

Estimation of Fire Frequency in Nainital District of Uttarakhand State by Using Satellite Images

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Abstract

A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Forests take many forms, depending on their latitude, local soil, rainfall and prevailing temperatures. A forest fire is any uncontrolled fire in combustible vegetation that occurs in the countryside or a wilderness area. A Forest fire frequency is an average time interval between successive fires. Fires in forested areas can be regarded as an environmental disaster caused by either natural forces or anthropogenic activities. Nainital district of Uttarakhand state experiences forest fires frequently every year with a peak during the months of April to July. The present study was done for Estimation of forest fire frequency from 2001-2016 of Nainital district of Uttarakhand state. Results were made by using the highest frequency of Nainital district was 9 and is categorized into 4 classes. The No fire areas contain 55% of total geographical area(TGA), Low fire areas contain 25%, Medium fire areas contain 18% and High fire area contains only 2% of TGA.

Keywords: MODIS; Forest fire; Fire frequency

Introduction

A forest is a large area covered with trees grouped so their foliage shades the ground. Forests are home to more than two-thirds of all known land species. Forests are the dominant terrestrial ecosystem of earth that provides timber, firewood and habitat [1]. The forests are the most victims of fires. A Forest Fire or wildfire is a fire in an area of combustible vegetation that occurs in the countryside or rural area. A wildfire can also be classified more specifically as a brush fire, bush fire, desert fire, forest fire, grass fire, hill fire, peat fire and vegetation fire. Forest fires are characterized in terms of combustible material present and the effect of weather on the fire [2,3]. The normal fire season in India is from the month of February to mid-June. Fires are one of the major hazards in forested and grassland. Control of fire is difficult, but it is feasible to map fire risk by geospatial technologies. Forest fire frequency is also called as fire rotation. A Forest fire frequency is defined as a mathematical expression of fire occurrence or rate, such as the average time interval between successive fires or the number of fires within a specific period of time. Forest fire frequency is mainly caused because of air temperature, relative humidity, wind speed, previous day rainfall, dew point temperature, air pressure, potential evapotranspiration, land surface temperature, precipitation rate, forest type, slope, aspect, elevation, normalized difference vegetation index, enhanced vegetation index, albedo, terrain ruggedness index, road network, rail network, human settlement, population and calorific value of fuel (live fuel, dead vegetation and litter).

Study Area

The study area is the Nainital district of the Uttarakhand state. It is located approximately in between 80°14' and 78°80' east longitude and

29°00' and 29°05' north latitude and falls in the Kumaun division. Nainital district is famous for its rich biodiversity in terms of both flora and fauna. Forest cover of the state, is 3,004 km² which consist around 70.67% of the total geographic area. Among these forests very dense forest is 602 km² moderately dense forest, 1,939 km² and open forest is around 463 km² and scrub also covers the area of 12 km². Hilly region of Nainital also receives the highest snowfall during the winter (Figure 1). The total forest area of state is 3,004 km² which is 70.67% of its total geographical area (Indian state of forest report) (Table 1).

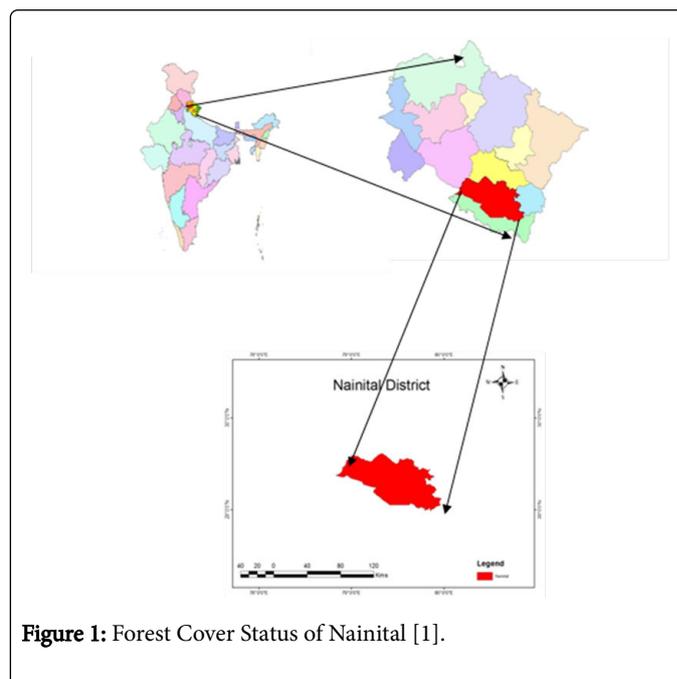


Figure 1: Forest Cover Status of Nainital [1].

Year	Geographical Area (km ²)	Very Dense Forest (km ²)	Moderate Dense Forest (km ²)	Open Forest (km ²)	Total (km ²)	% of Geographical Area (%)
2015	4,251	602	19,39	463	3004	70.67
2013	4,251	520	2,095	676	3,291	61.76
2011	4,251	601	1,923	566	3,090	72.69
2009	4,251	601	1,919	573	3,093	72.76
2007	4,251	601	1,919	573	3,093	72.76
2005	4,251	548	1,936	604	3,088	72.64
2003	4,251	548	1,944	602	3,094	72.78
2001	4,251	2,645		463	3108	73.11

Table 1: The total forest area of state and their details.

Duration of Study

The present study was done from January 2017 to May 2017 at Indian Institute of Remote Sensing, Gurukula Kangri Vishwavidyalaya, Haridwar and the study area is Nainital district of Uttarakhand state.

Datasets

Data used

MODIS (Moderate Resolution Imaging Spectroradiometer) is one of the widely used satellite sensors that scientists are using global and regional studies since 1999. It is a key instrument aboard NASA's Terra (EOS AM) and Aqua (EOS PM) satellites. MODIS will view the entire surface of the Earth every 1 or 2 days, making observations in 36 spectral bands, at moderate resolution (0.25-1 km), of land and ocean surface temperature, primary productivity, land surface cover, clouds, aerosols, water vapor, temperature profiles, and fires [4].

Specifications of MODIS data

Orbit: 705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), sun- synchronous, near- polar, circular.

Scan rate: 20.3 rpm cross track.

Swath dimension: 2330 km (cross track) by 10 km (along track at nadir).

Telescope: 17.78 cm diam. off-axis, a focal (collimated), with intermediate field stop.

Size: 1.0 × 1.6 × 1.0 m.

Weight: 228.7 kg.

Power: 162.5 W (single orbit average).

Data rate: 10.6 Mbps (pea daytime); 6.1 Mbps (orbital average).

Quantization: 12 bits.

Spatial resolution: 250 mt. (bands 1-2), 500 mt. (bands 3-7), 1000mt. (bands 8-36).

Design life: 6 years.

Software used

Using union operation in Arc map software we merged all the fire points from 2001 to 2016 in one shapefile.

Methodology

The main aim of this study is to estimation of fire frequency area of Nainital district from 2001 to 2016. MODIS hotspot data or active fire data (MOD14) have been downloaded from 2001-2016 from FIRMS (Fire Information for Resource Management System) and these datasets are in shape file format (.shp), Using union operation in Arc map software we merged all the fire points from 2001 to 2016 in one shapefile [5-7]. After that we created fishnet using data management tool in ARCMAP software. Fire points and raster are spatially joined to generate the fire frequency (Figure 2).

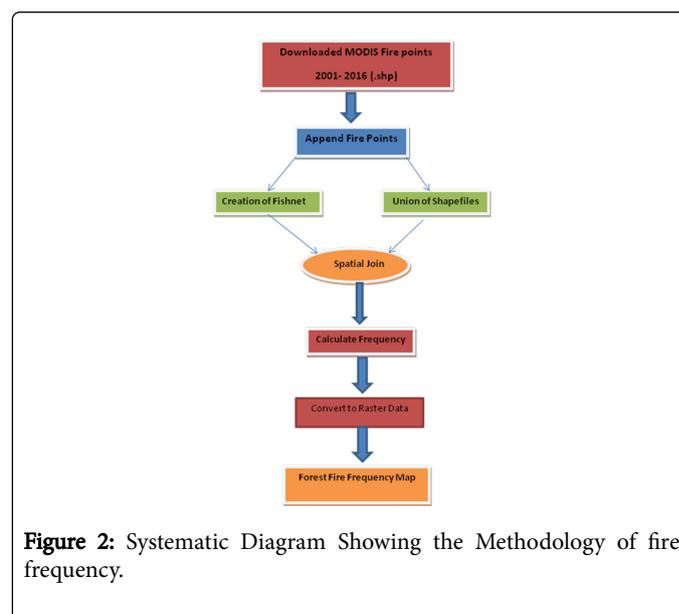


Figure 2: Systematic Diagram Showing the Methodology of fire frequency.

Results and Discussion

The highest frequency of Nainital district was 9 and we categorized frequency into 4 classes. The present study revealed that total fire points from 2001-2016 was 16248 out of which No fire areas have total of 8962 fire points from 2001-2016 that covers an area of 55% of total geographical area of the Nainital district. Whereas in low fire areas a total of 4172 fire points is found from 2001-2016 that covers an area of 25% of total geographical area of the Nainital district. In medium fire areas a total of 2895 fire points is present from 2001- 2016 that covers an area of 18% of total geographical area of the Nainital district.

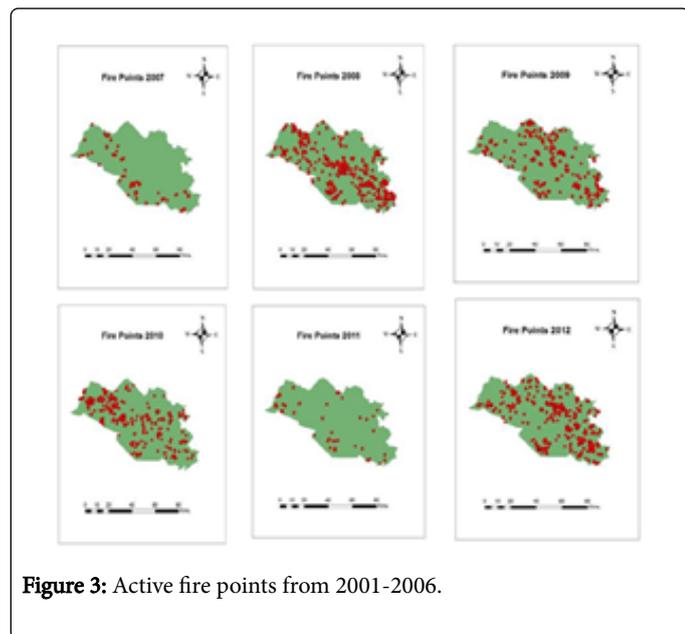


Figure 3: Active fire points from 2001-2006.

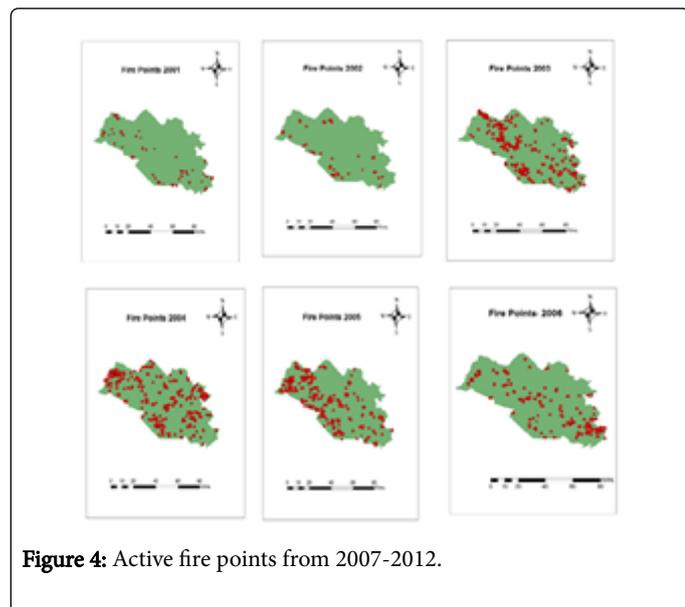


Figure 4: Active fire points from 2007-2012.

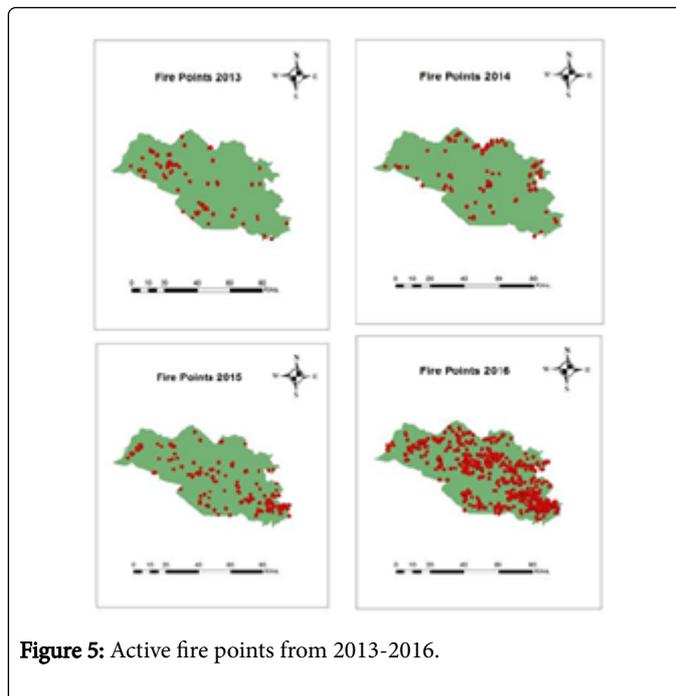


Figure 5: Active fire points from 2013-2016.

In High fire areas a total of 219 fire points is present from 2001-2016 that covers an area of 2% of total geographical area of the Nainital district. There was a slight decrease in fire points during 2002, 2007, 2011, and 2013 respectively [8-10]. While in all the remaining years there was a frequent increase in fire points. And these increase in fire points are due to air temperature, wind speed, relative humidity, precipitation rate, air pressure, development and urbanization (Figures 3-10).

According to the result the maximum fire points and percentage of total geographical area are in No fire areas and the minimum fire points and percentage of total geographical area are in high fire areas.

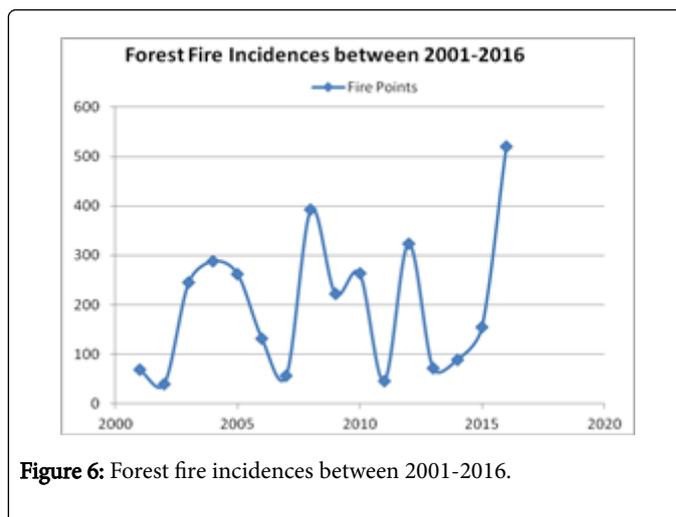


Figure 6: Forest fire incidences between 2001-2016.

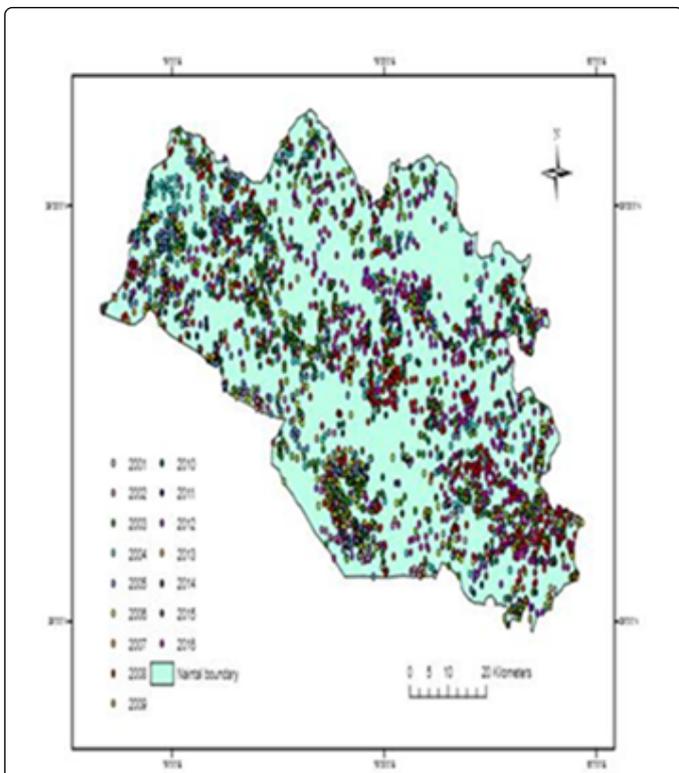


Figure 7: Active fire points from 2001-2016.

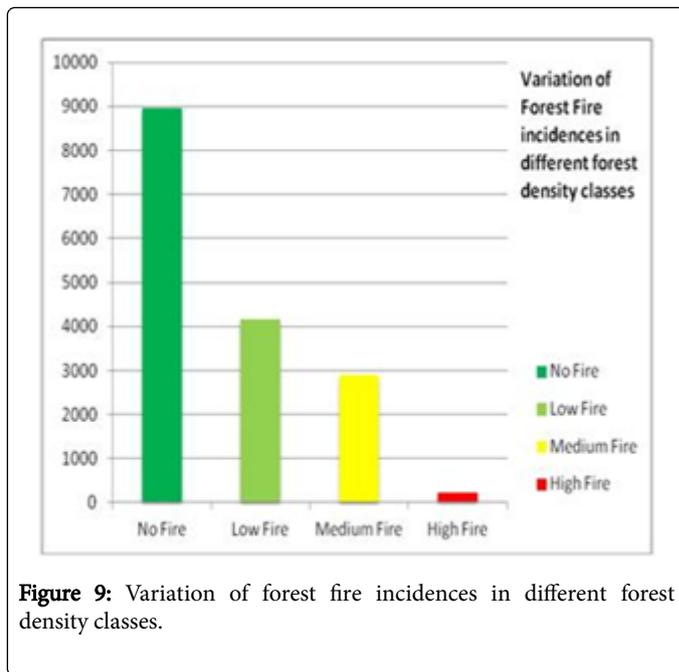


Figure 9: Variation of forest fire incidences in different forest density classes.

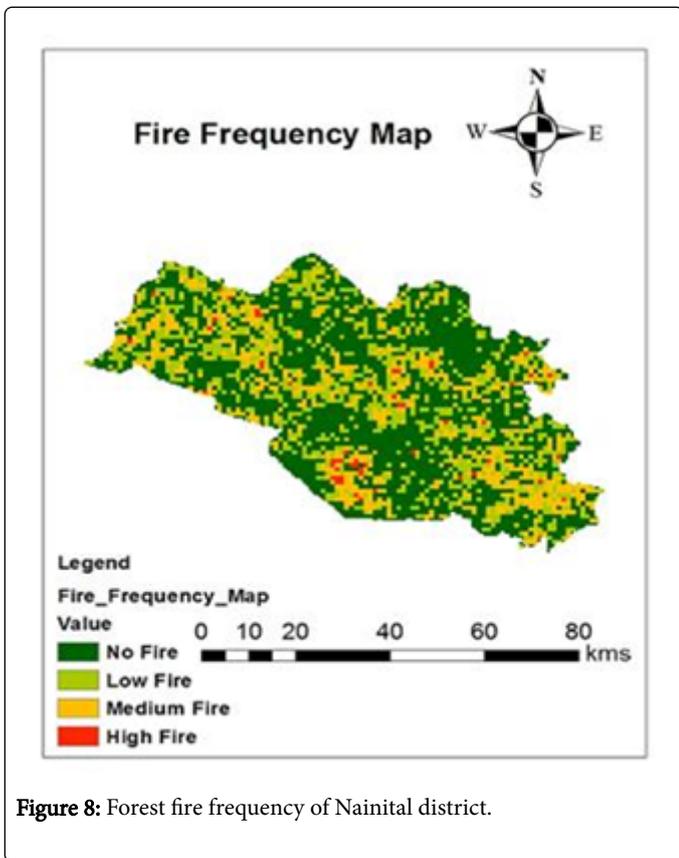


Figure 8: Forest fire frequency of Nainital district.

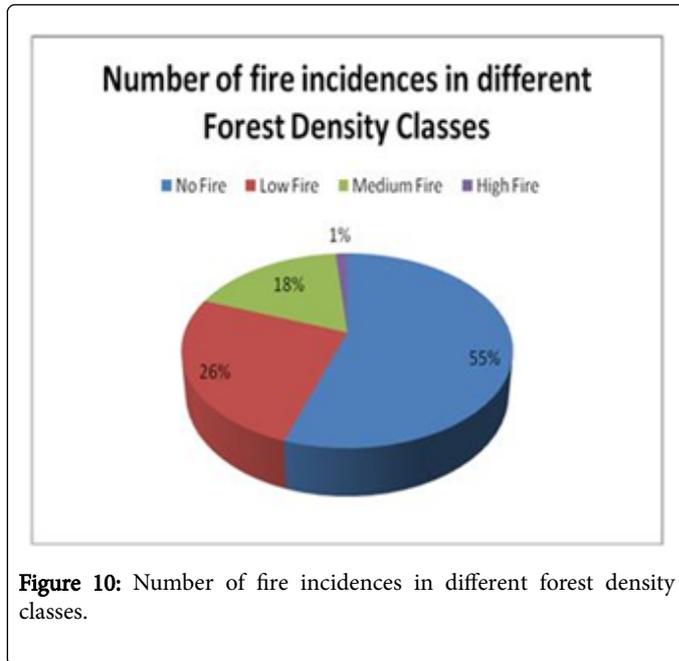


Figure 10: Number of fire incidences in different forest density classes.

Conclusion and Suggestions

The worst hit areas are Kairi kham, Kota range, Dolmar, Jyolikote, Devidhura, Kweral, Smanora range, Okhal dhunga, Kiari bandobast, Pawera, Gorla gaon, Kanda range, Pauvalghar, Chopra, Kuria gaon, Hari nagar, Katali, Paitana, Kot pandey, Dholi gaon, Dungri, Bargal, Garjoli, Budhlakote, Saur, Byasi, Hairakhan, Vinayak, Pngot and Gaoniyagaon where forests neighboring 100 villages and the forest ecosystem are under fire effect. Fires are lit by people for various reasons but fire become rampant when the fuel load is not removed and fire lines are not cleaned. Some measures to mitigate the impact of forest fire in the area. Some applied measures can be followed by the peoples where the forest fire took place with the help of forest

department and government should come in the action also to make policy and planning implementation. Some Management measures can be suggested:

- The focus should be on preventing fire from spreading.
- Awareness program for the preventing fire
- Local people should be involved.
- A long-term measure can be as annual time management plan prepared with maps of vulnerable areas and an early warning system tandem with the forest survey of India. The plan should be ready up to December.
- Control room also should be established by December through June.
- More fire lines are needed in forest area in Nainital.
- Modern technology should be used in preventing and controlling forest fire.
- There is an urgent need to initiate research in the field of fire detection behavior and fire ecology for better management of forest fire.
- Joint forest management committees are to be organized at village level.
- The maximum number of forest fire is manmade.
- Regular patrolling of forest should be done.
- Motivate the local people and serve their livelihood requirements and attractions.
- In the areas where the fire took place every year, litter should be reported at the short distance and, may be controlled.

There are many ways in which the impact of forest fire can mitigate. The tree like Banj, Oke, Myrica, Alder and Rhododendron should be included in Chir Pine forest. Forest humus can be converted into bio bricks and vermin compost. Modern Fire fighting techniques should be adopted such as radio acoustic sound system for early fire detection and Doppler radar. There should be a strong collaboration between forest department and village people. Fire forecasting and warning system should be implementing. There is an urgent requirement of develop separate wing for firefighting by the forest department. Most of the local people utilize the forests resources, therefore if efforts are made to provide them subsidies and involve them in forest

management practices. Their indigenous knowledge will definitely help us in controlling to some extent. The assessment of forest fire and degradation is most important factor to be considered for better management of forest resources of Uttarakhand. The satellite based remote sensing enabled to map and monitor vegetation resources in varying scale and time. The GIS and Remote sensing techniques enable to organize datasets to analysis and decision making process. The satellite images have a considerable value for forest fire mapping and ecological degradation assessment. It helps in decision making process and proper establishment of a management plan for the green cover areas. We have to understand that we cannot stop forest fires, but we can successfully control the fires.

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