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Detection and Estimation the Extent of Fire in the Golestan Forests, Iran using Modis and OLI Remote sensing images

Abolfazl. Moghaddam[1] Ali Sarkargar Ardekani[2] Jalal Karami[3]

1- Remote sensing& GIS Department, Islamic Azad University, Yazd Science and Research Branch, Iran

2- Remote sensing&GIS Department, Imam Hussein (AS) University, Iran

3- Remote sensing&GIS Department, Tarbiat Modarres University, Iran

Abstract

Remote sensing techniques are widely used in monitoring the active of fire cases. remote sensing Techniques can provide useful information about the forest fire procedure including before, during and after of it. in this study, NDVI was used to monitor health status, size and density of the Golestan forest, north east of Iran. the fire- affected areas was determined using the analysis of normalized vegetation index in the processing of satellite images of the forests of Golestan Province in northern Iran. The area under fire was detected and classified by image (or pixel) subtraction and change detection methods. The final results of this study indicated that the forest area affected by or under the fire has been detected and estimated totaling 11,250 hectares. The results also showed that the application of satellite data, and remote sensing techniques and methods have an effective role in the study of forest fires. The advantage of this method is that it is less expensive and fast - as compared to the field methods- with results having more potential for being updated.

Keywords: Fire, NDVI vegetation index, Satellite images

Introduction

Fore its high precision, many studies have been conducted traditionally and at different scales from global to regional, with the use of AVHRR to detect fire-burned or under fire areas. In recent years, Moderate Resolution Imaging Spectroradiometer (MODIS) sensor have opened a new window to the researchers for studying the fire, ranging from visible to the thermal infrared. Unique vegetation indices of MODIS sensor designed to provide spatial and temporal analysis of vegetation cover, provide adequate information about the various aspects of the plants. Due to the high temporal resolution of this sensor, it has provided the researchers with a good opportunity to study continuous phenomena. Modis sensor has 36 spectral bands, two bands of which have a spatial resolution of 250 m, 4 bands are with spatial resolution of 500 m, and the other bands have a spatial resolution of 1000 meters with a repeated imaging period of 16 days. Vegetation indices are mathematical transformations defined based on different bands of sensors and designed to assess and evaluate the plants in multispectral satellite observations. The bands that are most commonly used in the calculation of vegetation indices are red, infra-red and near-infrared bands.

As, due to the presence of chlorophyll in the green leaves, the plants show big difference in the level of reflection in these two spectral ranges, these indicators converts the information

related to spectral multi-band in satellite images to one bond (Jensen, 2005). One of the indicators of vegetation cover that are used in remote sensing and has also been used in this study is the NDVI index.

Materials and methods

The study area

The study area is the forests of Golestan Province, where dozens of fires happened in recent years. This province is one of the northeastern provinces of Iran which is considered as the wetlands of Mediterranean type. It has autumn and winter precipitation from mid-October to mid-May of the next year, and rarely summer precipitation is seen in this region. Its vegetation cover is mainly evangelical trees, hornbeams, beeches, oaks, bushes and wild plants. Compared with most areas of Iran, this region has considerable precipitation and vegetation (Parinaz Rahimizadeh Bajgiran et al, 2008). Of the total of 2,150.000 hectares of Golestan province, 865,000 hectares have been dedicated to winter pasturelands in the North and summer pasturelands in the South. Also, 451,000 hectares of which lead to forest areas. Since 1990, the status of forest fires, in terms of the frequency and level, has an increasing trend which could be associated with the changes in weather conditions; so that from 14 November to 11 December of the current year, fire status in the forests of this province has been registered for 135 times. Of these, a total of 59 cases occurred in the city of Minoodasht, 29 cases in Azadshahr, 20 cases in Rammian, 11 cases in Calateh, 8 cases in Aliabad, 8 cases in Gorgan, 2 cases in Kordkouy, and 2 cases in Bandar Gaz. (Department of Natural Resources Golestan Province)

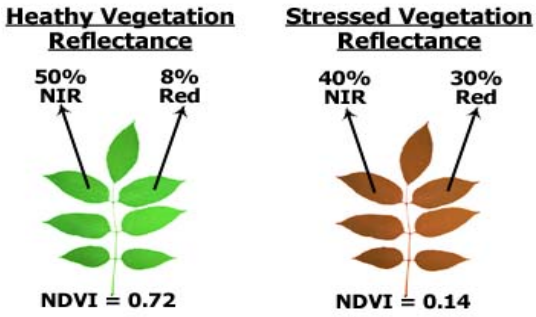
Figure 1: Satellite fire image from NASA's website on 12/12/2010

The fire studies

The first fire studies in Iran was conducted by Jazirehei in 1959. He reported that the fire causes better regeneration of desirable species through reducing the thickness of the dead coating of soil (Khorasani Nejad, 1995). He studied the impact of variables on the fire and concluded that in plain forests, the hot weather is the factor to cause fire which happens in the months of November and December. He also reported that in Mianband forests, the reduced moisture content of fuels, and in mountainous forests, the reduced rainfall are the causes of fire (Danshrad, 1992). He indicated that the fire return period (interval) in 16 regions of northern forests is between 10 to 14 years (Atrak Chali, 2001). He studied the fire return interval in Golestan forests and reported that average forest fire in the country is about 7,000 hectares and the return interval of wildfires is 11 to 13 years. But he announced a fire return interval of 5-7 years for Golestan forests. Many factors are certainly effective in the fire, some of which can be briefly referred to. One of the most important factors that cause fire in the forests is the reduced relative humidity of the air which occurs with warmer weather and drought. Reduced rainfall and dry weather followed by numerous fires in the forests of the cities of Gorgan and Behshahr in the past few years of drought (132000-2002) are among notable examples of the impact of the dry air on forest fires.

Fire regime

A fire regime is classified and determined by the headlines such as the type, intensity, duration, size, power and the fire season. In the meantime, type, severity and duration of fire have been reported as the most important factors. According to their level, fires are classified into the underground, surface, trunk, and crown fires (. (Ag ee-1993



NDVI Index

Normalized Difference Vegetation Index (NDVI) was first proposed by Rouse et al. in 1967, and then raised as an important vegetation index that is used in remote sensing. It is appropriate for areas with moderate or high vegetation density; because it is less sensitive to the bright-background soil and the effects of the atmosphere; but it is not suitable for areas with low vegetation.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

NDVI = NIR - RED / NIR + RED

Based on the technical interpretation, this index acts on the basis of band proportion, and in its spectral graph, the lines with the same chlorophyll meet each other in the center; so that changes

of the values of pixels are between +1 and -1. In fact, the basis of its performance is the high reflection of a healthy plant in the NIR band and its low reflection in the RED band of the electromagnetic spectrum. Accordingly, healthy plants usually have a high NDVI in a range between 0.5 and 1; and on the contrary, environments devoid of vegetation such as sea waters usually are with negative NDVI. The NDVI value of arid areas - having very weak vegetation - is almost zero because of the approximately equal reflectance in the RED and NIR bands (Lille sand, TM, Keifer, W., 1994).
NDVI values for each pixel of the satellite image of a region with special vegetation cover depends on numerous parameters including the type and density of plant, plant health and volume of water in plant tissues. Therefore, these conditions should be considered in the interpretation and comparison of different images (Lille sand, T.M., Keifer, W., 1994).

Change detection

The process of identifying differences in the state of an object or phenomenon by observing it at different times is called change detection. (Singh, 1989). In remote sensing, different methods of change detection analyze a sequence of images and consist of determining the differences and displaying them in spatial images. Since there are numerous ways to detect changes, image subtraction method and change detection were used to compare the results of the maps of the surface coating. In general, change detection methods are usually different and relative. In this study, executive operations are based on detecting the changes in vegetation index of "NDVI" which was evaluated and detected using the techniques of remote sensing and change detection:
1. Visual interpretation of images
o A - k-means
o B - IsoData
2. Subtraction of images and change detection
3. The principal components analysis

Research Methodology

The data used in this study was collected using desk studies, a review of other studies, interviews with experts of Forests, Range and Watershed Management Organization, collection of statistics and data by GPS in the fire affected areas of the province of Golestan. Field data includes primary data related to the fires in 2010 and satellite images used in this study were derived from MODIS sensor of Terra satellite.

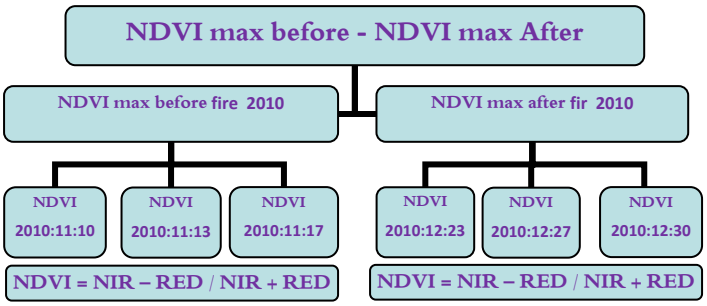


Figure 2: Flowchart to estimate the total level using the NDVI MAX images produced before and after the fire in the first year

Methodology

To remove the cloud, humidity and dust and, more importantly, the smoke from fires in the atmosphere, 3 cloud-free images (pictures) of the region before fire, on at least 3 dates, are determined using RGB True Color images of the same area obtained with a resolution of 250 m. Then NDVI max is obtained before fire using ERDAS, and NDVI max image immediately after the fire in the same year is produced based on the previous method. Then changes in the two images are detected using ERDAS 9.3 software and Change Detection Tools via the most famous resampling method of Nearest Neighbor in order to detect changes in the two images resulted from the maximum vegetation index before and after the fire. In the next step, the fire detection threshold level was determined through classifying the resulting image, after field visits to study areas and assessing GPS data; and ultimately the area affected by fire (burned with fire) was determined.

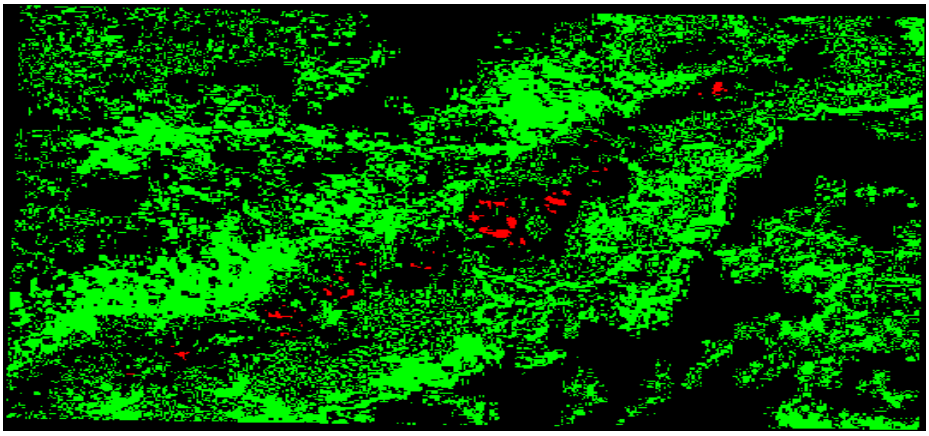


Figure 3 shows the output of ERDAS after detection of changes

Results:

In the field visit to the study areas, together with the use of controlled GPS data, a fire detection threshold level of 33.33 percent was determined. Finally, with an accuracy of 95%, an area of 11250 hectares affected by (burned by) fire was detected.

Discussion and Conclusion

NDVI index values at each pixel of the images taken can also be a criterion for describing the size and density of vegetation. As observed, with the use of remote sensing techniques and information from MODIS sensor, the extent of fire can be identified in the Spatial Information System. The advantage of this method compared to traditional and ground-based methods to identify the extent of burned areas (the areas affected by the fire) with acceptable accuracy is that this method, while inexpensive, is very fast with the results having high potential for being updated. Since this study was merely to identify the extent and type of fire, it has relied only to the MODIS data which has law spatial resolution. Obviously, it is recommended to use other satellite data, with different spatial and spectral resolution, to assess more comprehensively and accurately the fire phenomena in this region, as well as to use more precise satellite and field data.

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