DETECTING CLEAR-CUT AREA USING REMOTELY SENSED DATA IN ISTANBUL - SILE REGION

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SUMMARY

As is known to all, the world's natural sources are limited. For this reason, land management strategies are getting more important day by day.Remote sensing is one of the main solution for geographic information systems issues such as producing land cover-land use maps for presenting total forest areas, urban fabric and cadastral areas especially for cosmopolite cities. In turkey, Istanbul is the first city come to mind for correct city planning in order to monitor the boundaries especially forest cadastres. Nowadays, Remote Sensing technologies are commonly used for detecting cut-clear areas in worldwide forests. In Anatolian side of Istanbul, north-east part of city, pits areas because of mine work are observed in forest boundaries with using change detection methods. For this aim, remotely sensed images of Istanbul's are used with ten year period. Medium resolution images: Landsat 7 ETM + and high altitude aerial orthophotos are used as data source.The process was carried out with three different two-dimensional change detection methods. In the end of the study, classified raster images converted to vector format for determining clear-cut areas.

ÖZET

Bilindiği üzere, dünyada doğal kaynaklar oldukça limitli ve son yıllarda doğal kaynaklarımız gün geçtikçe azalmaktadır. Bu nedenle, doğal kaynakların bilinçli bir şekilde kullanılması ve takip edilmesi açısından arazi yönetimi günden güne daha da önem kazanmaktadır.

Coğrafi bilgi sistemlerinde, Uzaktan Algılama teknolojileri bu konuda kullanılan tekniklerin başında gelmektedir. Özellikle nüfus artışıyla beraber kentleşmenin arttığı şehirlerde ormanalanları, yerleşim bölgeleri, endüstriyel alanlar vb. Alanlar yeryüzü kullanım/örtüsü haritaları ile birbirinden ayırt edilerek farklı haritalar ve planlarla gösterilebilmektedir.

Günümüzde önemli yerleşim şehirlerinden olan İstanbul'da ormanalanları sınırlarının yüksek doğrulukla gösterilmesi orman kadastrosu açısından önemli konulardan biridir. Dünya ölçeğinde olduğu gibi ülkemizde de, orman alanlarının sınır takibinde Uzaktan Algılama teknolojileri kullanımı oldukça yaygındır. Bu çalışmada, İstanbul ilinin Anadoluya kasında bulunan kuzey ormanalanlarındaki değişimler farklı yöntemler ile on yılda meydana gelen değişimler hesaplanmıştır.

Çalışmada kullanılacak veri olarak, orta çözünürlüklü Landsat 7 ETM + ve yüksek çözünürlüklü ortofotolar seçilmiştir. Veriler üzerinde iki farklı görüntü işleme analizi -NDVI ve PCA- ile ormandaki alanları ayrı tarihler için hesaplanıp, daha hassas alan sonucu verebilecek orto fotolar üzerinden hesaplanan alan ile kıyaslanmıştır. Bu kıyaslama sonucunda, NDVI analizi sonucunda elde edilen bulguların, PCA analizi sonucundaki bulgulara kıyasla orman alanındaki değişimi daha isabetli olduğu görülmüştür.

1. INTRODUCTION

Forest area plays important role of the country land. In this context, % 27.7 of Turkey's total land area belongs to forests (URL-1). In Turkey, there is a related ministry (Ministry of Forest & Water Affairs) and diractorate (General Directorate of Forestry) for pursuiting the forest boundaries all over the country.

Istanbul is a metropol, gets immigration excessively a lot especially in the last decades. It affects the city's natural texture negatively. Besides Istanbul's demographic alteration, industry and production sites' density getting more and more. Also, raw materials need is increasing in the same ratio. As is known, natural resources are used all over the country sometimes unconsciously, including metropols.

In Istanbul, there are many new tree planting areas except for sowing and planting areas in order to inrease the total green area. Nevertheless, due to several reasons; deforestration threats are reducing the total forest areas day by day. Some changes are due to natural events or accidents such as forest fires and some of these are illegal individual actions. However, in some instances clear-cut due to big public projects requirements. Istanbul city is appropriate for forest nascency due to the geography, topography, climate and soil qualifications (No Name, 1993). As is known, forest cadastre is the procedure of detection with place, limitation, measurement, and registration. So, chasing forest borders is crucial issue about forest cadastre. According to year 2010 statistics Istanbul total area is 537,917.7 hectares; it is 238,710.4 hectares of forest area constitutes(URL-2).

Multi-temporal analysis depend on remote sensing data has been used to assess the impact of land cover and land use change (LCLUC), over the past three decades((Abd El-Kawy, Rød, Ismail, &Suliman, 2011; Weng, 2002),forest cover monitoring (Coppin & Bauer, 1994; Hais et al., 2009; Woodcock, Macomber, Pax-Lenney, & Cohen, 2001), and biodiversity (Hansen et al.,2001).Landsat products such as MMS,TM and ETM+ are extensively used as they provide a good accommodation between the spatial resolution and the temporal coverage (Williams, 2006) and are available cost free from the United States Geological Survey (USGS) (Woodcock et al., 2008).

In Şile region, mining continues for at least ten years. Hence, total forest areas are affected by these work. In this study, we focus on that region's forest coverage alteration in the last decade and determining of clear cut areas with using different methods and data.

2. MATERIAL AND METHOD

2.1 Test Site and Data

The study area covers more than 35 km^2 and is located in northern İstanbul, Şile Region (fig.1). In this area forests are dominated by, cermes oaks, chestnuts, maquis, pinus pineas and oaks (URL-3). Clear-cutting and leaving the areas for natural re-growth is pretty much in study site. Furthermore, significant forest change resulting from logging activities.

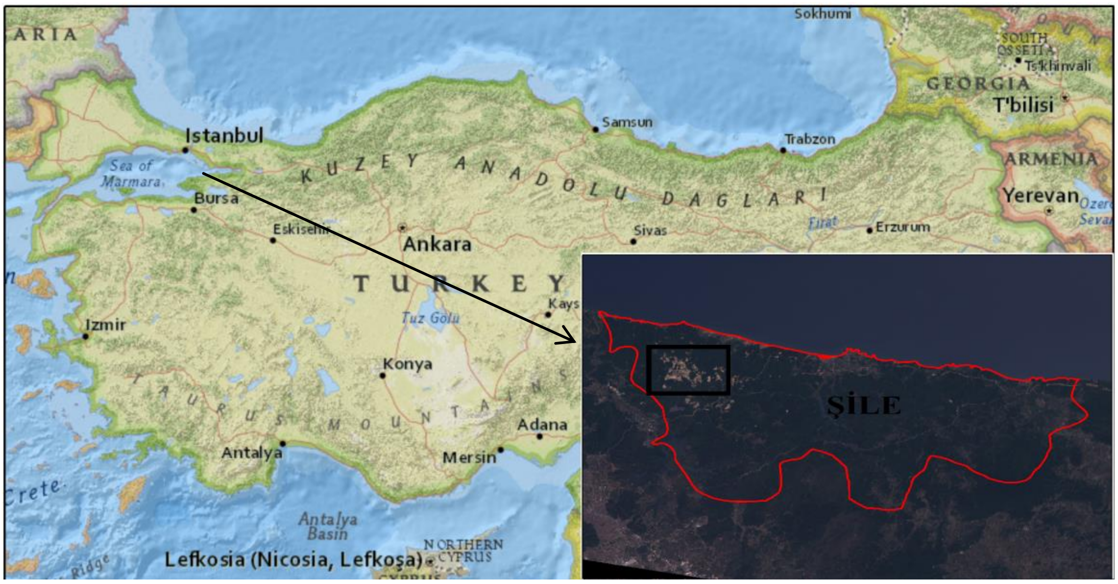


Fig. 1. Study area

The study area is fully covered by 6 aerial ortophotos and 7 Landsat 7 ETM+ images. Landsat Images and aerial orthophotos were used as listed in Table-1. A total of images having less than 30% cloud cover. In data pre-processing stage, each of the satellite image are radiometrically and geometrically corrected.

Table1. Remote sensing data used in this study

Sensor	Acguisition Date	Spatial Resolution
Landsat 7 ETM +	15 May 2000	30 m
Landsat 7 ETM +	2 July 2000	30 m
Landsat 7 ETM +	7 November 2000	30 m
Landsat 7 ETM +	25 April 2010	30 m
Landsat 7 ETM +	27 May 2010	30 m
Landsat 7 ETM +	12 June 2010	30 m
Landsat 7 ETM +	16 September 2010	30 m
6 Aerial Orthophotos (Mosaicked)	2010	0.3 m

The Landsat 7 ETM+ images used for this study are available cost free from the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Data Center via the Earth Explorer USGS web interface (URL-4). The Landsat 7 ETM+ datain GeoTIFFformat in the Universal Transverse Mercator (UTM) map projectionwith a World Geodetic System 84 (WGS84) datum. Each imageconsisted of six spectral reflective bands, two thermal bands and a panchromatic band. Six ETM+bands were processed and included in the final composite image: blue band 1 (450-520nm), green band 2 (520-600nm), red band 3 (630–690 nm), near infrared band 4 (760–900 nm), and two mid infrared bands 5 (1550–1750) and7 (2080–2350 nm).

The 6 mosaicked aerial ortophotos belonging to year 2010 were acquired from Istanbul Metropolitan Municipality Map Department. The ortophotos were mosaicked and transformed to UTM map projection and WGS 84 datum.

2.2 Clear-Cut Detection Approach

Remotely sensed data’s time, should be considered well first, especially for forest boundaries’ change detection. Because, some types of tree groups have seasonal changes . For preventing this delusion, choosing data, acqusition times in the meaning of month are important. In this case, for this study it is considered.

In this study mutitemporal images and aerial orthophotos were used to determine clear-cut areas.Three different techniques for clear-cut detection were tested: (1) multitemporal NDVI analysis (2) multitemporal PCA analysis and (3) screen on digitizing (fig.2).

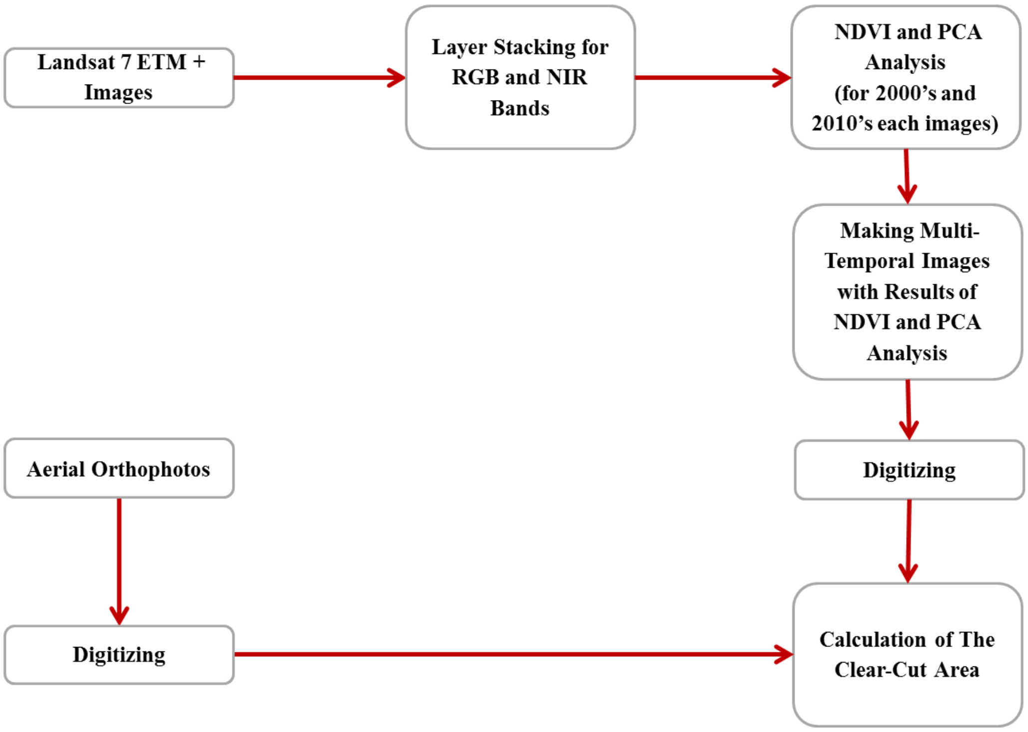
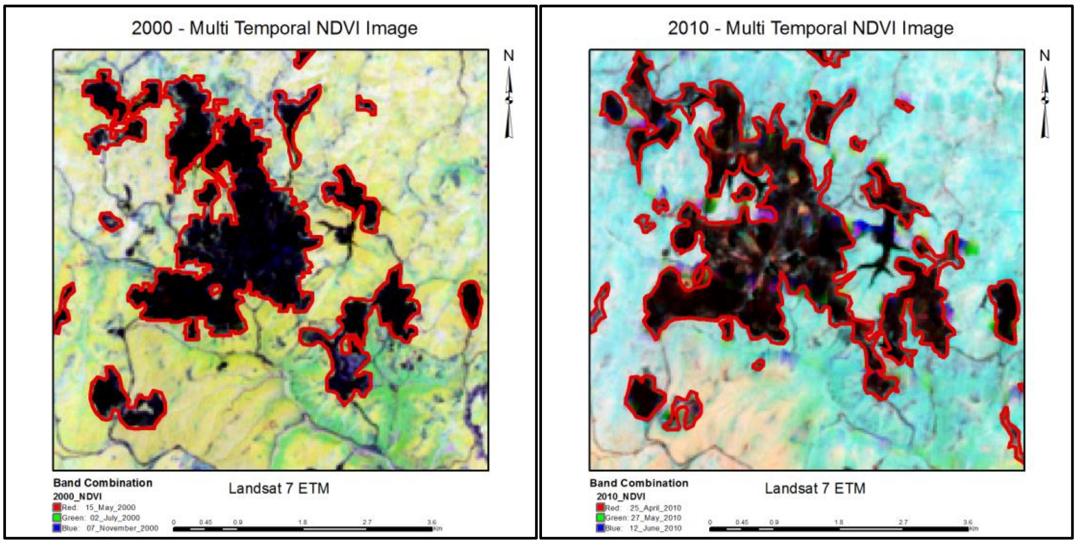


Fig. 2. Workflow diagram

In order to determine the area of a 10 year land use/cover change of the mining areas, 2000s and 2010s Landsat 7ETM+ images were used. Moreover, high resolution aerial orthophotos were used to determine the land use/cover of clear-cut areas in 2010. The clear-cut areas in satellite images were compared with theaerial orthophotos.

NDVI is a mathematical expression that uses the Near Infrared and visible red bands to seperate the differences between vegetation and non-vegetation (Morawitz et al., 2006). NDVI is used to measure change in green vegetation. In land use/cover change detection studies, NDVI differencing has been used widely (Singh, 1989; Mas, 1999). Multitemporal NDVI images were created for the study area using Landsat 7 ETM+ data from year 2000 and year 2010 and they were combined to create a single image to detect clear-cut areas. In 2000, the date of 15 May, 2 July, 7 November of NDVI images were created and multitemporal NDVI image were stacked by combining three NDVI images and in year 2010, the date of 25 April, 27 May, 12 June, 16 September of NDVI images were created and multitemporal NDVI image were created by combining four NDVI images (fig.3).

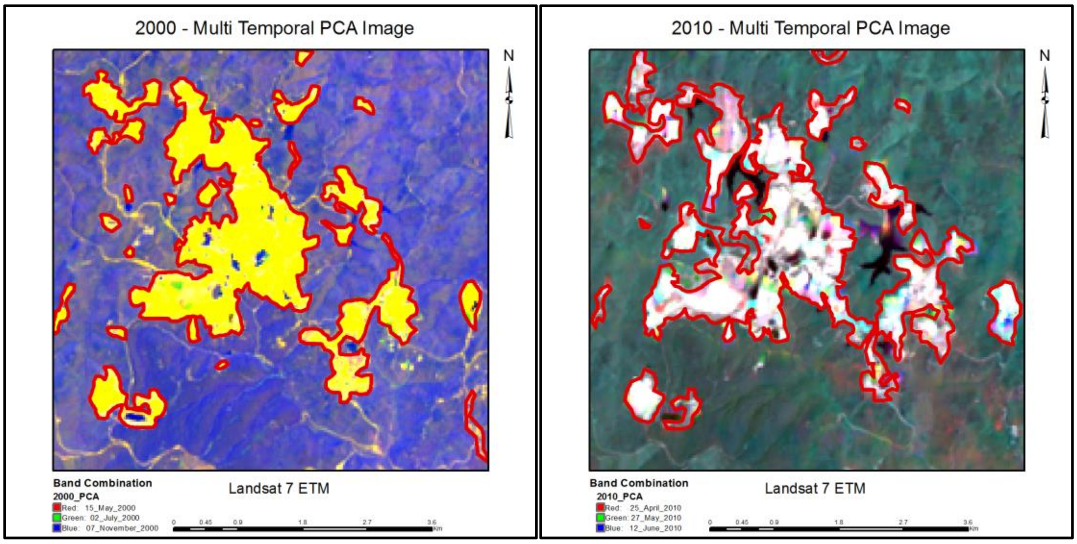


a) 2000 multitemporal NDVI b) 2010 multitemporal NDVI

Fig. 3. Multitemporal NDVI analysis

As a result of digitizing, clear-cut areas in the multitemporal NDVI image of the year 2000 and year 2010 was calculated 752.59 ha and 844.74 ha respectively.

According to Hirosowa et al. (1996), “PCA is a linear transformation of correlated variables into uncorrelated variables which does not change the number of variables (spectral or temporal bands)”.In this study, PCA was used to detect localized changes in forest clear-cut areas in multitemporal datasets. In year 2000, the date of 15 May, 2 July, 7 November of PCA images were created and multitemporal PCA image were created by combining three PCA images. In year 2010, the date of 25 April, 27 May, 12 June, 16 September of PCA images were created and multitemporal PCA image were created by combining four PCA images (fig.4).



a) 2000 multitemporal PCA b) 2010 multitemporal PCA

Fig. 4. Multitemporal PCA analysis

As a result of digitizing, clear-cut areas in the multitemporal PCA image of the year 2000 and year 2010 was calculated 708.29 ha and 799.42 ha respectively.

In order to calculate the clear-cut areas through aerial orthophoto applied to digitizing method and clear-cut areas were calculated (fig. 5).

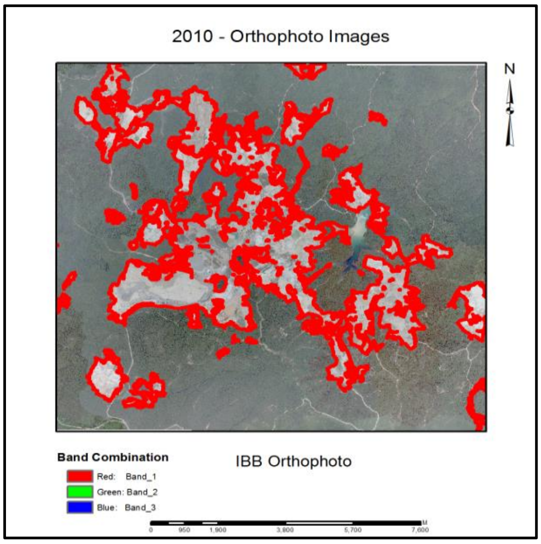


Fig. 5. 2010 Aerial Orthophoto Digitizing

As a result of digitizing, clear-cut areas in orthophotos of the year 2010 was calculated as 769 ha.

3. RESULTS AND DISCUSSION

NDVI and PCA analysis were performed to distinguish clear-cut area from land objects around the mine areas, especially forest and green areas. The clear-cut area is determined by the digitizing methods.Furthermore, determination of clear-cut area on aerial orthophotos is performed by digitizing methods.

In the end of the study, total clear cut area change was detected for the last decade in North forests of Istanbul. In year 2000, after multitemporal PCA analysis the area was calculated as 708.29 ha and year 2010 multitemporal PCA analysis was calculated as 799.42 ha. The difference of the total area was determined 91.13 ha. Another technique in order to find the clear-cut area detection in study region was NDVI. In year 2000, multitemporal NDVI analysis showed that clear-cut area was 752.59 ha. After ten year of this, the area was calculated 844.74 ha with NDVI in year 2010. The difference of area was 92.15 ha, for this technique. For more comprehensive study in this region, aerial orthophotos were chosen due to being high resolution data than the other data that used. With using aerial orthophotos, the mine area was calculated as 769 ha in 2010.On-screen digitizing technique is used for all area calculations.

When digitizing method was carried out, mining areas on NDVI and PCA images were compared with natural Landsat 7 ETM + images for visual interpretation and spectral values of water surfaces on NDVI and PCA images were taken into account. Moreover, water areas were distinguished from mining areas on PCA images. However, NDVI image water areas had same visual awareness with mining areas.

When comparing of two analysis: PCA and NDVI approaches, we can say that using PCA for calculating the clear-cut area would be more proper for this study. It is prooved that the result of the aerial ortho-photos is closer to PCA result more than NDVI. Because, orthophoto -high spatial resolution (0.3m)- take advantages for precise results than -medium spatial resolutions of (30 m) – Landsat 7 ETM +.

The paper is focused on the issues related to forestry cadastrel works. In this context, Remote Sensing technologies integration are used efficiently with comparing different methods and data.

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REFERENCES

Abd El-Kawy, O. R., Rød, J. K., Ismail, H. A., &Suliman, A. S.,2011, "Land use and landcover change detection in the western Nile delta of Egypt using remote sensingdata," Applied Geography, 31: 483-494.

Coppin, P. R., & Bauer, M. E., 1994, "Processing of multitemporal Landsat TM imageryto optimize extraction of forest cover change features," Geoscience and Remote Sensing, 32:918-927.

Hais, M., Jonásová, M., Langhammer, J., &Kucera, T., 2009, "Comparison of two typesof forest disturbance using multitemporal Landsat TM/ETM imagery and fieldvegetation data," Remote Sensing of Environment, 113 : 835-845.

Hansen, A. J., Neilson, R. P., Dale, V. H., Flather, C. H., Iverson, L. R., Currie, D. J., et al. 2001, "Global change in forests: responses of species, communities, and biomes", Bioscience, 51 : 765-779.

Hirosawa, Y.; Marsh, S.E.; Kliman, D.H. 1996, "Application of standardized principal componentanalysis to land-cover characterization using multitemporal AVHRR data," Remote Sensing of Environment, 58, 267–281.

Mas, J. F., 1999, "Monitoring Land-Cover Changes: A Comparison of Change DetectionTechniques," International Journal of Remote Sensing, 20(1):139–152.

MorawitzD., BlewettT.M., CohenA., AlbertiM., 2006, "Using NDVI to assess vegetative land cover change in central puget sound" Environmental Monitoring and Assessment, 114 (1–3): 85–106

No name, 1993. *Dünden Bugüne İstanbul Ansiklopedisi.* s.l.:Kültür Bakanlığı / Tarih Vakfı.

Singh, A., 1989, "Digital Change Detection Techniques Using Remotely-SensedData," International Journal of Remote Sensing, 10: 989–1003.

Weng, Q.,2002,"Land use change analysis in the Zhujiang Delta of China usingsatellite remote sensing, GIS and stochastic modeling," Journal of Environmental Management, 64 : 273-284.

Williams, D.,2006,"Landsat-7 science data users handbook[on line], URL.<http://landsathandbook.gsfc.nasa.gov/pdfs/Landsat7_Handbook.pdf> , January 2015.

Woodcock, C. E., Macomber, S. A., Pax-Lenney, M., & Cohen, W. B.,2001, "Monitoringlarge areas for forest change using Landsat: generalization across space, time and Landsat sensors," Remote Sensing of Environment, 78: 194-203.

Woodcock, C. E., Allen, R., Anderson, M., Belward, A., Bindschadler, R., Cohen, W., et al., 2008, “Free access to Landsat imagery,” Science, 320 : 1011

URL-1<http://www.tbmm.gov.tr/tutanak/donem24/yil5/ham/b03101h.htm>, Accessed on march 27, 2015

URL-2 <http://istanbulobm.ogm.gov.tr/SitePages/OGM/OGMDefault.aspx>, Accessed on march 27, 2015

URL-3 <http://www.ogm.gov.tr/sayfalar/ormanharitasi.aspx>, Accessed on march 2,2015

URL-4 <http://earthexplorer.usgs.gov/>, Accessed on january 27,2015

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Donmez, S. O. ,KaradenizveKafkasya’dagüvenlikveİşBirliğiPaneli, Kıyı-KenarUzunluğu İle OrantılıOlarak Kıta SahanlığıAidiyetiBelirleme: KaradenizÖrneği, 31.03.2014

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Kaya Ş.,Kavzoğlu T., Tonbul H.,(2014).Detection of Burn Area and Severity with MODIS Satellite Images and Spatial Autocorrelation Techniques[Poster].AGU Fall Meeting, San Fransisco. 15-17 Aralık 2014

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