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GRT

FOREST FIRE: VULNERABILITY ANALYSIS OF WESTERN HIMALAYAN REGION USING REMOTE SENSING AND GIS TECHNIQUES

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Abstract:- The adverse impact of uncontrolled forest fire on the ecology and environment is well known. Over hundreds of years forest fire has been viewed by many as an environmental horror. Forest fires occur either because of anthropological or natural causes. Growing population, escalating exploitation of natural resources, erratic rainfall, and extensive dry spells during winters, early summers and decrease in annual rainfall in recent past due to climate change has increased incidence of forest fires in the world. Fire has been linked with reduced soil fertility, destruction of biodiversity, global warming and damage to forests, land resources and of course human assets. The majority of fires around the globe are caused by human activity. Lightning is probably the most common natural cause of fire. It has been estimated that annually fires burn across up to 500 million hectares of woodland, open forests, tropical and sub-tropical savannahs, 10-15 million hectares of boreal and temperate forest and 20-40 million hectares of tropical forests.

To manage the sustainability of forest areas, reliable data on forest fire are necessary but the global forest fire data especially in Indian context is crude estimate and insufficient. In this situation remote sensing and GIS techniques can be a big aid to acquire reliable data on forest fire resulting in vulnerability analysis of forest area prone to forest fire.

Burned forested areas have patterns of varying burn severity as a consequence of various topographic, vegetation, and meteorological factors. These patterns can be detected and mapped using satellite data. FSI is monitoring (Near Real Time Monitoring of Forest Fires) forest fires of the country since 2004 using remote sensing based system developed by the University of Maryland (USA) MODIS Rapid Response System. The detection of forest fires is made on the daily basis through the website http://maps.geog.umd.edu. After collecting, coordinates of the fire spots, FSI maps the forest fires through GIS analysis. The coordinates of all the forest fire spots are then sent to the respective State Forest Departments through fax and email for control during fire season. From the feedback received from SFDs, it has been observed that the detected forest fires are correct on more than 95% points.

In the present study, an attempt has been made to identify the vulnerable area of forest fire and frequency of occurrence of forest fire of the western Himalaya. It includes the states of Uttarakhand, Himanchal Pradesh and Jammu & Kashmir to analyse forest fire trends at district level.

INTRODUCTION

The origin of natural forest fire is due to spontaneous combustion and spark produced by rockslide, lightning and volcanic eruption. Whereas the anthropogenic induced forest fires are either intentionally or unintentionally created. Both types of fire, natural or anthropogenic, may manifest themselves as (i) Creep fire, (ii) Surface fire, (iii) Ground fires and (iv) Crown fire.

(i) Creep Fire, is that which spreads slowly over the forest floors and buns with a low flame. In certain areas the fire is confined to the humus layer which lies above the top soil.

(ii) Ground fire is usually confined to the vegetation of the lower canopy destroying shrubs and herbs. It can also scorch the tree bases.

(iii) Surface fire burns the shrubs, trees species and trees of the middle canopy.

(iv)Crown fire is the most devastating type of forest fire, which destroys the entire upper canopy of a forest.

Generally forest fires are started by human actions, nature produces the conditions that make a fire more likely. Once-green and moist vegetation is converted into flammable fuel by dry weather; strong winds carry fire rapidly over land; and combustion is encouraged by warm temperatures. When these factors are present, a single spark from lightning, a burning campfire or other source is all that is needed to ignite a wildfire that can ravage tens of thousands of acres and burn for weeks in any terrestrial forest landscape, the spread of fire depends upon Heat, Oxygen and fuel type, commonly known as the fire triangle (Fig-1)

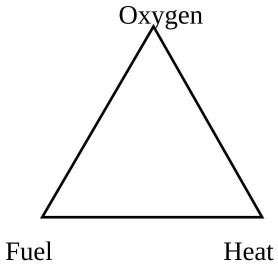

Figure 1: Fire triangle

Effects of fire on vegetation depend on a number of factors along a complex path defined by frequency, magnitude, extent, season, phonological state of the vegetation, combined effects with other disturbances such as storms, diseases, pest attack, etc.

Fire is a paradox - it can kill plants and animals and cause extensive ecological damage, but it is also extremely beneficial, the source of forest regeneration and of nutrient recycling. Fire, the experts say, is nature's way of recycling the essential nutrients, especially nitrogen.

But it is important to remember that fires under extreme weather conditions can be devastating to these forests. In contrast, fire causes severe damage to tropical forest ecosystems, which are characterised by high levels of humidity and moisture. They do not normally burn and are extremely prone to severe fire damage.

Forest is the most important natural resource in the Himalayan region that creates a very delicate balance man and ecosystem. Over the past few decades, the Himalayan forests have experienced unprecedented land-use changes driven by rapid human population growth and intensifying anthropogenic activities, such as agriculture and expanding human settlements that has led to the accelerated rate of forest fire incidences.

The most vulnerable stretches of the world to forest fire are the youngest mountain ranges of Himalayas. Because of the more rain density, the forests of Eastern Himalayas are less vulnerable to forest fires as compared to those in Western Himalayas. the forests of Uttarakhand can be divided into mixed, deciduous, or coniferous. The coniferous forests are largely composed of pine, while the deciduous are dominated by oak and rhododendron. The mixed forests have both deciduous and coniferous trees in varying proportions. Forests enable rural life in the state. Green oak leaves for fodder, oak leaf litter for compost, pine litter for bedding animals and packing fruit, and wood from both for the kitchen fire, are needed to run a rural household. Added to these are the ecological benefits of forests which include water recharge, and the economical benefits which include collection of pine sap.

Present study makes an attempt to analyse the forest fire frequency in western Himalaya that includes states of Uttranchal, Himanchal Pradesh and Jammu & Kashmir. The coniferous forest in the Himalayan region comprising of fir (Albies spp), spruce (Picea smithiana), Cedrus deodra, Pinus roxburgii etc. is very prone to fire. The importance of forest in these states lies in the fact that J & K State has 20230 Sq.Kms under forests, which account for 19.95% of the geographical area of State including Ladakh region and 47.80% excluding Ladakh while 64.79 % of geographical area in Uttarakhand and 66.52 % of Himanchal Pradesh comprises under forest.

With large scale expansion of chir forests in Himalayan mountains, the frequency and intensity of forest fires have increased alarmingly. In 1995, the fires, particularly in the Uttarakhand hills had destroyed more than 3, 75,000 hectares of forest wealth. In all around 34, 24,857 hectares or 63.91percent forest area of Uttarakhand is vulnerable to forest fire

Fire burned landscapes are suitable targets for remote sensing research because of the obvious physical changes the fire has on the land cover. Characteristic changes of burned areas include canopy consumption, ground charring, and soil colour alteration. These characteristics are detectable using satellite sensors if the patch size of the burn is within the resolution range of the satellite sensor.

Remote sensing is a useful tool for mapping the extent of the burn, understanding the biological responses due to differential surface heating (i.e. fire severity), and quantifying the extent and pattern of these burned areas.

2.1. Specific Objectives

The specific objectives of the present study are as follows:

- Study the forest fire vulnerability in Western Himalaya using time series data of Global Fire Mapper and Forest cover map of India
- Identify and categorise the Districts based on the degree of forest fire severity

3.1. Methodology and Data Base

The present study went into studying fire occurrence between the periods of 2004 to 2011 using MODIS(Moderate Resolution Imaging Spectrometer) satellite sensor. The satellite which has high level of periodicity (data four times a day) has proved to immense value in real time assessment and monitoring of forest fires. MODIS provide global hotspots/fire locations and brunt area information to natural resource management with easy use format as Fire Information for Resource Management System (FIRMS) that integrate remote sensing and GIS technologies.

In the Fire Mapper, the active fire spots are the locations of fire spots of the world irrespective of the forest or non forest area. The downloaded positional coordinates for the total fire locations of fire are projected on the forest cover map of India prepared by Forest Survey of India (FSI) to select active fire locations within forest area. Detailed methodological steps are given in fallowing flow chart.

Methodology

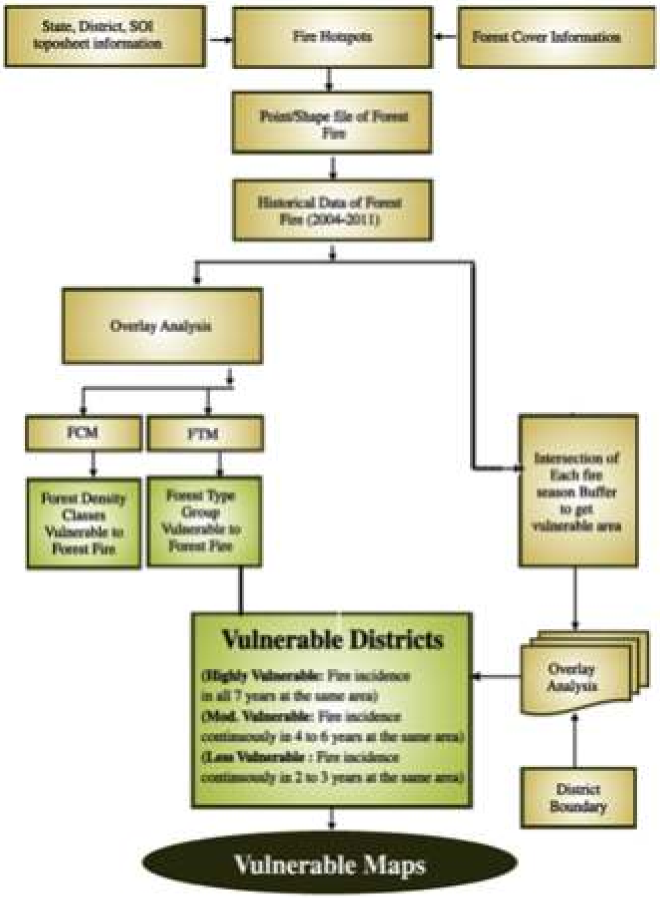

Figure 3: Basic Approach of generating Fire Vulnerability Map

4.1. MODIS Based Web Fire Mapper

The Moderate Resolution Imaging Spectrometer (MODIS)is an instrument that is on board satellite platforms owned by NASA – Terra(launched on May 4th 2004) and Aqua (launched on May 04th 2002) the MODIS instrument has 36 spectral bands available to view the earth of 2330 km and the view entire surface of the earth every one to two days. The image resolution used in detecting fires is 1 km.

A fire spot is detected by MODIS sensor using data from the middle infrared and thermal infrared bands. The active fire is displayed as a 1 km pixel on the ground; the fire location is the centre of the pixel. This does not necessarily mean that the fire is spread 1 km in size. While it is not possible to determine the exact fire size, the system gives at least one fire it is located within the 1 km size pixel. If the multiple fires are detected within the same 1 km location, the system will only display one pixel for that area. Hence the MODIS fire representation provides information of the potential fire pixel which has a dimension of 1km x 1 km. Even though the information is coarse, yet the availability of of the information at high temporal interval is of great significance. The thermal sensor of MODIS is heat sensitive, is capable of clearly visualizing the fire points on the ground. The Terra MODIS instrument acquires data twice daily (10:30 am and 10:30.pm IST) as does Aqua MODIS (2:30 pm and 2:30 am IST). Therefore four daily MODIS observations are available. FIRMS deliver active fires detected using the MODIS active fire locations processed by the MODIS Response System.

5.1. Data, Material and Software Used

Downloaded Web Fire Mapper products of Indian region, forest cover map of survey of India are main data source used in the present analysis. To analyse data products ERDAS Imagine and ArcGIS 9.2 GIS Software have been used.

6.1. Analysis and Results

6.1.1. Temporal Analysis of Forest Fire Incidences in Western Himalayan Region

The most crucial information provided by the forest fire Mapper is the crucial time period of forest fire in the area. This information can provide the frequency of forest fire in the region so that the vulnerable week/ month regarding forest fire could be identified. It the following table crucial period of forest fire has been identified by counting of frequency of forest fire in the western Himalayan states.

Sl. No.	*State*	*Crucial Period for Forest Fire*	
		From	*To*
1	Uttarakhand	1st Week of April	4th Week of April
2	Himanchal Pradesh	2nd Week of April	1st Week of May
3	Jammu & Kashmir	2nd Week of May	3rd Week of June

Table 1: Vulnerability in terms of time period: Crucial Time for Forest Fire in Western Himalayan Region

Present study tried to estimate the duration time for the maximum forest fire occurrence in a state. It looked into such periods of forest fire occurrence when the frequency of occurrence of forest fire has been maximum. The estimation of the crucial time period has been carried out by averaging out the day wise frequency of the total fire points of all the studied years. Scatter plot of the average forest fire frequencies have been generated for each western Himalayan state. 1/3rd from the peak value has been calculated to get the crucial period of forest fires for each state.

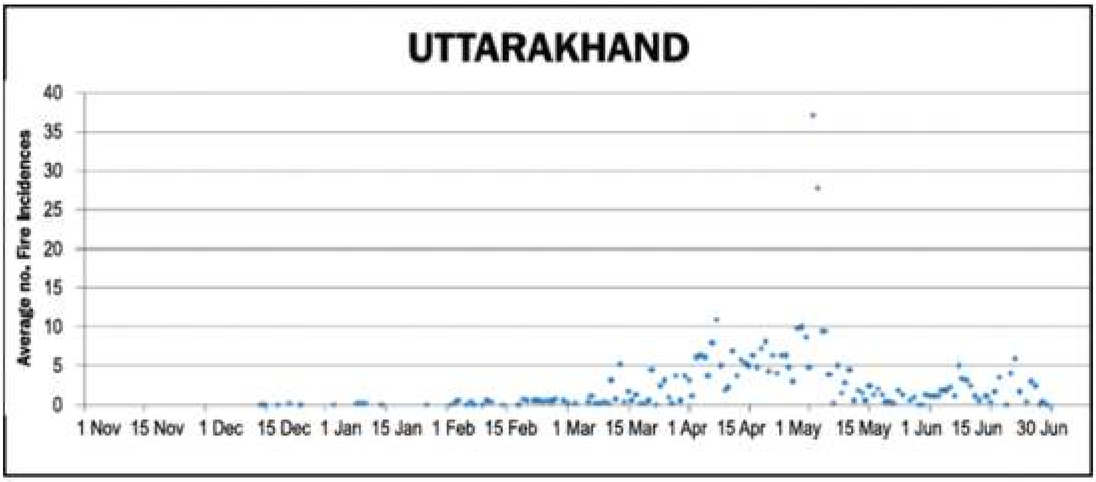

Figure 4: Scatter Diagram of Forest Fire Incidences of Uttarakhand

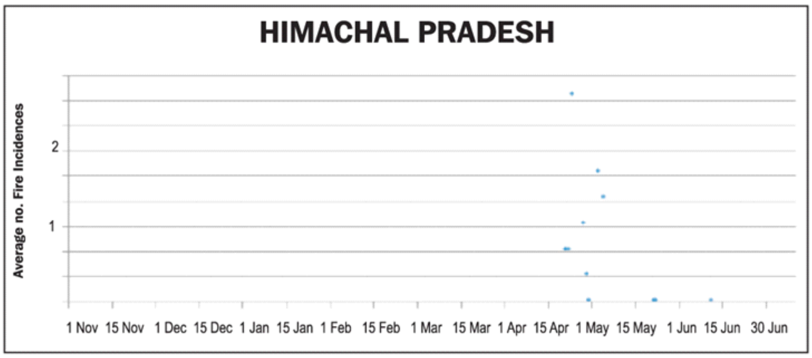

Figure 5: Scatter Diagram of Forest Fire Incidences of Himanchal Pradesh

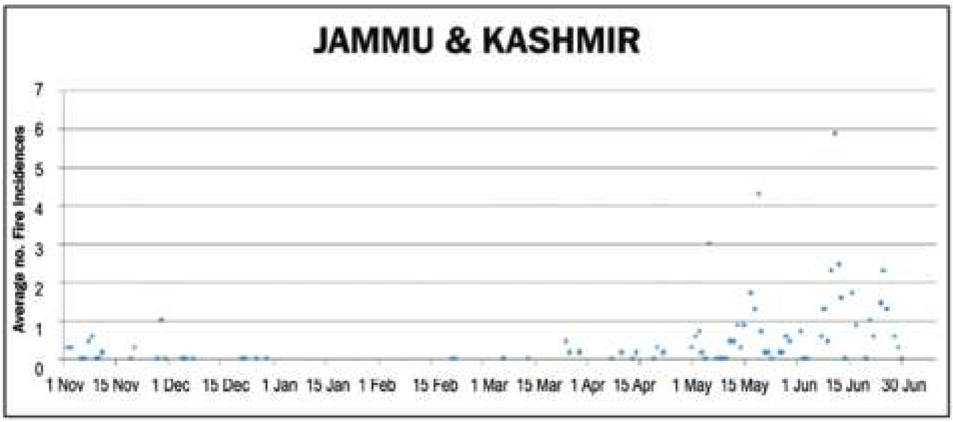

Figure 6: Scatter Diagram of Forest Fire Incidences of Jammu & Kashmir

It is evident from the above scatter plot that the month of April and May are very crucial regarding forest fire in western Himalayan region. In Uttarakhand, frequent forest fire incidences have started from second week of March but peak time observed during the month of April. It is clear that most forest fire state is Uttarakhand where maximum number of forest fire instances has been observed. This area have also register longest period of forest fire where few forest fire instances have been reported in the season of winter also, that last till end of June.

Himanchal Pradesh has registered the least number of forest fires in this region. Here, crucial period of fires prolonged less than one month from second week of April to first week of May.

Jammu Kashmir is the region that has registered forest fire incidences in the month of November and December also but the crucial period of forest fires in the state is second week of May to third week of June.

6.1.2. Spatial Analysis of Forest Fire Incidences – Classifying Fire Vulnerability Level at District level in Western Himalayan Region

Vulnerability Level	*State*	*District*	*Total Forest cover (Sq. km.)**	*Scrub Area (Sq. Km).**
Moderate	UT	Almora	1577	10
Moderate		Bageswar	1381	4
Moderate		Chamoli	2695	6
Low		Champawat	1181	8
High		Dehradoon	1607	24
Moderate		Haridwar	619	0

High		Nanital	3090	13
High		Pauri Garhwal	3289	59
Moderate		Pithoragarh	2094	32
Low	HP	Hamirpur	244	0
Low		Kangra	2064	11
Low		Kullu	1959	23
Low		Mandi	1675	29
Low		Shimla	2386	32
Moderate		Sirmaur	1385	56
Moderate		Solan	850	38
High		Una	523	0
Low	J& K	Jammu	882	43
Moderate		Poonch	729	9
Moderate		Rajouri	1240	8
Low		Anantnag	1438	23
Low		Srinagar	752	1
Low		Udhampur	2689	47

Table 2: Fire Vulnerable Districts in Western Himalayan Region

Highly Vulnerable- Fire Incidence in all 7 sample years at the same area
Moderately Vulnerable – Fire Incidence continuously in 4 to 6 years at the same area
Less Vulnerable- Fire Incidence continuously in 2 to 3 years at the same area

*Data by Forest Survey of India, 2013

Spatial Analysis of fire vulnerability have been analysed on the basis of fire frequency of incidence of forest fire at the district level. The districts of all three states have been categorized. District where fire incidence has been reported every year are considered as High fire vulnerable districts, fire incidence reported 4 to 6 six years are considered as Moderately Vulnerable Districts whereas districts where fire incidence reported 2 to 3 times during sample years are considered as Less Vulnerable Districts. The area of scrub is also included separately because it is observed that some districts where scrub area is bigger the tendencies of forest fires are higher. In Uttarakhand region this tendency is more prevalent where highly vulnerable fire prone districts have bigger area under scrub. Actually in summer season dried scrub helps to spread forest fire. In Uttarakhand, total 9 districts found prone to forest fire. Dehradun, Nanital and Pauri Garhwal are the districts that have high vulnerability of forest fire. It is important to note that these districts have high population pressure on natural resources. So forest fire can be linked with intensive use of natural resources. Almora, Bageswar, Chamoli, Pithoragarh and Haridwar are districts that are moderately prone to forest fire while in Champawat low forest fire vulnerability have been observed. In the state of Himanchal Pradesh, total 8 districts are prone to forest fire. The Low Vulnerability of fire has been observed in Hmirpur, Kangra, Kullu, Mandi, and Shimla whereas Moderate levels of forest fire have been registered in Sirmaur and Solan districts. Una is the only districts in the state where High Vulnerability offorest fire have been observed. Northern most state of Himalaya is Jammu & Kashmir where Jammu, Anantnag, Udhampur and Shrinagr are districts where forest fires are prevalent at Low level but Poonch and Rajouri are the districts where frequency of forest fire are at Moderate Level.

CONCLUSION

Forest fire is a regular feature in the Western Himalayan region. So to save the most important natural resource of the western Himalayan region sustainable forest practices are inevitable that demand reliable and timely forest fire data. Because, the data and analysis about the forest fire in a developing country like country is very weak and needs more serious attempts. To overcome this problem, new innovative methods need to be used. Satellite data as MODIS data may be of quiet significance to evolve new innovative techniques in the field of Forest Fire Management. However to support satellite data, many field-based attempts should also be made at various levels to collect forest fire statistics in the country.

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