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Application of Remote Sensing Techniques in Determining the Risk Taking Level of Different Seasons on Fire Generation in Terms of NDVI Index During the Year Case Study: Golestan Province, Iran

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Abstract: Knowledge of the nature of seasons and months in terms of the fire risk is very important in environmental planning, land management and forest resource management in order to achieve the sustainable development. One of the applications of remote sensing in this regard is the continuous monitoring of the zone to detect changes. Currently, the vegetation mapping is used to generate information for macro and micro planning. In order to monitor changes across the Golestan province forests through different seasons in 2000-2015, all images of MOD13Q1 MODIS were prepared during this period. Then, the images of the Normalized Difference Vegetation Index (NDVI) were prepared for the four seasons and twelve months of the year. The classification of the indices included lands covered with excellent, moderate, weak and very poor coverage was conducted in order to investigate the changes. Then, the comparison was then performed by LAND FIRE points and the validity of the classification results was evaluated. It was concluded that the seasons of the year from high risk to low risk were winter, summer, fall and spring, respectively. In the high-risk season, winter, January was the most dangerous month and in the low risk season, spring, may was the lowest month of the year.

Keywords: Forest Cover Surface Changes, NDVI Vegetation Index, Remote Sensing, Fire

Introduction

Forest is a dynamic ecosystem that its components are in equilibrium in normal mode. Understanding the characteristics of vegetation and the relationships between plant species and environmental factors has always been an issue for ecologists (Depew, 2004; Hoersch *et al*., 2002; Magee *et al*., 2008). Ecological fires are one of the main factors in determining the diversity and distribution of wildlife species (Bajocco *et al*., 2009). On the other hand, fire occurs at different times and places, so field studies are costly and time-consuming (Kerr and Ostrovsky, 2003).

In tropical, mountainous countries, fire is used as a land management tool to clear forested land for agriculture (Biswas *et al*., 2015) Forest fire due to natural and anthropogenic factors (Adab *et al*., 2013) causes economic losses to people in this region and increases the emission of carbon that influences climate change (Chowdhury and Hassan, 2015).

Though, the fire impacts are relatively low compared with other major disasters, like floods, landslides and earthquakes, forest fires have direct and indirect impacts that include death and damage to buildings and infrastructures, as well as an adverse effect on people's health (Stephenson *et al*., 2013; Doerr and Santın, 2016; Martin, 2016).

Fire studies in Iran started in 1960 by Jazireei (2005). Many studies have been carried out so far on the prediction models of fire risk zones and the development of hazard zonation maps in different parts of the world. Dong *et al*. (2005) conducted a study on two forest zones in the Tuqiang section of China to map out the fire risk zones with the help of Geographic Information System (GIS), Remote Sensing (RS). In this research, fire risk zones were described by specifying weights. Matin *et al*. (2017): In a research titled Understanding forest fire patterns and risk in Nepal using remote sensing, geographic information system and historical fire data Pointed out Three main factors are involved in the ignition and spread of forest fires, namely fuel availability, temperature and ignition potential. Using these factors a spatially distributed fire risk index was calculated for Nepal based on a linear model using weights and ratings. The input parameters for the risk assessment model were generated using remote sensing based land cover, temperature and active fire data and topographic data.

Saxena *et al*. (2005) developed a fire hazard map in a study to model space spatial data for mapping hazardous zones in the Himalayas and Sevillax regions of India. Sharma *et al*. (2009) produced the fire hazard zonation map using the GIS and remote sensing data by weight composition method and combining the charts of fuel type indicators, slope, direction and distance gain and with different weights obtained based on the importance of effective fire variables. Adab *et al*. (2011) conducted a research using Molgan fire forecasting indices and the GIS technique for fire hazard zonation in forest zones of Mazandaran province in 2004 during a 15-year period. Mohammadi *et al*. (2010) have used environmental factors (slope, direction, height, rain, climate, wind speed, humidity, temperature, vegetation type, vegetation density) and biological factors (distance from the village, distance from the road) for hazard zonation in the forests of Golestan province. Earth observation data and models have been widely used for fire monitoring, danger forecasting and risk mapping. Geospatial models have been used in some parts of the world to map fire risk indices (Jaiswal *et al*., 2002; Saglam *et al*., 2008; Adab *et al*., 2013; Mohammadi *et al*., 2014; Sivrikaya *et al*., 2014).

In addition to detecting high-risk fire zones, identifying effective fire times is one of the basic tools for achieving fire control and dealing solutions. Natural fires have active or inactive cycles, including normal or silent time. At this time, the forest has no significant fires and it can be considered as the calm time of forest from the fire crisis. The half-crisis or standby times can be called semi-critical times due to fire in highlands or shrubland forests that sometimes have extensive levels and grassland fuels. The intra and extra organizational crisis or standby time is when the highest incidence of fire and the burned surface occurred. To this end, the study of the sensitive periods of the fire in the present study was carried out to compare the amount of vegetation rate using NDVI index in different seasons in a mean 15-year. The studied areas were classified in terms of their risk taking at different times.

Materials and Methods

Study Area

Golestan province is located in the southeastern part of Caspian Sea. The area of this province is 20,387 square kilometers. This province is located 36°30 'to 38° 08' northern latitude and 53° 51' and 56° 22' eastern longitude. The southern parts of this province are mountainous and northern parts of it are desert area. The area of forests in this province is 451,705 hectares that is 22 percent of the total area of the province. Due to lower annual precipitation and proximity to arid regions in the eastern part of the country, Golestan province forests are more vulnerable to fire (Yadegarnejad *et al*., 2017). Geographical location of the study area is shown in Fig. (1).

Initially, the MOD13Q1 MODIS images from 2000 to 2015 were prepared from April to March by extracting the NDVI index from the images in IDRISI software. Then, the mean image was prepared for each month and season.

After classification, the resulting images were converted from excellent to very weak grades based on the mean and standard deviation. Comparison of four season images and presentation of changes were done. The accuracy assessment was made using 2657 Land Fire points, respectively, from the lowest and most risky seasons of the year and the two seasons were examined by month. Then, changes in these high-risk months and seasons were analyzed using Land Change Modeler (LCM) modeling. The Kappa scale was calculated to ensure the accuracy of production maps.

Normalized Difference Vegetation Index

NDVI is the most important vegetation index in remote sensing. It is widely used for analyzing the land use changes including vegetation and other factors. This index is suitable for areas with moderate and higher vegetation density because it is less susceptible to soil and effects of the atmosphere. However, it is not suitable for areas with less vegetation coverage. The equation of this index (1) is as follows:

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

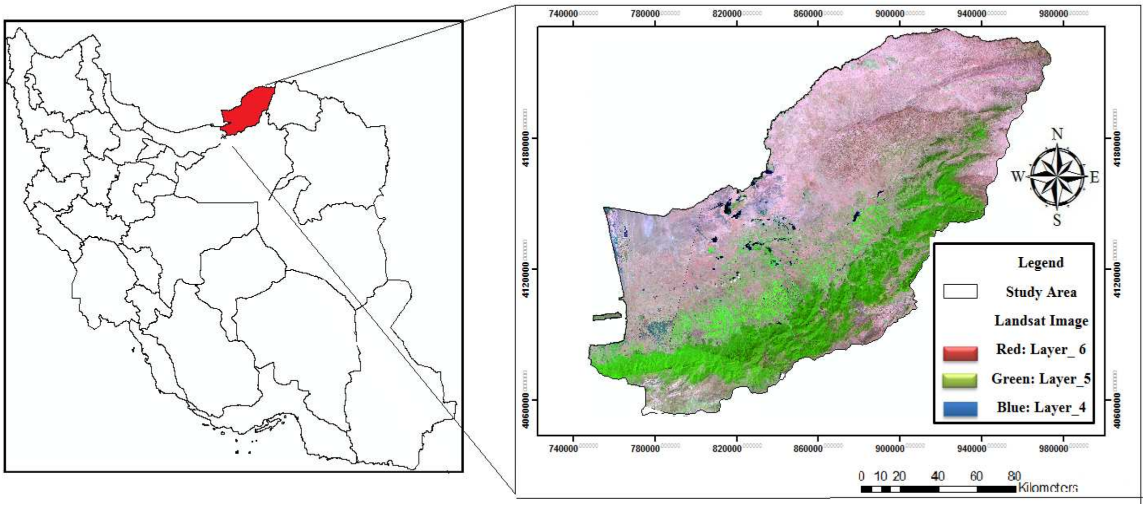

Fig. 1: The geographical location of the study area within Iran, Golestan provinces

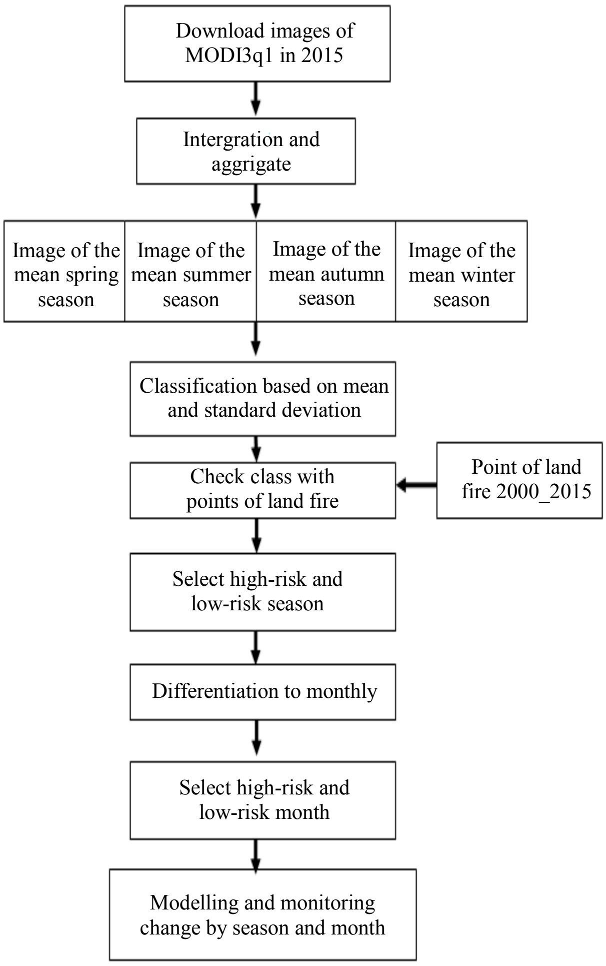

Fig. 2: The first step is to provide forest map and fire points

This index value varies from -1 to +1 and its function actually is based on high reflection of the healthy plant in NIR band and its low reflection in RED band of the electromagnetic spectrum (Pettorelli *et al*., 2005; Wang *et al*., 2013). Therefore, the index values can be a criterion for expressing the extent and density of vegetation. Therefore, the vulnerability of plants to the occurrence of fire can be determined using the index as well as remote sensing and obtained information. Chart 1 shows the overall steps of this study

Discussion

Study of Vegetation Differences

In order to investigate the lack of bias, the effect of the season on the indices was aggregated to eliminate the effect of the season and obtain normal data. Then the mean of NDVI index was prepared in 3 years for each season (Fig. 2 to 6).

In order to study the variation of vegetation during different seasons, the NDVI outlet maps were divided into four vegetation classes based on the mean and standard deviation (Fig. 7 to 10). Then, the percentage of the area allocated to each class was calculated for each plot (Table 1).

Comparison of maps derived from classification was used to assess the accuracy of the changes map with Land Fire data obtained from fire points 2000 to 2015 containing 2657 points with cover information (Fig. 5). Based on the results, the seasons were determined from high risk to low risk as winter, summer, fall and spring. In the process of variation analysis, the high risk season, winter and the low risk season, spring, was studied by month. From the three months of winter, January has the highest risk and from the three months of spring, may had the lowest risk (Fig. 10 and 11). Then, the images of January and May and spring and winter were used to model the amount of vegetation changes to better manage resources.

Table 1: The classes of classified images

Area (h)						
May	January	Winter	Fall	Summer	Spring	Class
331824	108701	143117	77532	120208	68667	Very Low
198202	336483	289359	3034604	3091079	2970228	Low
857518	1290884	1023628	1129138	1032316	1169954	Median
334424	742641	318958	405697	391359	416153	High

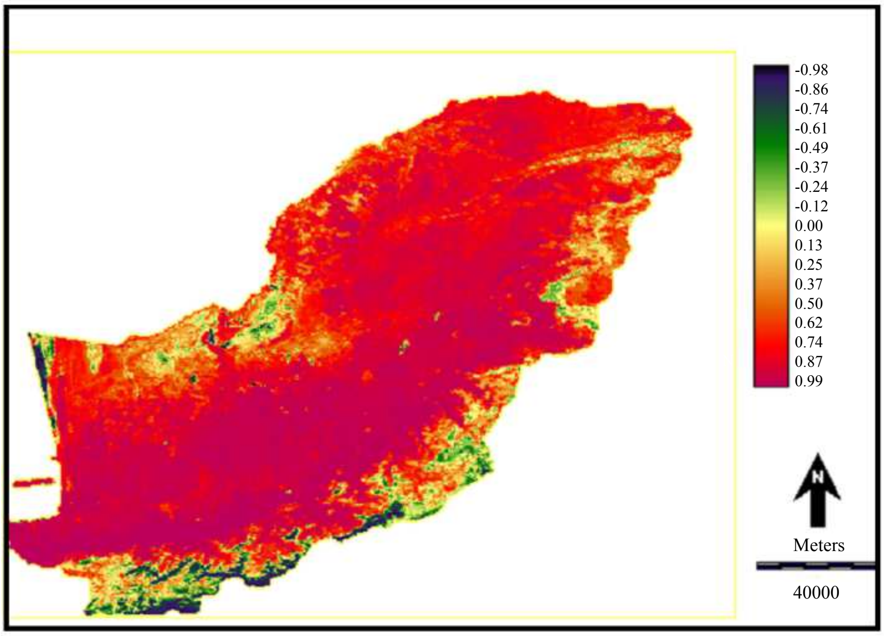

Fig. 3: NDVI index spring

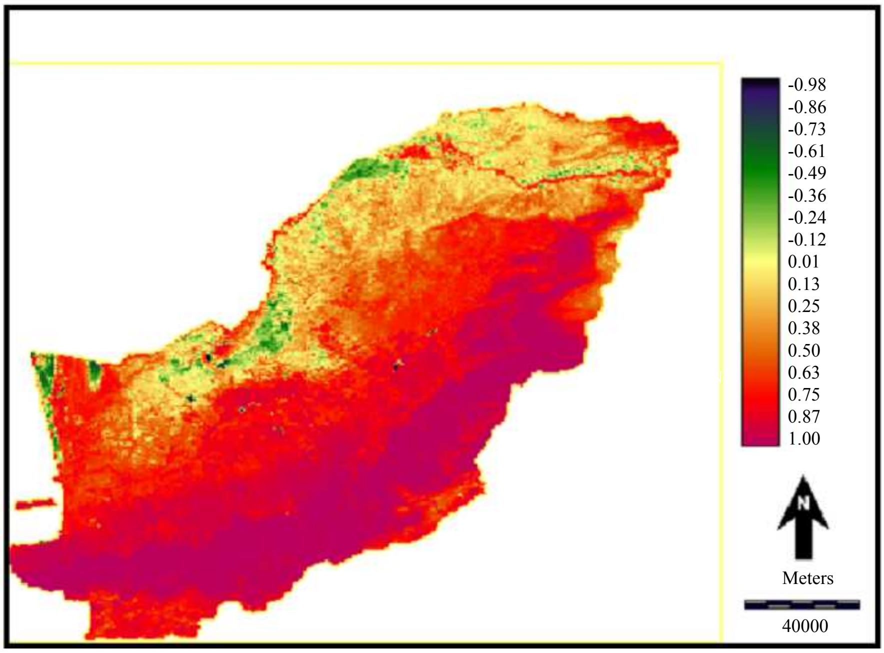

Fig. 4: NDVI index summer

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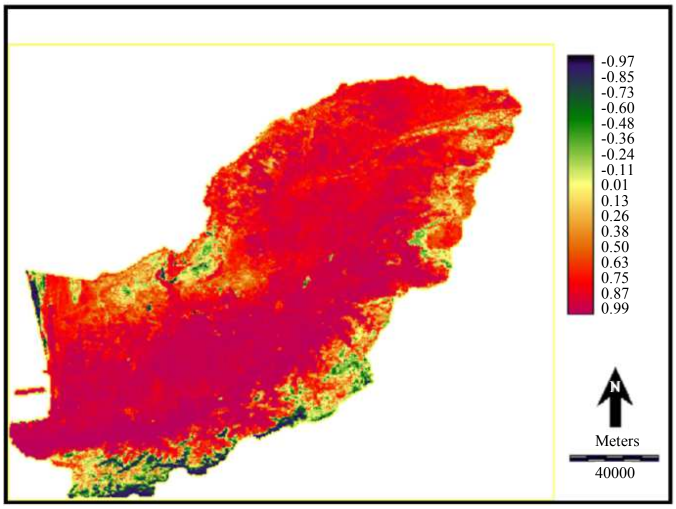

Fig. 5: NDVI Index the fall

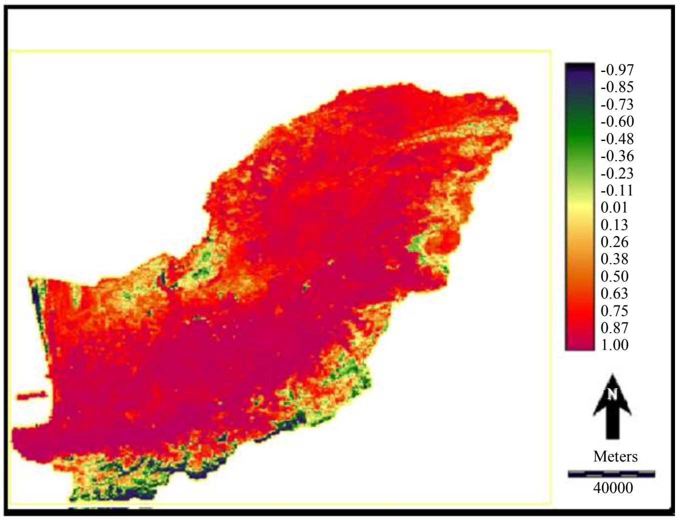

Fig. 6: NDVI index winter

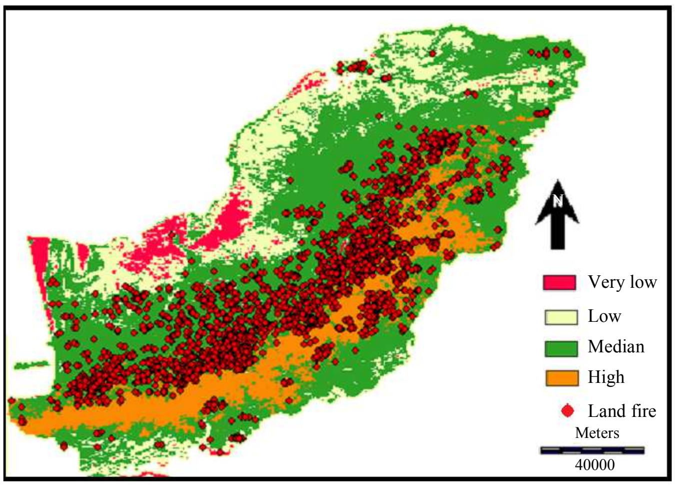

Fig. 7: Classification map of NDVI index for spring

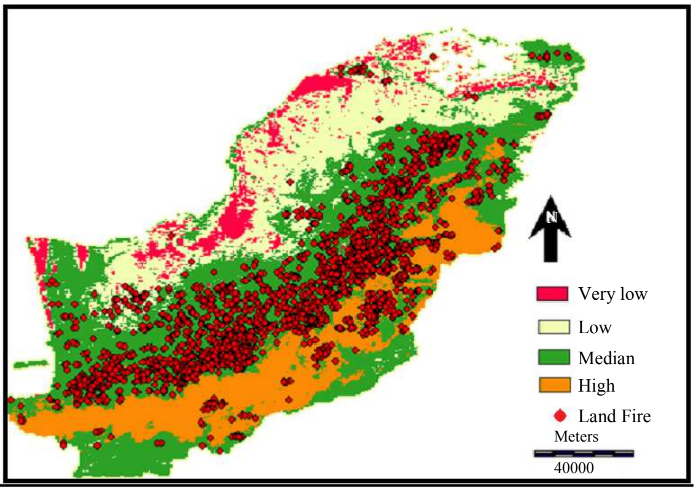

Fig. 8: Classification map of NDVI index for summer

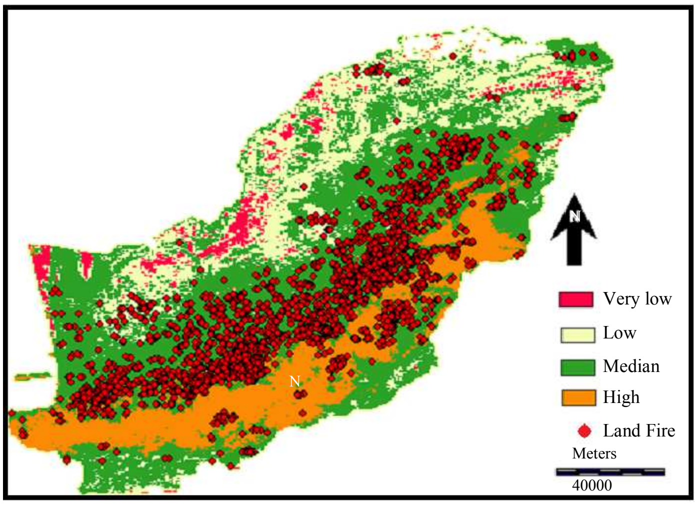

Fig. 9: Classification map of NDVI index for fall

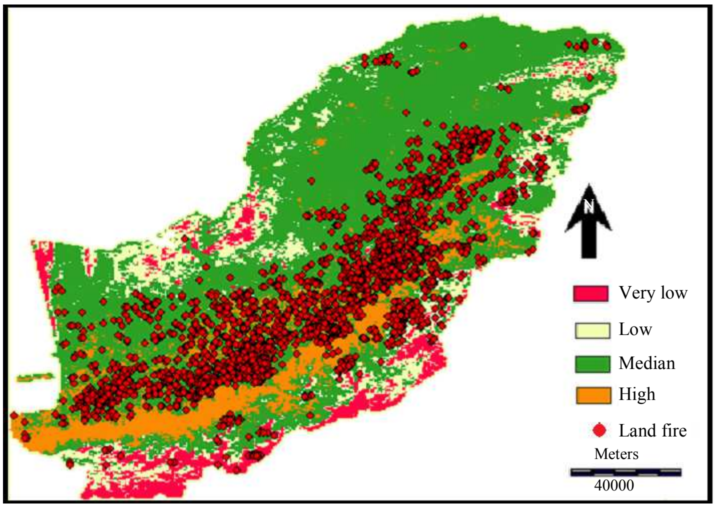

Fig. 10: Classification map of NDVI index for winter

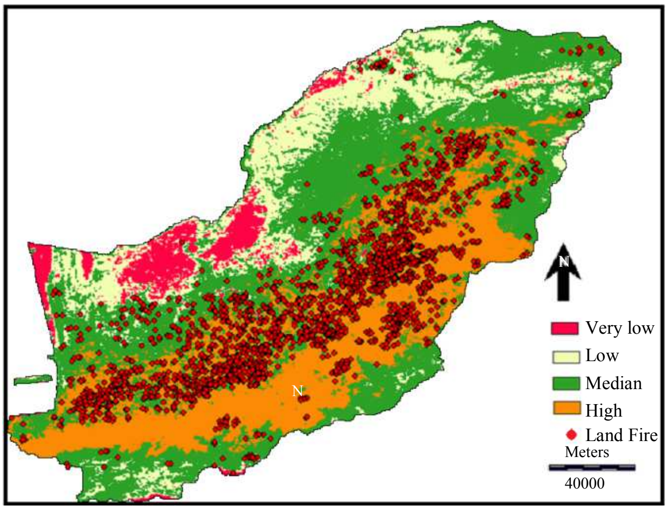

Fig. 11: Classification map of NDVI index for January

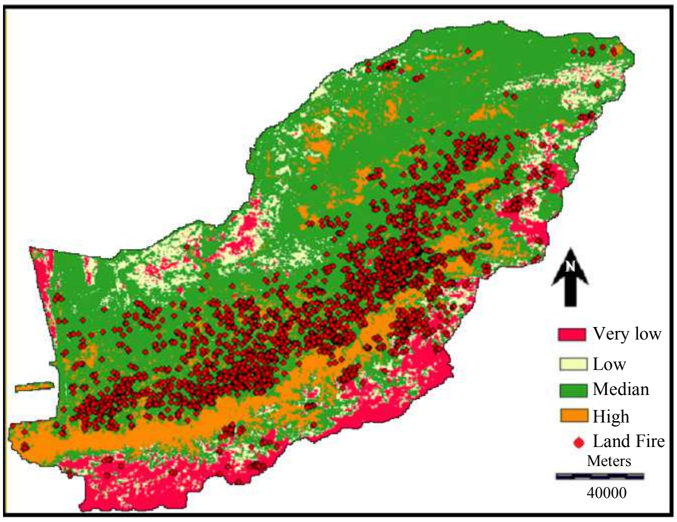

Fig. 12: Classification map of NDVI index for May

Table 2: The classes of classified images of change rates compared to each other

May to January	Spring to winter	Type of change	Class
53460	41033	Change very low to low	1
3861740	3681012	Change low to low	2
50525	115718	Change median to low	3
43916	11593	Change high to low	4
24550	2822	Change very low to Median	5
246001	238845	Change low to median	6
587147	875277	Change Median to median	7
433183	206853	Change high to median	8
69	23	Change very low to high	10
191	166	Change low to high	11
82527	121641	Change median to high	12
235137	197125	Change high to high	14

Results

The Classification maps were compared and their changes were identified after choosing risky times. Comparing the results of the four periods of time, the greatest decrease was observed in good vegetation cover. Winter has the least-developed area of no-risk zones while risky zones are increasing more percent of fire points are

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in hazardous classes, which has a significant increase compared to other seasons. The main components of the images in spring and winter, as well as January and May, were evaluated using LCM modeling.

The highest level of variation was in the moderate coverage in terms of area and excellent coverage in terms of quality. The reduction in the excellent class from May than January is much higher than in the seasons, indicating an increase in risk in January.

The greatest changes have mainly occurred in the middle cover and its conversion to other classes. May has grown very poorly over the entire year and the area of the excellent class has reduced. The class change maps also indicate the location of the change of each using, which are shown in Fig. 12 and 13 and Table 2. The poor class changes are important in creating a fire risk because it has the highest fire risk as shown in the images below.

The changes area of the mixed classes relative to each other is presented in the following table.

In addition to the need for predictive models of fire risk areas, it is required to monitor the high risk times in precision for better forest management and prevention of fire events. The most important factors for decreasing the vegetation rate of the forest zones are the temperature and relative moisture, which increases the risk of fire and unsustainable environment (Rezaei *et al*., 2008).

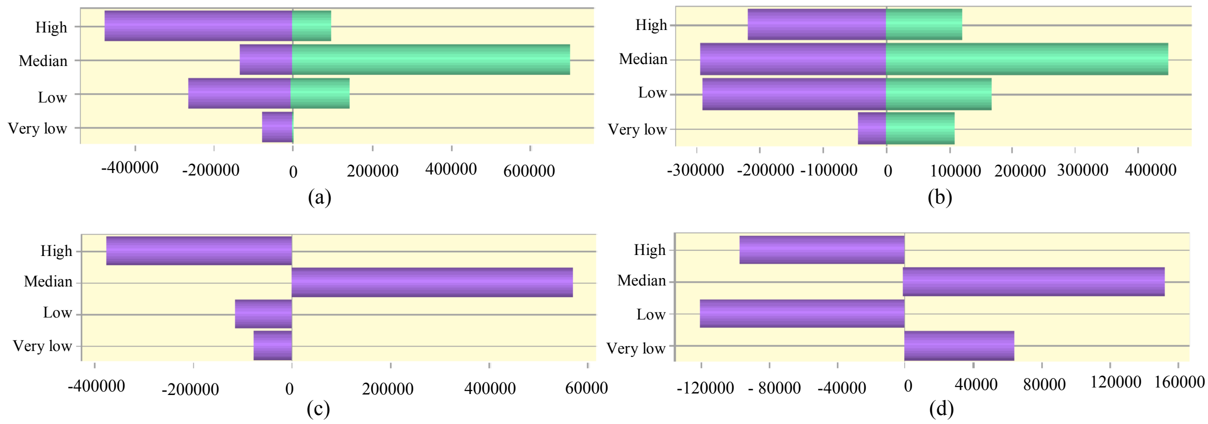

Fig. 13: (a) The reduction and increase in the area of vegetation classes from spring compared to winter per hectare (b) The reduction and increase in the area of vegetation classes from January compared to May per hectare (c) The amount of change in each class from winter to spring (d) The amount of change in each class from May to

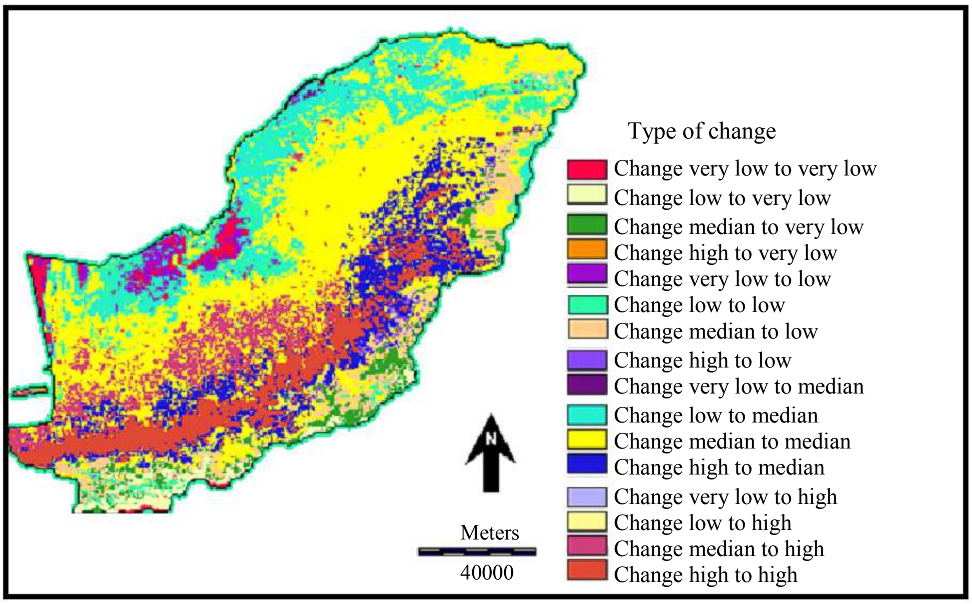

Fig. 14: Change rate map from spring to winter

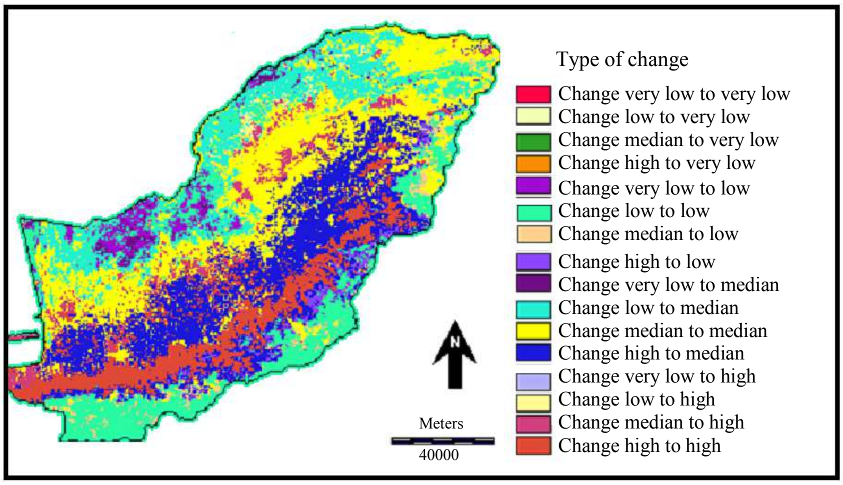

Fig. 15: Change rate map from May to January

The recognition and monitoring time of the qualitative and quantitative changes in forest areas and the factors affecting these changes is very important. Since the field study in some parts of the forest is costly and cruel; the remote sensing images were used to obtain the required maps (Abdolahi *et al*., 2011). In this regard, Modis satellite data in Golestan province were used to visualize forest changes throughout the year. The vegetation indices are the most used examples of band computing, which is used to calculate vegetation percentages or to calculate plant vegetation in a zone over different periods. In the following, it is recommended to increase the number of standby zones at high risk times to prevent the fire (Fig. 14 and 15).

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Author's Contributions

Akram Karimi and Sara Abdollahi: Write the manuscript.

Kaveh Ostad-Ali-Askari: He write the manuscript and revise it.

Saeid Eslamian and Vijay P. Singh: Write the manuscript.

Nicolas R. Dalezios: He design the study and revise manuscript.

Ethics

In this article, all ethical principles related to scientific-research articles such as validity and authenticity, originality, data collection in a standard manner, integrity and accuracy of research, etc. are observed.

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