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Research Article

Satellite data as indicators of oak forests canopy cover change (Case study Kamfirouze oak forests)

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Abstract

Oak forests of Zagros mountainous ridge, provide important ecosystem services that play a major role in local communities' survival. Nearly all communities in the vicinity of these valuable forested areas are dependent on the ecosystem services from different views like water, fuel, and husbandry. Different factors like human activities, miss management, climate change, Oak roller moth population outbreak threat these valuable ecosystems survival and sustaining. To document the effect of these factors on the canopy covers change during recent years, we used ASTER satellite data and NDVI algorithm to document Kamfirouze oak forests canopy cover changes. Our analysis indicates that in spite of an increase in planted lands (29.35%) in recent decades, the total area of these forests decreased by 15.1 percent and bare lands area has been decreased by up to 7.5% as well. Decreasing trend of the forest canopy cover can be related to the land-use change as the most important factor as well as other factors like illegal timber consumption in the area. The overall finding of this project confirms a more than 10 percent decrease in recent years.

Keywords: ASTER satellite data, NDVI index, plant canopy cover, RS, Zagros Oak forests.

Introduction

Nowadays humans are faced with different environmental challenges like catastrophes, land use and land cover change, illegal timber consumption and overgrazing. Global climate change, unsustainable management of water resources, increasing pressure on natural resources, soil and farming mismanagement, dust storms and pest outbreaks are some of the major factors that threats the natural ecosystems and human viability in turn. Around 41% of the Earth's total land surface has been covered by drylands where around half of them are economically productive however experience low and often sporadic rainfall and extreme variability in temperatures (CCD 1997). In spite of such harsh environmental conditions, these areas host a great variety of native biodiversity that have developed special strategies to cope with these harsh conditions. These fragile ecosystems are very sensitive to human-induced activities like grazing and logging activities, and some changes in precipitation intensity and rainfall variability which happened for many terrestrial ecosystems worldwide made them more fragile and sensitive (IPCC2013).

Oak forests can be regarded as one of the most fragile ecosystems in Iran which are prone to severe habitat destruction. In especially dryland areas, native tree species such as oak provide important ecosystem services like shadow and food for animals, contribution to soil organic matter and protection of soil against erosion, increasing water infiltration and biodiversity, thus increasing woodlands' resilience (Soares *et al.* 2018). However, Holm-oak trees are facing high mortality rates and low natural regeneration due to both environmental and anthropogenic factors, which call for reforestation actions. Remote sensing is a common and powerful tool in change detection and forest canopy cover estimation. Spatial and temporal tree canopy cover tracking using remote-sensing techniques could allow conservation agencies like Department of Environment or Ministry of Agriculture to understand which factors promote or hinder forests' mortality, growth, and regeneration at large spatial scales, and help to prioritize areas for restoration, stopping or mitigating threatening factors or plantation. Most studies evaluating tree canopy cover change over space and hardly over a time period, while addressing some small areas. Those performing large-scale analysis of satellite images rarely provide ground-validated information. Some authors (e.g. Soares *et al*. 2018) used satellite imagery to quantify spatial and temporal changes in tree cover and removing these limitations. Soares *et al* (2018) report that their findings provide important tools in improving forest management strategies. Different studies have been carried out using satellite data which all confirm the usefulness of this area of knowledge in forest management and conservation (Rafieyan 2003, Ghazanfari *et al*. 2004, Sadeghi 2005, Masoud 2006, Kennedy 2007, Rasuly *et al*. 2010, Borrelli *et al*. 2014, Griffiths *et al*. 2014)

Some authors believe that the resolution and type of selected satellite data are dependent on the type of landscapes. Detection of low/medium tree canopy cover, for instance in open woodland dominated by evergreen oak species with scattered trees stand can be accomplished with the help of high and medium spatial resolution satellite imagery (Carreiras *et al*. 2006). In this study, we used satellite imagery data to document the canopy cover change of Oak forests during 30 years ago and help decision-makers and forest manager to detect the most important causative factors which are accessible and can be taken under control.

Material and Methods

Study Area

The oak tree is the most important and populous tree species in western Iran, especially in the Zagros region. The line close to 1300 km of the Zagros Mountain Range from Western Azerbaijan Province to Fars Province. The oak trees cover an estimated 5 million hectares of land in Western Iran. The study site is located in the south of Iran, Fars province (52° 21´ N, 30° 13´ E) (Fig. 1). Its height from sea level is around 1,800 meters, so has a relatively moderate climate.

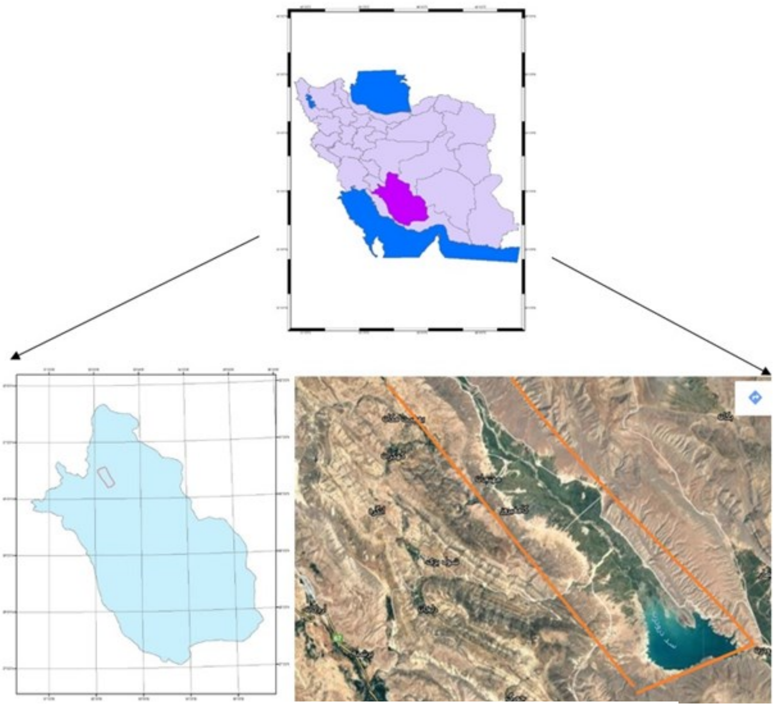

Figure 1. Study area in the southern parts of Iran

Techniques

Satellite images from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) (Abrams, 2000) with each band calibrated at radiance-at-sensor units (L1B) were obtained for the study area. The images were taken on separate dates; images were taken on 2001, 2008 and 2017. These images were further geometrically corrected using Ground Control Points (GCPs) that comes with the images and to local projection system. The study dealt with several vegetation indices so atmospheric and radiometric calibration was implemented to eliminate possible atmospheric perturbations using Fast line of sight Atmospheric Analysis of Spectral hypercubes (FLAASH) method. FLAASH method supports visible wavelengths, near infra-red and short infra-red to wavelengths of 2.5 micrometers. To do this calibration, the input algorithm was changed from BSQ to BIL at first then the main image was saved in ENVI program after being reflexing. The output was a scaled 0-100 % surface reflectance. This was implemented in ATCOR2 software using the latest ASTER calibration file. After radiometric and atmospheric calibration the image was imported into a desktop and Arcpad Mobile GIS platform for further processing and the field examinations, respectively. It is unable to high-light a delicately balanced amount in cover relation between mass and size. For this reason, it has been getting better by using the power degree of the infrared response (Fig. 2). Since the study area was widespread, the ASTER images were mosaic into a single image and then subsetted (Fig. 3).

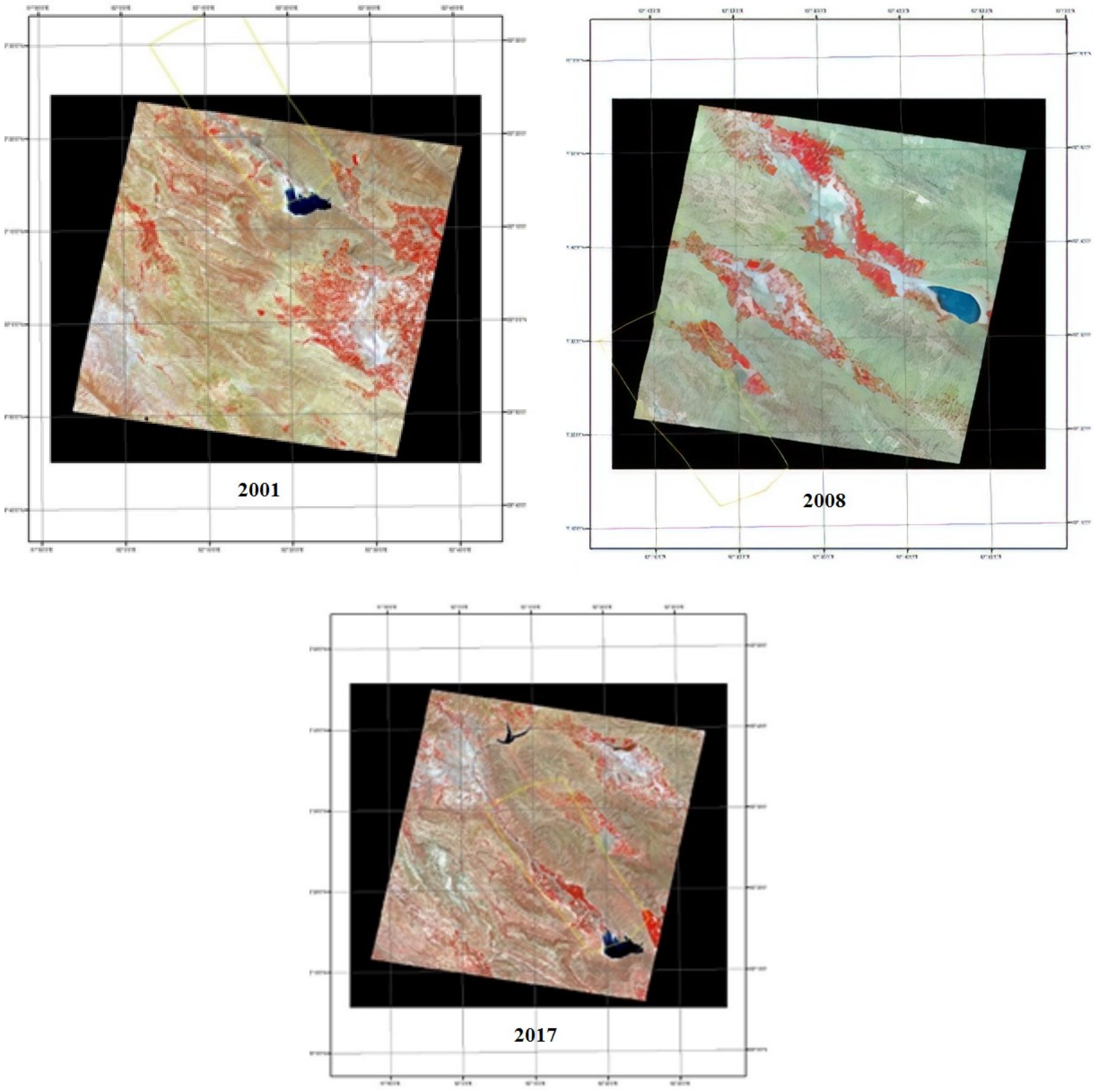

Figure 2. The raw images from different years

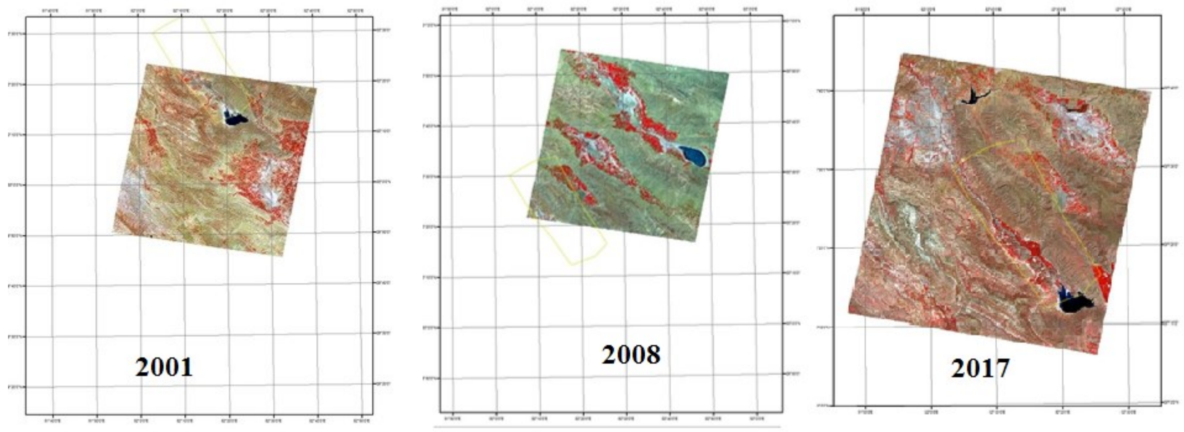

Figure 3. Atmospheric radiometric calibration

NDVI is used to identify the high and low vegetation areas. The most spectral bands used in this research have been located in the range of red and near the infrared band which can be related to the chlorophyll effect in the lower reflection of these spectral bands. To calculate NDVI index, the following formula was used then the vegetation map was extracted.

$NDVI = (band3 - band)/(band3 + band2)$

Canopy cover density map was estimated using the following formula. The most important problem in canopy cover density classification referred back to the soil and its surface spectral intervention especially in more open areas that have the most soil reflection. Regarding the climatic condition and mountainous topography of the study where host diverse vegetation classes, the vegetation map was presented in Arcmap environment.

FCD=√VD*SSI+1-1

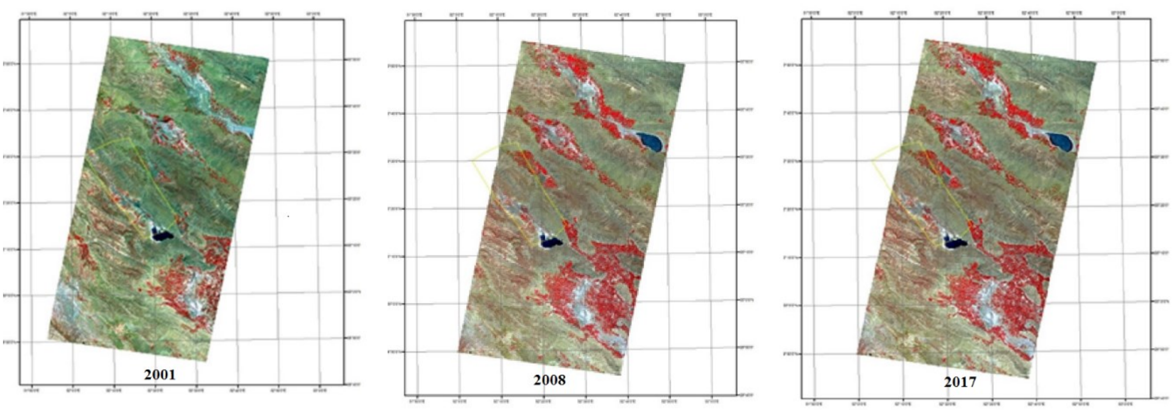

Figure 4. The ASTER images were mosaic into a single image

Result

Maps resulted from NDVI for different target years were shown in the following figure (Fig. 4). Data on the vegetation types of the study area indicate the existence of different vegetation types like Oak, terebinth and turpentine tree (*Pistacia terebinthus)*, as well as other plant species like *Crataegus pontica*, *Amigdalus orientalis, Ficus carica*, *Prunus cerasifera*, *Thymus Valgaris*, *Prangos ferulacea*, *Peganum harmala*, and different kind of Polygonaceae family.

The analysis regarding the canopy cover change during the study period indicated that from 2001 to 2017, the average area of the forest has been diminished around 15.1 % (from 21695 ha in 2001 to 18415 ha in 2017). This decrease in forest area has happened at the expense of increasing the more agricultural area and land-use change (from 2602 ha in 2001 to 10238 ha in 2017). The net change of other land uses has been presented in the following table (Table 1 and Fig. 6).

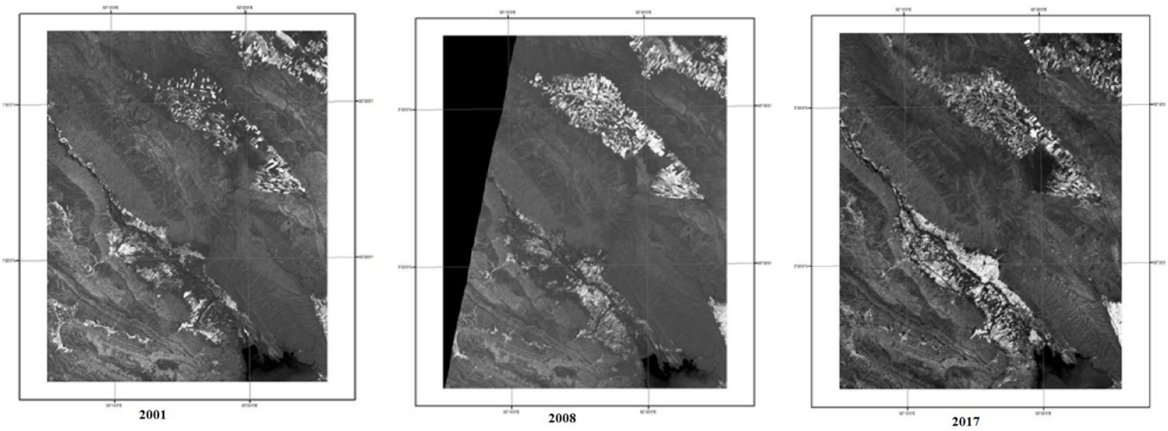

Figure 5. Maps created base on NDVI

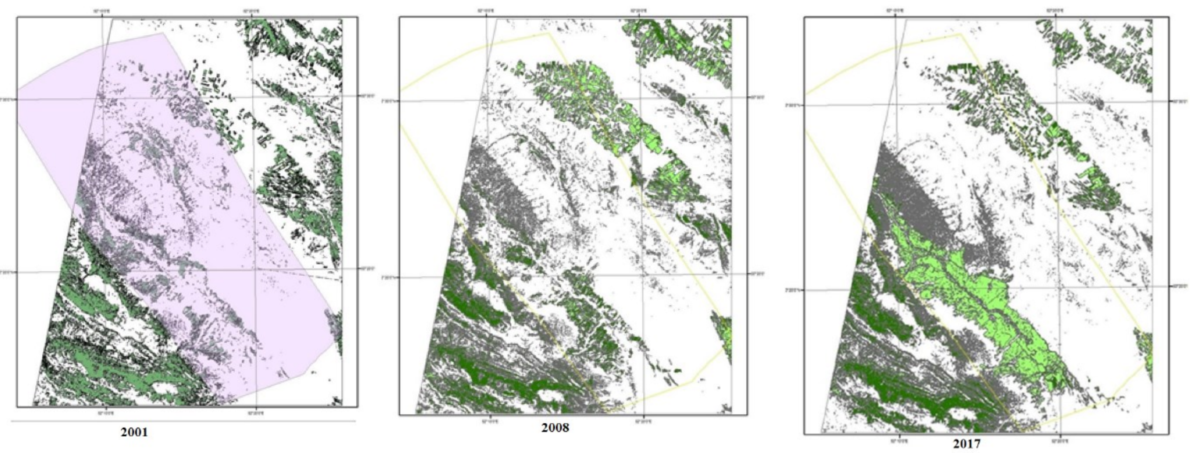

Figure 6. Forest cover change during the study period

Table 1. Change of land use cover from 2001 to 2017 in the study area

Year	Area (ha)	Type	Result (ha)
2001	98024.428	None vegetative cover	
2001	21695.008	Forest	
2001	2602.30	Farmlands	
2008	93739.17	None vegetative cover	-485.25
2008	19697.141	Forest	-1997.867
2008	5881.708	Farmlands	3279.402
2017	90660.26	None vegetative cover	-3078.909
2017	18415.81	Forest	-1281.325
2017	10238.43	Farmlands	4356.722

Conclusion

More than 30000 ha of Zagros oak forests have been located in Kamfirouze area where around 500 ha has been disappeared because of different causes mainly human-induced ones. 20 years ago, the farmlands show increasing growth trend while around 15 percent of the forested area has been diminished and around 7.5 % was added to the bare lands as well. The main reason for such a considerable loss of forested area in Kamfirouze referred back to the land use and land cover change. Since the study area is one of the most important areas in rice farming and regarding the rapid increase in the financial value of this product, most of the forest was illegally clear cut and changed to the rice farms. Data shows that the rice farms have been increased from 4000 ha to 10000 ha just for 35 years. Using heavy machines and expanding access routes can be regarded as the second most important cause of deforestation in the study area. Such kind of change and logging area can be seen especially along the rivers. The third factor can be related to illegal logging which happened by locals to use as fuel. The study area settlement has no urban gas network and they have relied on these forests as a source of fuelwood. Urban areas expansion in southern Kamfirouze and making clear lands to construction can be mention as the final cause of deforestation in this area.

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