IDENTIFICATION OF FIRE PRONE FOREST AREAS BASED ON GIS ANALYSIS OF ARCHIVED FOREST FIRE POINTS DETECTED IN THE LAST THIRTEEN YEARS FOREST SURVEY OF INDIA □□□□□□ □□ □□ □ Government…

Technical Report · January 2019

CITATIONS
0

READS
240

2 authors, including:

Satyendra Shatty
Forest Survey of India
7 PUBLICATIONS **1** CITATION

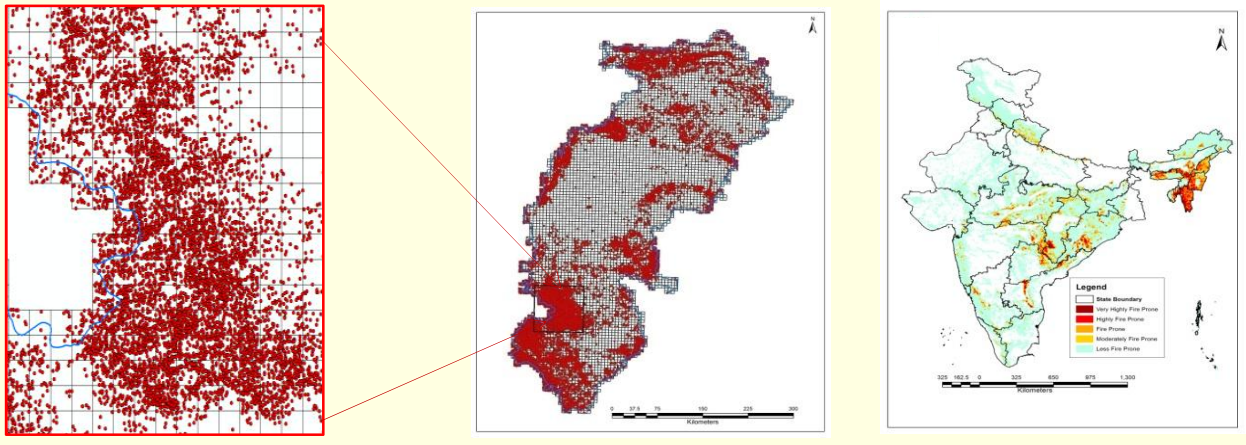
SEE PROFILE

सत्यमेव जयते

TECHNICAL INFORMATION SERIES

Volume I No. 1 2019

IDENTIFICATION OF FIRE PRONE FOREST AREAS BASED ON GIS ANALYSIS OF ARCHIVED FOREST FIRE POINTS DETECTED IN THE LAST THIRTEEN YEARS



भारतीय वन सर्वेक्षण
FOREST SURVEY OF INDIA
Ministry of Environment, Forest & Climate Change
Government of India

TECHNICAL INFORMATION SERIES

Volume I No. 1 2019

Identification of Fire Prone Forest Areas Based on GIS Analysis of Archived Forest Fire Points Detected in the Last Thirteen Years

Contributors:

Satyendra Kumar, Senior Technical Associate, FSI
Abhishek Chaudhary, Senior Technical Associate, FSI
Tapas Biswas, Technical Associate, FSI
Dr. Sourav Ghosh, Senior Technical Consultant, FSI

Under the guidance of:

Dr. Subhash Ashutosh, IFS

Director General, Forest Survey of India

Forest Survey of India

Ministry of Environment, Forest & Climate Change, Government of India

Kaulagarh Road, Dehradun - 248195

Identification of Fire Prone Forest Areas Based on GIS Analysis of Archived Forest Fire Points Detected in the Last Thirteen Years

1. Introduction

Forest fires cause large scale destruction of forest resources and biodiversity in the country every year. One forest fire incident may nullify all efforts of conservation and plantations done in the past several years. A recent analysis done by FSI, shows that nearly 36% of country's forests are prone to fires and of this, over 10% are highly prone. Forest fires in our country are largely of anthropogenic origin and therefore preventable to a large extent. Apart from public awareness and their participation in controlling forest fires, use of all the technological options for prevention, detection, early warning, fire fighting and damage assessment should be employed under a scientifically prepared forest fire management plan for each district or forest division. Geospatial technological tools and techniques have been very effectively used in forest fire management world over in the last couple of decades. Forest Survey of India also took an early initiative in using geospatial technology in forest fire applications in the country. First ever burnt area mapping at the national level using satellite data was undertaken during 1995 to 97. Near real time forest fire detection and dissemination of alerts was started in the year 2004. FSI has come a long way since then. FSI's alert system has evolved to an advanced level in the last one decade and a half. FSI has also standardized an early warning alert system using short term weather forecast data and forest fuel load based on forest types and forest inventory data. Forest fire early warning alerts could be an effective way to prevent forest fires. Modern technological tools particularly of geospatial technologies hold great promise in forest fire monitoring and control in the country.

1.1 Causes of forest fire

Forest fires are caused by both anthropogenic as well as natural reasons.

Anthropogenic fire

When a source of fire like naked flame, cigarette smoking, electric spark or any man-made causes of ignitions come into contact with inflammable materials within forest, it causes forest fires. Such fires may be intentional or accidental. People living in the vicinity of forests often intentionally ignite fires for inducing growth of grass or clear forest floors for collecting Non-Timber Forest Products (NTFPS). Such fires many times become uncontrollable.

Natural Fire

Some forest fires start from natural causes like lightning, rolling stones, friction of dry bamboos and stems of trees. Moreover, high atmospheric temperatures and dryness (low humidity) offer favourable circumstance for a fire to commence.

In India, however over 95 % of fire incidences are of anthropogenic origin.

1.2 Types of forest fire

Forest fires are generally of three types.

Surface fire

Surface fire is a very fast moving fire, which consumes small vegetation and surface litter along with loose debris. This type of forest fires are mostly common in India.

Crown Fire

Crown fire advances from top to top of trees or shrubs without any close link with surface fire. It is the fastest way of spreading fire and most destructive for trees as well as wildlife. It is rarely observed in India.

Ground fire

A true ground fire is not easily predictable as it spreads within, rather than top of organic matter. It consumes organic matter like duff, musk or peat present beneath the surface litter of the forest floor. It has unique characteristic of having a smouldering edge with no flame and little smoke. Ground fires are most hard to tackle. There should be proper policy and practices to control these type of Fires (Saigal 1989).

1.3 Fire as a Forest Management Tool

Not all fire in the forest is bad. While it is still imperative to prevent catastrophic wildfires. Fire is necessary for the proper functioning of forest ecosystems. The way to gain the benefits of fire is through prescribed burns. These are intentional fires set under very controlled conditions to avoid adverse consequences. Prescribed burning is one of many options in the forest management tools.

Fire can be used for a number of management goals, including (but not limited to); the restoration of natural ecosystems, reduction of wildfire hazards, to improve wildlife habitat, to increase regeneration of native species, removal of pests and diseased trees and the reduction of invasive species population.

However, use of controlled burning as a management tool has reduced in our country over the years due to various reasons.

2. Near Real Time Forest Fire Detection System Developed by FSI

Geospatial point data showing forest fires provided by National Remote Sensing Centre (NRSC) is acquired and provided to FSI on near real time basis. The active fire spots or hotspots are generated by using MODIS and SNPP-VIIRS satellite sensors. The locations of fires as received from NRSC are regardless of land use and land cover. These coordinates are superimposed on the latest forest cover map of India, prepared by Forest Survey of India, to eliminate any fire hotspots coming from industrial, agricultural or any other sources other than forest. Attributes like state, district and Survey of India 1:50000 topo-sheet's numbers are attached with each coordinate of the forest fire locations as attribute information. The processed forest fire information is then converted into *.KML (Keyhole Mark-up Language) format, and is e-mailed to the appointed nodal officers of each state. The sms messages are also sent to every registered user in the country. Forest fire detection and dissemination of alerts is done twice daily during the fire season i.e December to next year June. This activity is being done in FSI since 2004.

3. Mapping of Fire Prone Forest Areas

Frequency of detected forest fires in an area over a period of time indicates proneness of the area to forest fires. Map showing forest area in different classes of fire proneness can be an effective management tool for controlling forest fires. Such map can be used for optimally utilizing scarce resources available for controlling forest fires in fire season. Increased vigil in highly fire prone forest areas may effectively prevent forest fires.

Considering usefulness of mapping fire prone forest areas, analysis of the detected forest fire points in GIS framework along with a grid coverage of 5 Km X 5 Km and latest forest cover has been done for whole country. The basic data for the study is the record of accumulated forest fire points (FFP) which have been detected by FSI in the last 13 years since 2004. These FFPs may not be exactly the number of forest fire occurrences in the country as these FFPs include repeated detections due to continuance of forest fires at many places. The data of FFPs may not be uniform for all the years because threshold value of confidence for detecting forest fires and also forest fire season has not been kept same in all the past thirteen years. Never the less record of FFPs accumulated in the past thirteen years is an unbiased data which is strongly correlated with fire proneness of an area.

3.1 Objective

Mapping of fire prone forest areas under different fire prone classes for each state of the country and determine forest area under each fire proneness classes.

3.2. Methodology

All forest fire points detected by FSI during the period 2004-05 (fire season) to 2017 (fire-season), have been considered for the study. A vector coverage of all the Forest Fire Points (FFPs) was created for the analysis.

Input data used in the study are given below:

i. The Forest Fire Points (FFPs) considered in the analysis include all fresh detections and continuing forest fires detected repetitively till the fire is active.

ii. Standard grids of equal area (5km X 5km) of FSI received from NRSC.

iii. Latest forest cover map of India, prepared for 15th cycle by FSI as, 'India State of Forest Report 2017' (ISFR 2017).

iv. Administrative boundaries of Indian states procured from Survey of India have also been used for identifying the fire prone forest areas.

A GIS overlay analysis has been done by overlaying forest fire points coverage over the 5 Km X 5 Km grid coverage. Thereafter, frequency of forest fire points in each grid has been determined by the frequency of forest fire points observed in the respective grids ranging from 1 to 176. Average annual frequency of observed forest fire in the grid has been computed by dividing total frequency by number of years i.e. 13.

The following diagram (Fig.1) shows the flow chart of the methodology.

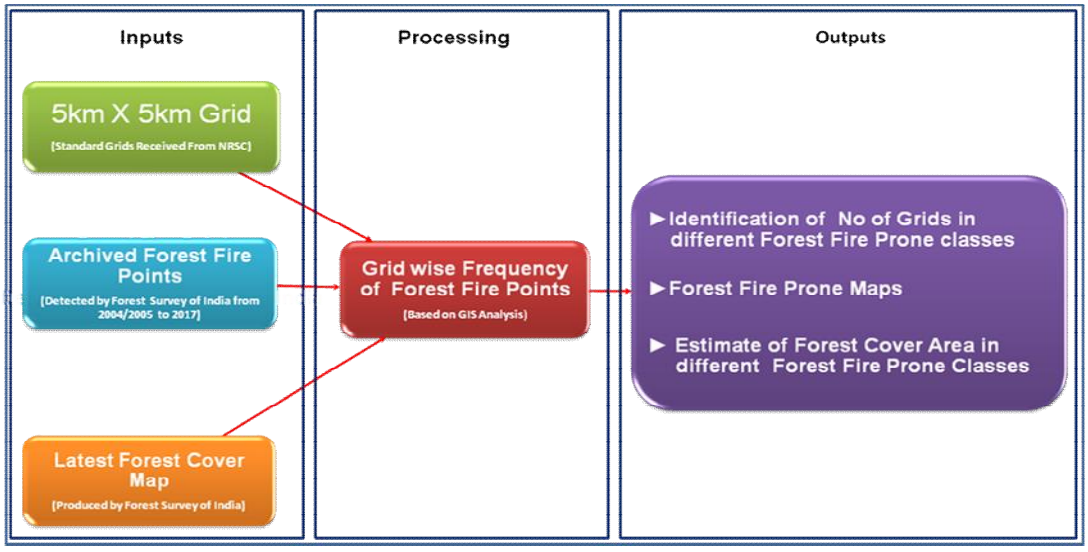


Fig. 1 Schematic diagram used in identification of Forest fire prone area

Based on the above analysis, maps showing fire prone forest areas have been generated for all the states and the country showing different intensity of fire proneness.

3.3 Forest Fire Points Detected by FSI

Total number of forest fire points in the last thirteen years in each State and UTs are shown in the following table.

Table 1: Detected forest fire points from 2004 - 05 to 2017 Fire Seasons

State/UTs	Forest Fire Points
Andaman & Nicobar Islands	165
Andhra Pradesh	15,582
Arunachal Pradesh	6,422
Assam	20,862
Bihar	2,229
Chandigarh	1
Chhattisgarh	25,995
Dadra & Nagar Haveli	9
Delhi	8
Goa	70
Gujarat	2,393
Haryana	448
Himachal Pradesh	1,178
Jammu & Kashmir	977
Jharkhand	6,562
Karnataka	7,352
Kerala	1,719
Madhya Pradesh	24,422
Maharashtra	20,686
Manipur	17,907
Meghalaya	12,820
Mizoram	32,659
Nagaland	11,296
Odisha	26,719
Puducherry	9
Punjab	837
Rajasthan	1,159

State/UTs	Forest Fire Points
Sikkim	28
Tamil Nadu	2,067
Telangana	11,643
Tripura	9,603
Uttar Pradesh	5,483
Uttarakhand	6,665
West Bengal	1,783
TOTAL	**2,77,758**

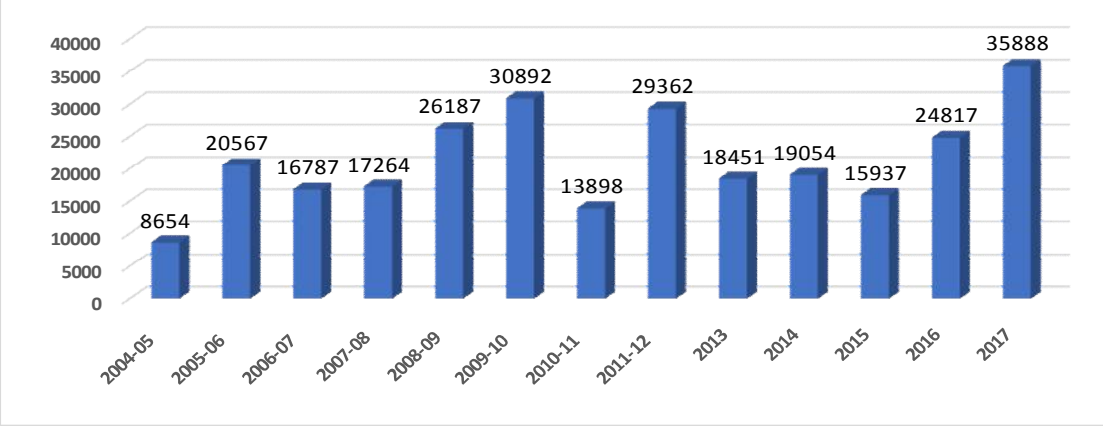


Fig. 2: Graphical Representation showing the total forest fires in 13 Years

The year wise total number of detected forest fire points in the last thirteen years is show in the above bar chart (Fig, 2).

3.4 Criteria for identification of forest fire prone classes

Fire proneness has been categorized into different severity classes based on frequency of forest fire points of the last 13 years in each grid of the size 5 Km X 5 Km. Average annual frequency of FFPs in each grid has also been calculated by simple division of total frequency by 13 i.e. the number of years. Criteria of different fire proneness classes which has been followed in the study are as follows.

i. Extremely fire prone forest area
   Average frequency of forest fire ≥4 in a grid per year
   (i.e. ≥ 52 detected forest fire points in the last 13 years)
ii. Highly fire prone forest area
   Average frequency of forest fire (≥ 2 and <4) in a grid per year

(≥ 26 and < 52 detected forest fire points in the last 13 years)

iii. Fire prone forest area
Average frequency of forest fire (≥ 1 and <2) in grid per year
(≥ 13 and < 26 detected forest fire points in the last 13 years)

iv. Moderately fire prone forest area
Average frequency of forest fire (≥ 0.5 and <1) in grid per year
(≥ 6 and < 13 detected forest fire points in the last 13 years)

v. Less fire prone forest area
Average frequency of forest fire (< 0.5) in grid per year
(<6 detected forest fire points in the last 13 years)

3.5 Determining of Forest Cover in Different Fire Prone Classes

To assess extent of forest cover under different fire prone classes the latest forest cover map produced by FSI in the 15th cycle has been overlaid on the vector grid coverage of fire prone classes created by following the methodology described above. The forest cover map used in this step has been modified to exclude TOF so that the analysis results in identifying fire prone forest areas for natural forest which are largely recorded forests under the control of State Forest Departments. Results of this analysis are given in the Table 4.

4. Results and Discussion

The total number of forested grids in India are 69,652 out of which 29,345 (42.13 %) grids are affected by forest fires (Table 2) at least once, as detected by FSI. The minimum frequency of forest fire in a grid is 1 and maximum is 176.

Table: 2 Statistics at a glance

Total no of grids (5km x 5km)	1,34,043
Total no of forested grids	69,652
No. of forest fire point/FFP (from 2004 to 2017)	2,77,758
No. of grids where forest fire were detected	29,345
Frequency of forest fire	Min - 1 Max - 176

Forest cover in different fire prone classes are given in Table 3. Nearly, 4 % of the country's forest cover is extremely prone to fire, where as 6 % of forest cover is highly prone. Thus about 10% of forest cover in the country is exposed to a very high threat of forest fire. In all, over 36 % of the country's forest cover is prone to frequent forest fires. Figure 3 depicts distribution of fire prone forest areas in different categories in pie chart.

Table: 3 Forest cover in different fire prone classes

S.No.	Forest Fire Prone Classes	No. of Grids*	Forest Cover** (in km^2)	% of Total forest cover
1	Extremely fire prone	665	25,617	3.89
2	Highly fire prone	2,259	39,500	6.01
3	Fire prone	3,708	75,952	11.50
4	Moderately fire prone	5,496	96,422	14.70
5	Less fire prone	57,489	4,20,625	63.90
Total		69617	6,58,116	100.00

*Grid size 5km x 5km
** Forest Cover excluding TOF

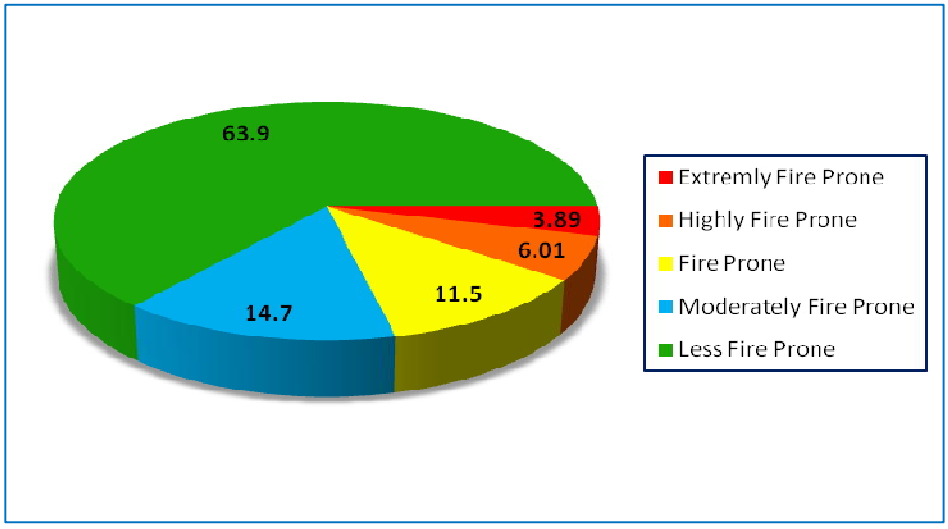


Fig. 3 Diagrammatic Representation showing the percentages of Fire Prone Areas

Maps of fire prone forest areas have been created for all the states and union territories of the country.

Fig. 4 shows an illustration of fire prone forest areas for Chhattisgarh State.

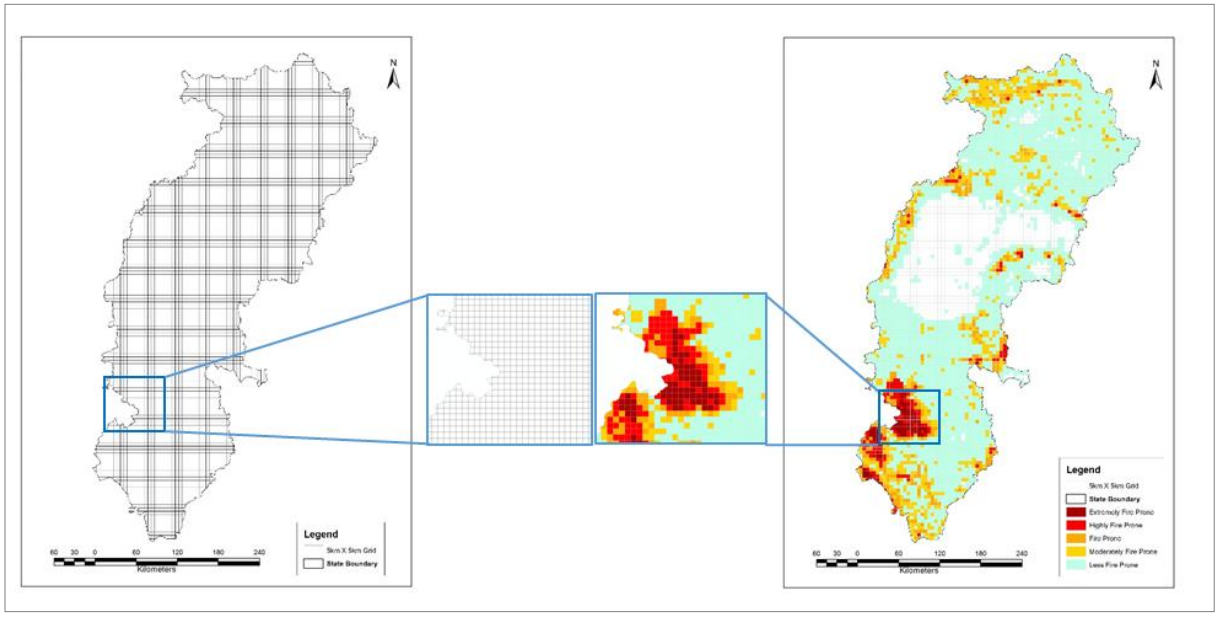


Fig. 4 Grids of 5 X 5 Km showing the fire prone forest area of Chhattisgarh State

Table 4 gives area and percentage of forest cover in different fire prone classes for all the States and UTs of the country. It may be seen that forest in the north eastern and central part of the country have most of the fire prone forest areas. List of top 10 States in terms of percentage of forest cover in extremely fire prone areas is given below.

Sl. No.	STATE / UTs	% of Forest Cover under extremely fire prone class
1	Mizoram	29.91
2	Tripura	26.95
3	Assam	21.98
4	Meghalaya	5.74
5	Manipur	4.48
6	Andhra Pradesh	4.27
7	Telangana	4.21
8	Chhattisgarh	3.90
9	Maharashtra	3.40
10	Nagaland	3.05

Fig. 6 depicts the above in the bar charts.

Similarly, top 10 States according to percentage of forest cover in highly fire prone category are given in the following table.

Sl. No.	STATE / UTs	% of Forest Cover under highly prone class
1	Mizoram	38.46
2	Manipur	33.13
3	Tripura	21.90
4	Nagaland	18.48
5	Meghalaya	18.38
6	Andhra Pradesh	13.04
7	Odisha	7.73
8	Bihar	7.15
9	Uttar Pradesh	7.10
10	Telangana	6.89

Fig. 5 shows the country's map of fire prone forest area.

Maps showing fire prone forest areas produced from this study can be effectively utilized in formulating knowledge base strategy for forest fire control in the states. forest areas under different severity of fire proneness may be accorded priority accordingly.

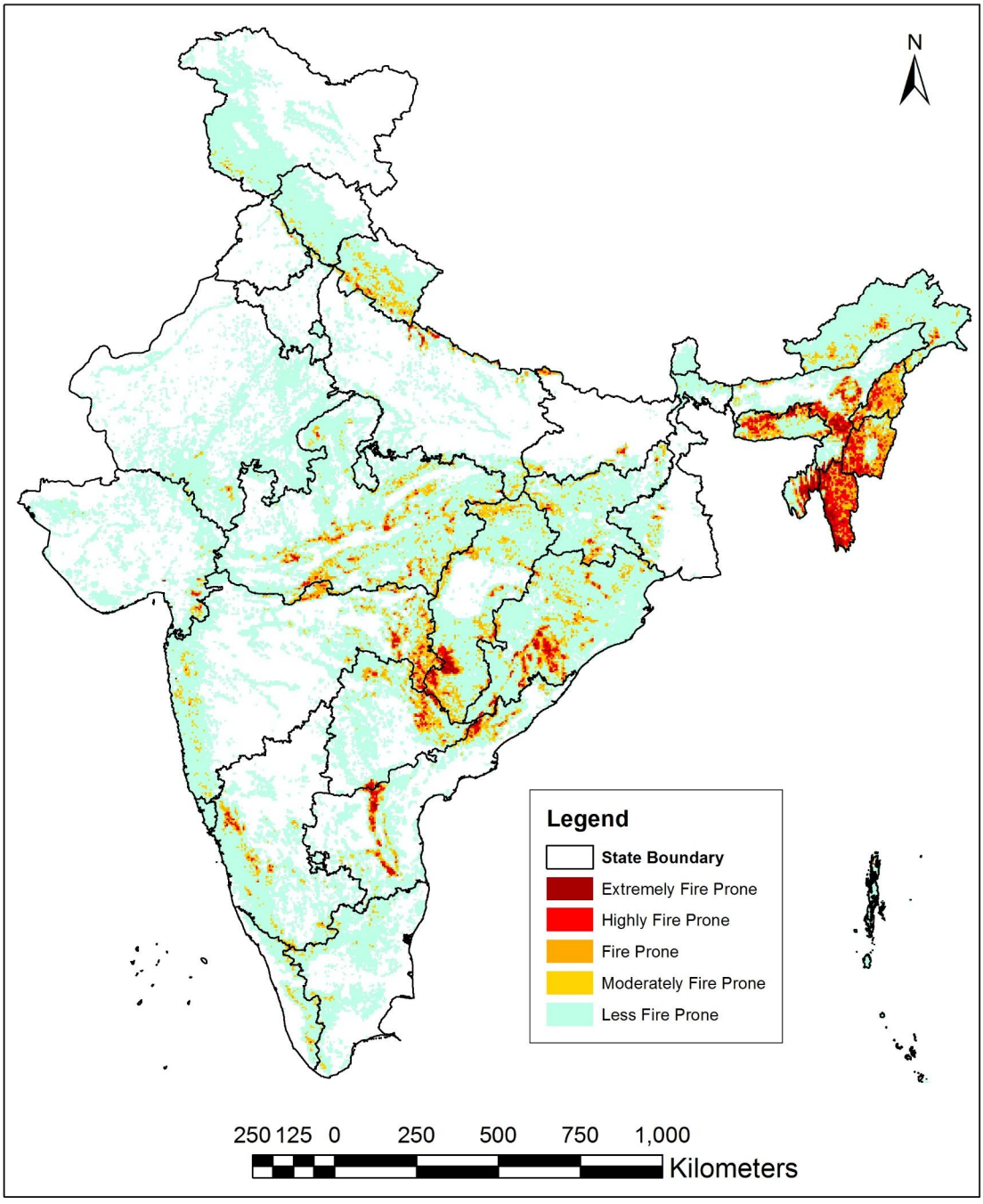


Fig. 5 Map Showing fire prone forest areas under different fire prone classes

Table 4: Forest Cover* Area under different Fire Prone Classes

(Area in Km^2)

STATE / UTs	Extreme Fire Prone		Highly Fire Prone		Fire Prone		Moderately Fire Prone		Less Fire Prone	
	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover
Andaman & Nicobar Islands	0	0	32	0.52	26	0.42	23	0.38	6044	98.68
Andhra Pradesh	1095	4.27	3611	13.04	4152	15.27	5089	18.72	13244	48.7
Arunachal Pradesh	13	0.02	648	0.97	2334	3.49	4598	6.87	59371	88.65
Assam	5493	21.98	1522	6.1	3619	14.48	3428	13.72	10923	43.72
Bihar	0	0	371	7.15	917	17.68	1180	22.74	2720	52.43
Chandigarh	0	0	0	0	0	0	0	0	10	100
Chhattisgarh	2140	3.9	3327	6.04	7452	13.55	12287	22.34	29784	54.17
Dadra & Nagar Haveli	0	0	0	0	0	0	0	0	194	100
Daman & Diu	0	0	0	0	0	0	0	0	16	100
Delhi	0	0	0	0	0	0	0	0	131	100
Goa	0	0	0	0	0	0	1	0.05	1925	99.95
Gujarat	32	0.25	329	2.69	424	3.45	1036	8.43	10467	85.18
Haryana	0	0	25	2.33	63	5.87	194	18.08	791	73.72
Himachal Pradesh	0	0	4	0.03	172	1.18	670	4.59	13748	94.2
Jammu & Kashmir	0	0	18	0.08	84	0.38	584	2.65	21355	96.89
Jharkhand	47	0.21	488	2.18	2048	9.16	4370	19.54	15414	68.91
Karnataka	95	0.29	863	2.61	2301	6.96	3301	9.99	26494	80.15
Kerala	0	0	22	0.18	460	3.84	1396	11.67	10087	84.31
Madhya Pradesh	109	0.14	2893	3.79	9077	11.87	14806	19.36	49599	64.84
Maharashtra	1677	3.4	1966	4.01	7667	15.6	8181	16.65	29642	60.34
Manipur	769	4.48	5755	33.13	6219	35.85	2665	15.36	1937	11.18
Meghalaya	983	5.74	3152	18.38	3452	20.13	3047	17.77	6512	37.98
Mizoram	5423	29.91	7009	38.46	4481	24.64	972	5.35	299	1.64
Nagaland	380	3.05	2309	18.48	4752	38.05	3204	25.65	1844	14.77
Odisha	1449	2.82	3940	7.73	6808	13.32	10200	19.96	28706	56.17
Puducherry	0	0	0	0	0	0	0	0	0	100
Punjab	0	0	8	0.56	242	17.09	414	29.24	752	53.11
Rajasthan	0	0	50	0.32	384	2.48	561	3.62	14491	93.58

STATE / UTs	Extreme Fire Prone		Highly Fire Prone		Fire Prone		Moderately Fire Prone		Less Fire Prone	
	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover	Forest cover area	% of total forest cover
Sikkim	0	0	0	0	0	0	0	0	3213	100
Tamil Nadu	0	0	0	0	439	2.19	1589	7.92	18036	89.89
Telangana	911	4.21	1322	6.89	3540	17.59	3743	18.6	10606	52.71
Tripura	1862	26.95	1555	21.9	881	12.62	751	10.76	1939	27.77
Uttar Pradesh	104	0.92	805	7.1	1344	11.86	2002	17.66	7079	62.46
Uttarakhand	40	0.17	389	1.6	2254	9.32	5238	21.66	16264	67.25
West Bengal	0	0	82	0.99	360	4.33	892	10.72	6988	83.96

* excludes Trees Outside Forests (TOF)

5. Conclusion

The study has led to a country wide mapping of fire prone forest areas based on forest fire points detected by FSI in the last 13 years. With the robust data of fairly long period, the identification of fire prone forest areas presents a credible spatial data which can be effectively utilized for policy, planning, strategy formulation and fire management at the local level. Further studies are required to analyse factors responsible for high forest fire incidences in high fire prone forest areas to understand the causes of frequent fires, so that specific micro level plans can be prepared for controlling forest fires. Considering the scarce resources available to control forest fires in fire season, the grid based fire prone map can be a very useful input in planning deployment of resources effectively. The study also provides a rational basis for funds allocation for management and control of forest fires both at the Central and State levels. The study paves way for future studies in the areas of high proneness to understand socio-economic and ecological causes and impact of forest fires on the ecosystems.

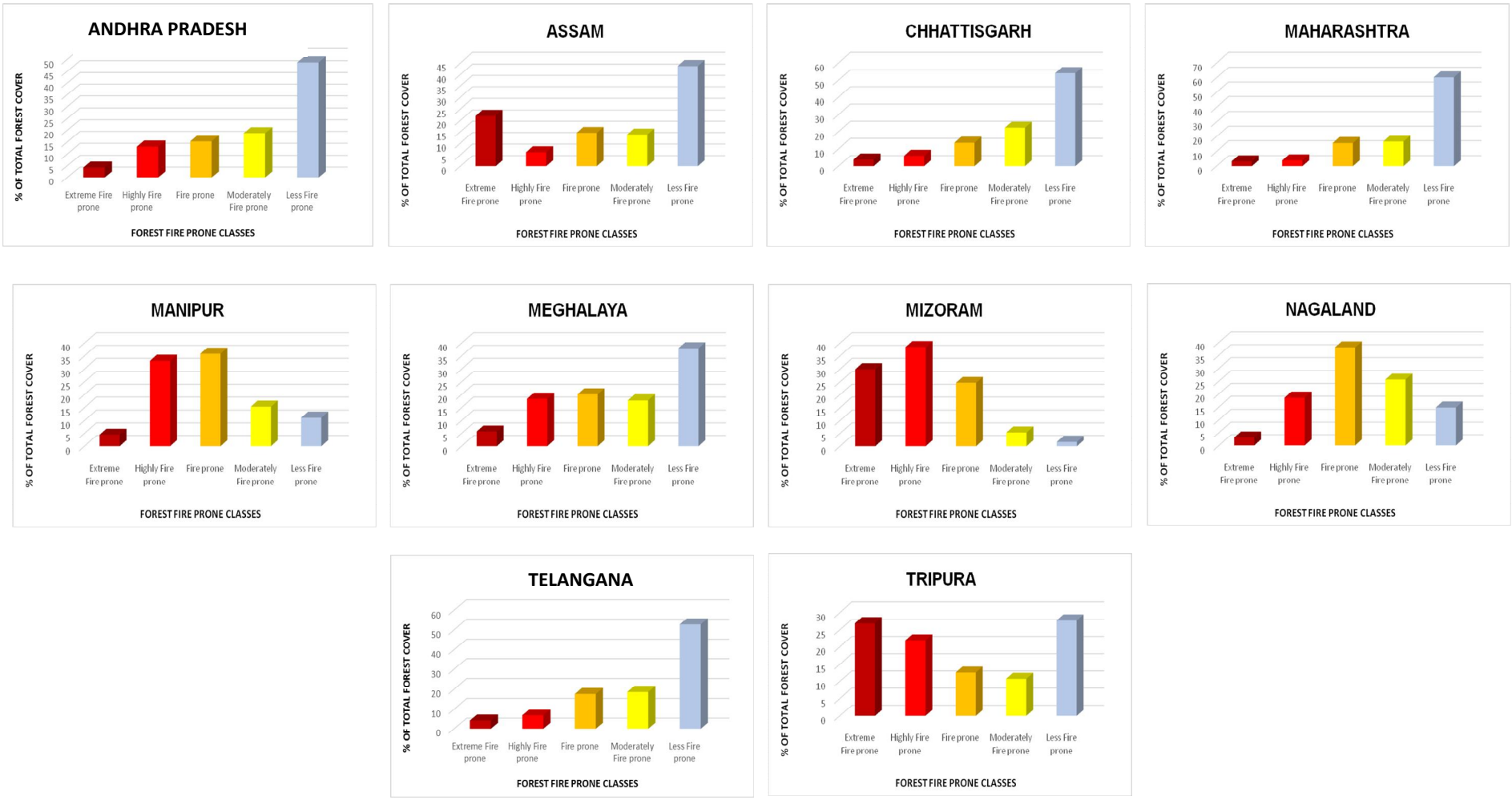


Fig. 6: Diagrammatic Representation of Top 10 States having Extremely High Fire Prone Forest Cover

6. References

FSI (2017) *India State of Forest Report 2017*. Forest Survey of India, Ministry of Environment, Forest & Climate Change, Government of India, Dehradun.

FSI (2012) *Vulnerability of India's Forest to Fire report 2012*. Forest Survey of India, Ministry of Environment, Forest & Climate Change, Government of India, Dehradun.

Giglio, Louis (2010) *MODIS Collection 5 Active Fire Product User's Guide Version 2.4 Inc,* Science, Systems and Applications, Department of Geography, University of Maryland.

Saigal, P.M. (1989) A suggested classification of forest fires in India by types and causes. *In*: *Proceedings of the National Seminar on Forest Fire Fighting*, Kulamaru, Kerala, India, 2–3 November 1989.

Suggested Websites for Further References:

1. *www.wikipedia.com*
2. *https://modis.gsfc.nasa.gov/about/*
3. *www.fsi.nic.in*
4. *https://himachal.nic.in/WriteReadData/l892s/172_l892s/5-54447247.pdf*
5. *http://www.fao.org/countryprofiles/index/en/?iso3=IND*
6. *https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms*

For Further Contact:

- sk7shatty7@gmail.com
- sgindiamobile@gmail.com