correction was applied so that the images can represent the objects on the land surface correctly. The speckle effect on the SAR image reduces the distinctiveness of land classes. In removing the noise on the image: Refined Lee filter was applied (Zhang et al. 2019). Also, the window size was determined to 11 * 11 to protect the image texture. Finally, Range Doppler Orthorectification, a method suggested by Schubert and Small (2008), was used for geometric correction. The pre-processing steps applied to the Sentinel-1 images are shown in detail in Figure 2. All 13 bands in Sentinel-2 products do not have the same resolution. 13 bands were resampled. Then, images were re-coordinate using the Reproject algorithm.

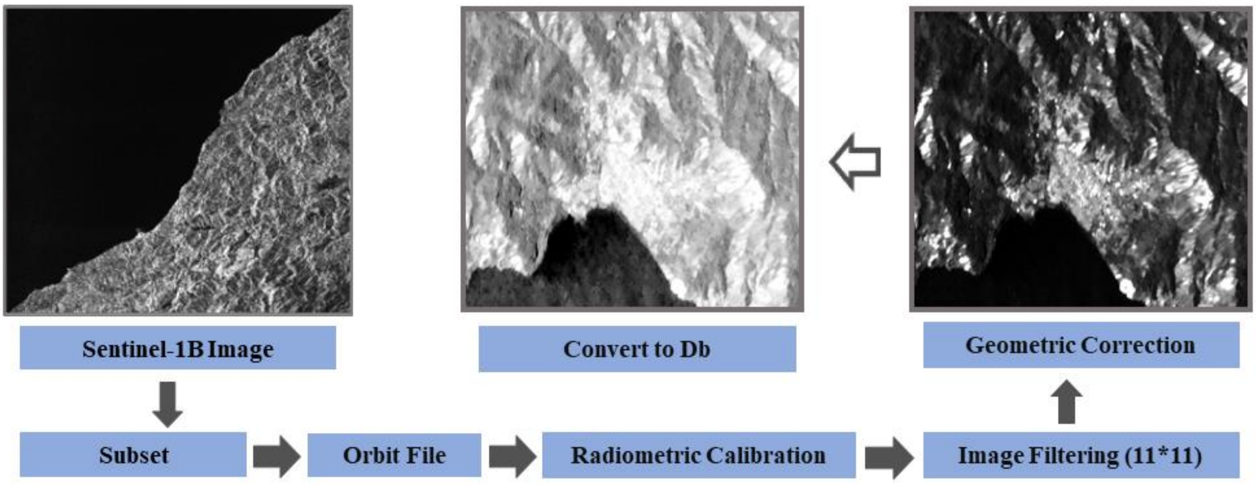

Figure 1: SAR image pre-processing steps

In remote sensing, images need to be improved both visual and quantitatively to comment on them more accurately. The aim here is to increase the information to be obtained from the image. To enhanced the spectral information content of SAR images, the difference in average values of images of the lowest (6, 12, 18, and 30 March) and highest (16 and 28 July; 9 and 21 August) volumetric density of banana trees were taken. The equation used for the average image is as follows:

$$f(x) = 1/\mathrm{k} + \sum_{i=1}^{n} (\mathrm{wi\ Xi})$$

i=1,2,………,n wi, j: Weight, Xi,j: Brightness value,
wi=1 for i=1 and k=n and $f(x)$: Band average.

The change in banana trees were determined by taking the difference of the average images. The average difference image is shown in Figure 3.

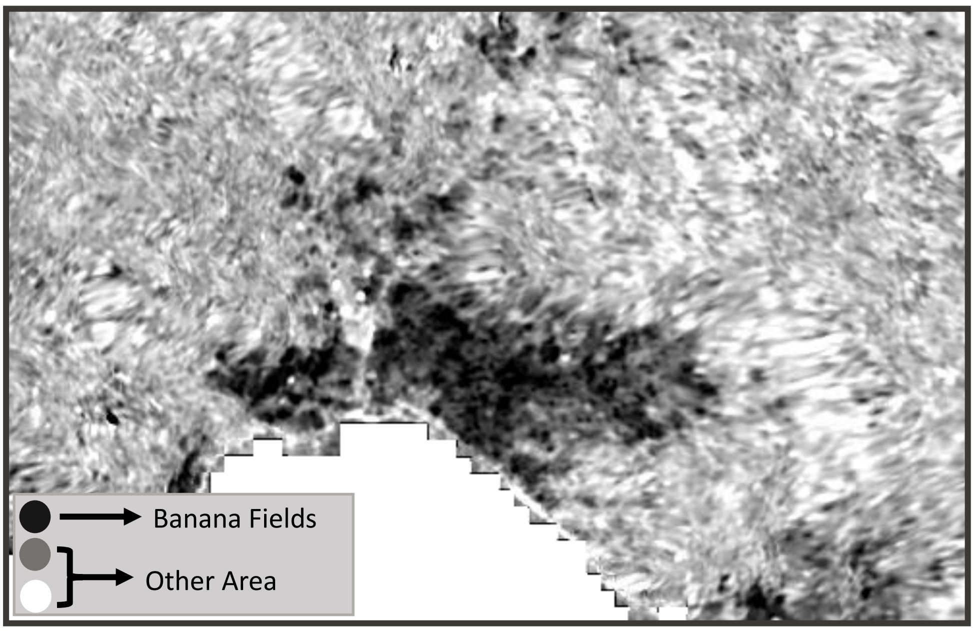

Figure 3: SAR, the average difference image

Multi-band satellite images can be classified using different indexes. Green leaves have an evident spectral reflection in visible (VIS) and near-infrared (NIR) wavelengths. The reflection values of

green leaves in the blue and red regions are very low and higher in green. Therefore, the leaves appear green to the human eye. Enhanced Vegetation Index (EVI) was applied to classify the study area. The equation used for the EVI is as follows:

$$2.5 * \frac{(NIR - RED)}{(NIR + C1 * RED - C2 * BLUE + L)}$$

(L=1, C1=6 and C2=7.5) It includes the C1 and C2 coefficient to correct the aerosol scatter in the atmosphere and the L coefficient to adjust the backgrounds such as soil and canopy. RGB image and Enhanced Vegetation Index results are shown in Figures 4.

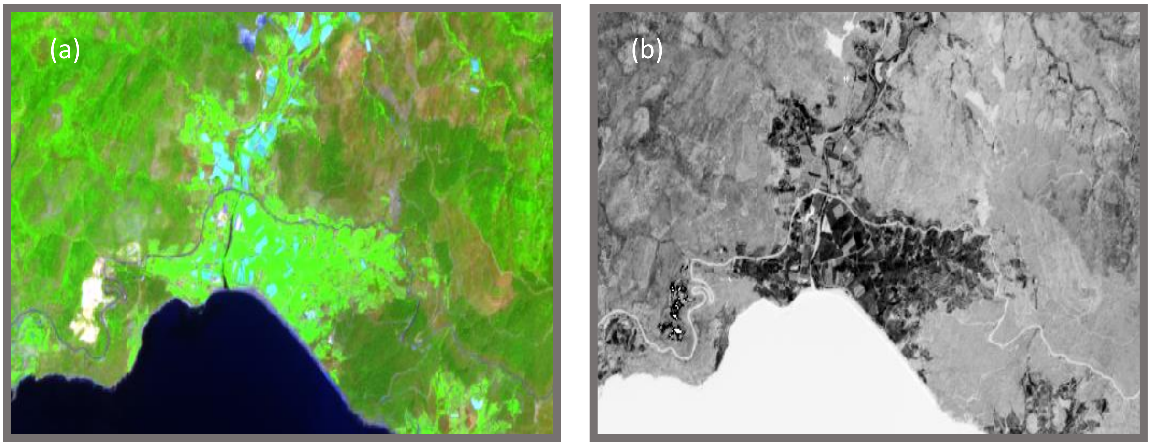

Figure 4: a) Sentinel-2, RBG image, b) Enhanced Vegetation Index (EVI)

3. RESULTS

In this work, two methods are applied to separate the banana fields. As much as radar systems provide data collection in all weather conditions whether on day or night, the performance of radar sensing is affected by transmitter power, and antenna size, weather, atmospheric effects, and other signal sources. In order to minimize these negative effects, the difference in average values of images of the lowest and highest volumetric density of banana trees were taken. The Sentinel-2 optical dataset was classified with Enhanced Vegetation Index (EVI). EVI is sensitive to structural variations of the vegetation. Therefore, it enabled easily separation of greenhouse and open areas grown banana fields. The minimum and maximum threshold values of banana areas were determined with the help of a histogram on the result images. Histogram graph of banana areas are shown in Figure 5.

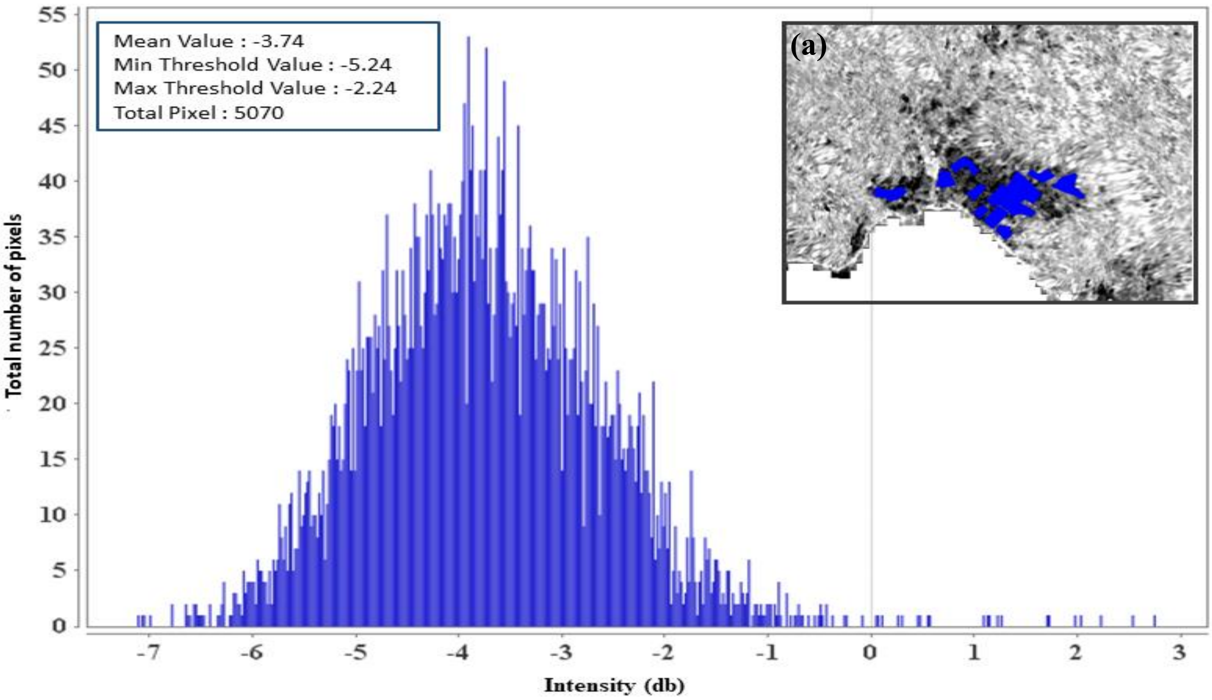

Figure 5 : Average image difference histogram graph (a) Radar, Average image difference

Vector data representing the banana areas on the radar image were obtained manually from the Sentinel-2 optical image. The minimum and maximum threshold values of banana backscatter was obtained by adding -1.50 dB and +1.50 dB to the average value on the histogram. Threshold values and results applied to the images are shown in figure 6.

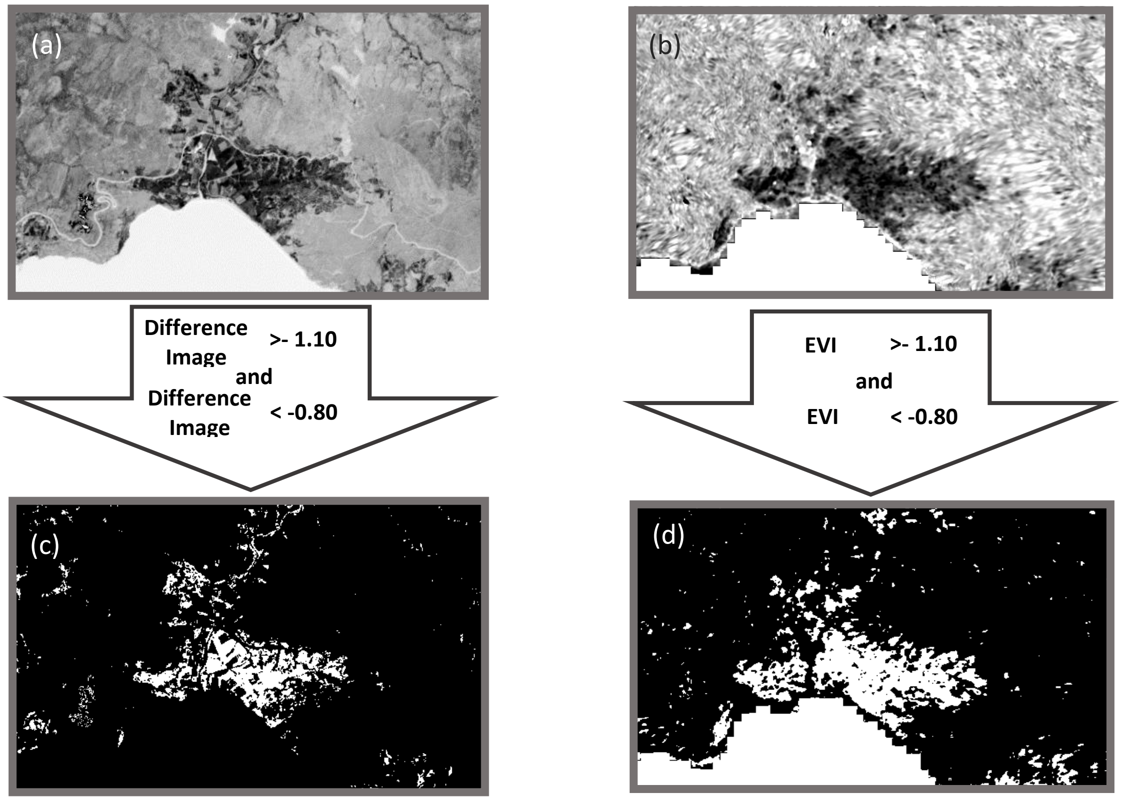

Figure 6: a) Classified image with EVI, b) Average difference image, c, and d) Threshold applied image

In the final stage of the study, raster images were converted to vector data. A morphological filter was applied to the images in order to eliminate the small areas outside the banana area. The filtering results applied to the images are shown in detail in Figures 7,and 8. In addition, in the to evaluate the accuracy of the banana areas, the banana areas were digitized manually from the high-resolution Google Earth image. Banana areas extracted from the images are shown in Table 7, and 8.

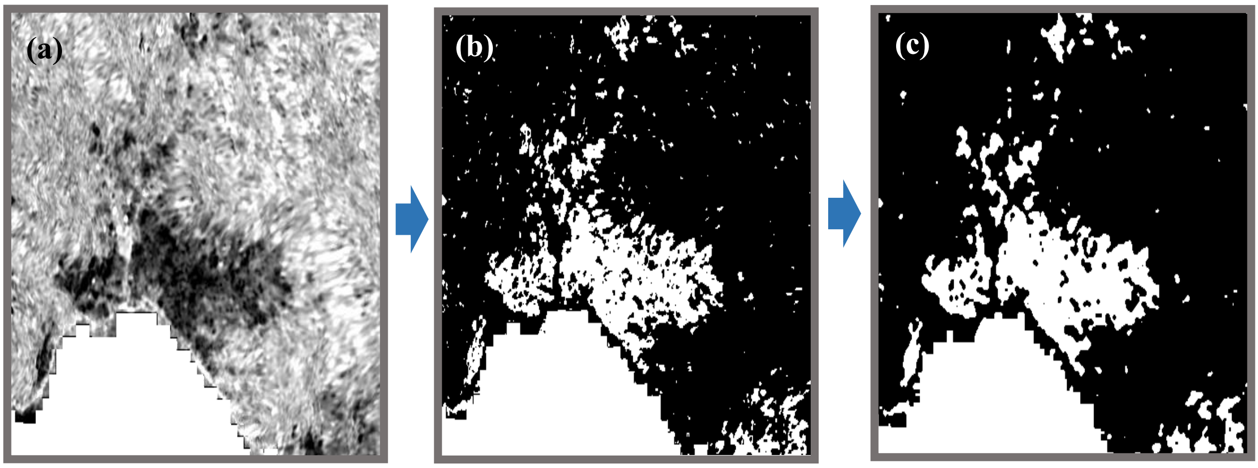

Figure 7: a) Average difference image, b) Threshold applied image C) Morphological Filtered image

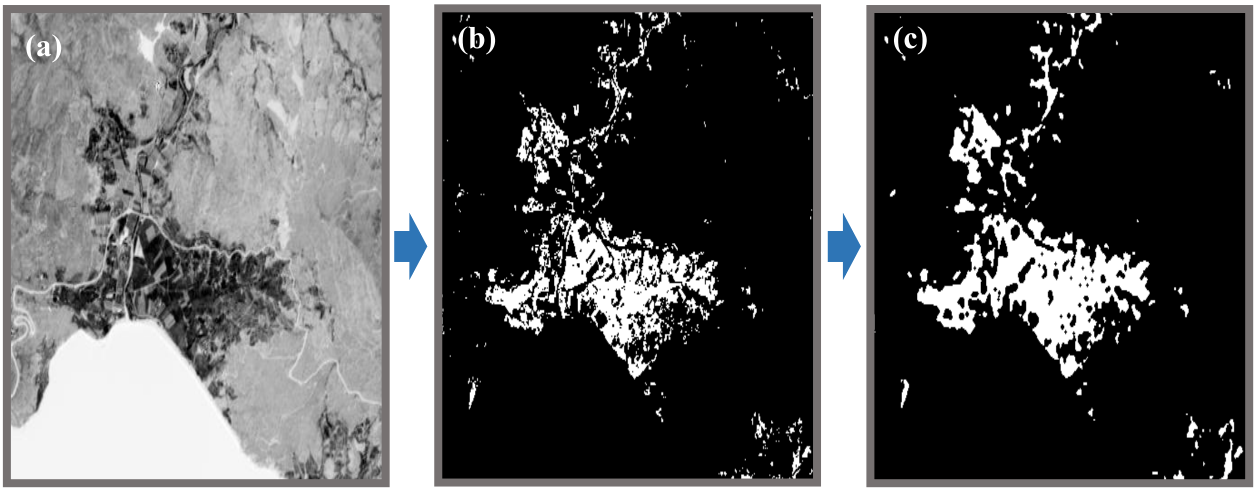

Figure 8: a) Classified image with EVI, b) Threshold applied image C) Morphological Filtered image

Table

SATELLITE IMAGE	METHODS		
	Average Image Difference	Enhanced Vegetation Index (EVI)	Manuel (Reference Data)
Sentinel-1 SAR	184.83 ha	-	
Sentinel-2 Optical	-	143.11 ha	
Google Earth	-	-	163.27 ha

4. CONCLUSIONS

The rapidly increasing population in the world and our country, the demand for banana production is increasing. The aim of this study is to separate banana fields from other areas using Sentinel-1 SAR and Sentinel-2 optical satellite images. Two methods were applied to separate the banana fields including forests. The banana fields are open areas and also greenhouses. As the agricultural cycle, the banana trees volume decreases from February till March, this is also time period of maintenance of the banana greenhouses. After this period, the volume of the banana trees increases, which are the indicators for their separation from the other trees. Radar images are useful for identifying these changes. Also, different indexes are used to classify multispectral satellite images. To support the results obtained from the SAR dataset, the area study with Enhanced Vegetation Index (EVI) was classified on the Sentinel-2 optical dataset. The minimum and maximum threshold values of banana areas were determined with the help of a histogram on the images. The areas obtained from Sentinel-1 SAR and Sentinel-2 optical images were calculated. The results from Sentinel SAR images is closer to the area which was generated from Google Earth compared to the results from optical images.

Different methods used in the study showed that the SAR dataset provided better results in agricultural areas. In future studies, using radar systems that has different wavelengths ve different band polarizations expected accuracy of calculations

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