05

FOREST FIRE MONITORING

Introduction 5.1

Forest Fires have long been an integral part of the forest environment and have played an important role in shaping the forest ecosystems, their conservation and management. Although, fire has benefits in terms of clearing the forest floor and paving way for regeneration of new grass, herbs and saplings, yet these are marginal when compared to the huge losses linked to it. Controlled forest fires are often used as important resource management tools for enhancing ecological conditions and eliminating excessive fuel build up in the forest areas.

Controlled or uncontrolled fire in an ecosystem may change the species mix, habitat structure and biodiversity (Global Wildfire Information System, 2019)[1] . These are associated with extreme fire-danger conditions driven by meteorological factors such as a lack of precipitation, high wind speeds, low humidity and high temperatures. Human carelessness is also a common cause of forest fires. Forest fires have severe impacts, causing the loss of human life, biodiversity, habitat, production and productivity; degradation of landscapes; and disruption of livelihoods.

Global Scenario 5.1.1

Global Forest Resource Assessment (GFRA) 2020 and other scientific studies have reported that the wild lands including forest areas are increasingly facing difficult fire weather conditions, extended fire seasons and large fires influenced by climate change, which is likely to have immense costs in terms of loss of biodiversity, ecosystem services, human well-being, livelihoods and national economies. Globally about 98 million ha of forest were affected by fire in 2015, which comprises 3 % of global forest area. This was mainly in the tropical domain, where about 4 percent of the total forest area was burnt (GFRA 2020)[2] . The resultant release of greenhouse gases (GHGs) and sequestrated carbon locked within trees is further leading to global warming and deterioration of the environment. The Fifth Assessment Report of the Inter-governmental Panel on Climate Change has also reported an estimated 260,000 to 600,000 premature deaths of human/ wildlife annually, due to exposure to smoke from landscape fires (including forest fires). The report also finds that annual carbon emissions from forest fires range between 2.5 billion to 4.0 billion tons of CO_2, adding large volumes of greenhouse gases to the atmosphere.

Persistent hotter and drier weather due to climate change and other human factors such as land conversion for agriculture and poor forest management are the main drivers behind the increase of forest fire. WWF International in its 2020 report has estimated that humans are responsible for around 75% of all wildfires and much of the increase in fire incidents during 2020 can be directly linked to human actions. In April 2020, the number of fire alerts across the globe were up by 13% as compared to last year - which was already a record year for fires[3].

[1] *Global Wildfire Information System, 2019, https://gwis.jrc.ec.europa.eu/*

[2] *Global Forest Resources Assessment 2020 Main Report, Report by Food and Agriculture Organization of the United Nations (https://doi.org/10.4060/ca9825en)*

[3] *Fires, forests and the future: A crisis raging out of control (2020), Joint Report by the World Wide Fund for Nature (WWF), Switzerland and Boston Consulting Group (BCG), US.*

5.1.2 Indian Scenario

In India, severe fires occur in many forest types particularly dry deciduous forest, while evergreen, semi-evergreen and montane temperate forests are comparatively less prone (ISFR 2015)[4] . More than 36% of the country's forest cover has been estimated to be prone to frequent forest fires. Nearly 4 % of the country's forest cover is extremely prone to fire, whereas 6% of forest cover is found to be very highly fire prone (ISFR 2019)[5] .

The forest fire season in the country is normally from Nov to June, and with majority of fires being caused due to man-made factors. The National Action Plan on Forest Fires (NAPFF)[6] was formulated by the MoEF&CC, Government of India in 2018 with the objective of revamping the forest fire management in the country. It aims to minimize forest fires from taking place by informing, enabling and empowering forest fringe communities, and also incentivizing them to work in tandem with the State Forest Departments (SFDs). This plan also aims at substantially reducing the vulnerabilities of forests across the diverse forest ecosystems in the Indian subcontinent against fire hazards, enhancing the capabilities of forest and other personnel and institutions in fighting fires, use of technology and speeding up recovery after a fire event.

Technology such as satellite based forest fire detection and alerts dissemination in near real-time, early warning information, tracking of large fires and related activities are of critical importance in timely prevention and control of forest fires.

5.2 Role of FSI in Forest Fire Monitoring

Since 2004, Forest Survey of India (FSI) has been assisting the State Forest Departments and other agencies to deal with the problems associated with forest fire by using the latest remote sensing and communication technology. Starting from providing forest fire alerts of fire incidences detected by MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor on-board Aqua and Terra Satellite of NASA, the Forest fire alert system of FSI has undergone significant improvement in the recent years. Chronology of evolution of the FSI forest fire system is given in Table 5.1. During fire season, the following country-wide forest fire related services are being provided:

- Near Real-Time Forest Fire Monitoring
- Large Forest Fire Monitoring
- Early Warning Alert based on Forest Fire Danger Rating System
- FSI Van Agni Geo-portal
- Identification of Fire Prone Forest Areas
- Sharing of WMS (Web Map Service) & WFS (Web Feature Service) services to State Forest Departments.

[4] *ISFR 2015, India State of Forest Report 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.*

[5] *ISFR 2019, India State of Forest Report 2019, Forest Survey of India, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.*

[6] *National Action Plan on Forest Fire (2018), Report by Forest Protection Division, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.*

Table 5.1 Evolution of FSI Forest Fire Alert System

Year	Milestone
2004	Started dissemination of forest fire alerts based on MODIS data up to district level through e-mail/ FAX
2008	Initiation of SMS alerts on number of fires in State/ District
2012	• Introduced KML files in e-mail alerts up to district level along with SMS alerts • Publication of "Vulnerability of India's forests to fires" report
2016	• Introduction of automated e-mail alerts to nodal officers using python script • Pilot study on country-wide burnt scar assessment for 2015 and 2016 • Pre-warning alerts piloted for Uttarakhand, Himachal Pradesh and Madhya Pradesh
2017	• Complete automation of entire FSI Forest Fire Alert System • SNPP-VIIRS sensor added to FSI forest fire monitoring system • Forest Fire Alert dissemination up to Beat level • Pre-warning alerts piloted for pan-India
2018	Introduction of improved feedback system for forest fire alerts
2019	• Initiation of satellite based Large forest fire monitoring program • FSI Van Agni Geo-portal • Early-warning alert based on Fire Weather Index • Identification of Fire prone forest area
2020	• Strengthening of large forest fire monitoring system and FSI Van Agni Geo-portal • WMS, WFS and API to State Forest Departments
2021	• Special monitoring of large forest fire events like Dzukou Valley, Similipal TR, Bandhavgarh TR etc • Special reports on unusual increase of forest fire alert in the State

Near Real-Time Forest Fire Monitoring 5.2.1

Currently, Forest Survey of India (FSI) has been alerting State Forest Departments towards forest fire incidences detected by MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor on-board Aqua and Terra Satellite of NASA and SNPP - VIIRS (Suomi National Polar-orbiting Partnership - Visible Infrared Imaging Radiometer Suite) sensor, at least six times in 24 hours. The fire hotspots detected by MODIS (1 km X 1 km resolution) and SNPP-VIIRS (375 m X 375 m resolution) sensors are received at Shadnagar Earth station (National Remote Sensing Centre) and processed using standard algorithm. The fire hotspots are electronically shared with FSI, which are further processed automatically at FSI headquarter Dehradun and alerts are generated and disseminated to the registered end users as SMS and also in the form of KML through e-mail to SFDs. Automation of the entire process has reduced the processing time, as a result of which the information is disseminated to SFDs in the shortest possible time, leading to quick responses by the field teams in fire containment activities.

A comparison between the two sensor viz. MODIS and SNPP-VIIRS has been given in Table 5.2.

Table 5.2 Comparison between the two sensor viz. MODIS and SNPP-VIIRS

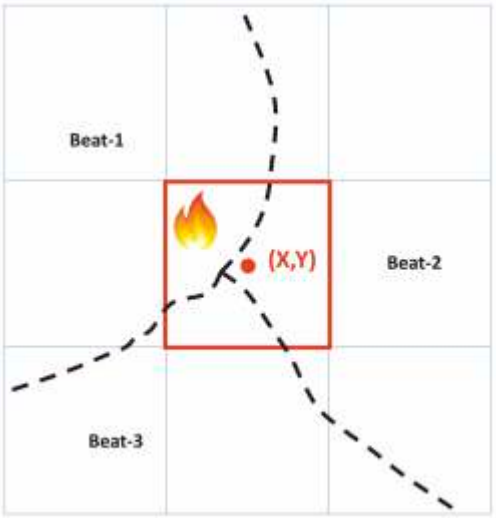
Feature	MODIS Moderate Resolution Imaging Spectro-radiometer	SNPP-VIIRS Visible Infrared Imaging Radiometer Suite
Sensor	36 spectral bands (channel 21, 22, 31)	5 HR Imagery channels (I-bands), 16 moderate resolution channels (M-bands), and a D/N Band (M13 and M15)
Satellite	Aqua and Terra	Suomi National Polar-orbiting Partnership (NPP) satellite
Launch	Dec 1999 and May 2002	Oct 2011
Algorithm	Contextual	Thresholding and Contextual (Hybrid)
Equatorial Pass	Terra- 10:30 am & 10:30 pm; Aqua- 01:30 am & 01:30 pm	01:30 am and 01:30 pm
Resolution	1 km x 1 km	375 m x 375 m

The process of generation and dissemination of forest fire alerts is described below.

a) The fire hotspots received from National Remote Sensing Centre (NRSC) comprise all the hotspots detected by the sensors i.e. the features on the ground above certain threshold temperature, irrespective of whether they fall within forests or outside. Initially, the point data is converted into square polygons representing pixels, based on the spatial resolution of MODIS and SNPP-VIIRS sensor. Further, these forest fire pixels are filtered using a custom filter which is a combination of Recorded Forest Area boundaries as well as Forest cover data. State/UT-wise details of the level of customization in forest fire alerts is shown in Table 5.3. Forest fire information is enriched by adding attributes like State, District, Circle, Division, Range, Block, Beat, Compartment number etc. to the filtered forest fire pixels.

   Figure 5.1 depicts the pixel based analysis and dissemination of forest fire alerts being carried out by FSI currently. From the Figure, it is clear that irrespective of the number of administrative levels (beat, compartment etc.) falling over the pixel in which the fire hotspot is detected, the forest fire alerts, communicating the location of the centroid of the affected pixel is sent to subscribers of all the administrative levels.

Figure 5.1 Pixel based analysis and dissemination of forest fire alerts



- As per ground observation, the forest fire is observed in Beat-1
- Forest fire alerts giving location of centroid of the pixel (X, Y) in which the fire hotspot is observed by sensor are sent to all three Beats (Beat 1, 2 & 3)

b) Based on the analysis of the near real-time forest fire data and feedback from the SFD's, FSI has developed a filter to mask out fires from mining areas, Industrial areas etc., which may otherwise add false alarms to the forest fire alert system. After filtering, all the subscribers are notified through SMS about the forest fires that have been detected within their area of interest. This information is also shared with State Nodal Officers through e-mail. The information is also uploaded online on the FSI website (www.fsi.nic.in) and Van Agni Geo-portal (http://vanagniportal.fsiforestfire.gov.in/fsi_fire/fire.html). Work flow for alerts generation and dissemination of the information/SMS is presented in the following schematic diagram given at Figure 5.2.

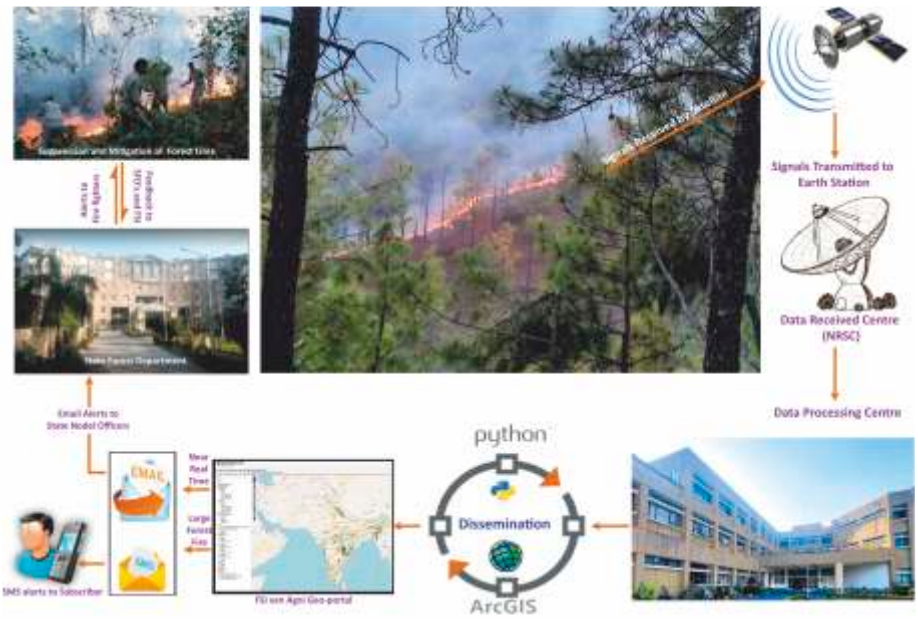


Figure 5.2 Work Flow of Near Real-Time Forest Fire Monitoring

Table 5.3 Details of levels of customization in forest fire alerts

Sl. No.	State/UT	Alert Level	RFA details included in alerts (Yes/No)
1	Andhra Pradesh	Beat	Yes
2	Arunachal Pradesh	District	No
3	Assam	District	No
4	Bihar	Beat	No
5	Chhattisgarh	Beat	Yes
6	Delhi	District	No
7	Goa	Beat	Yes
8	Gujarat	Beat	No
9	Haryana	Beat	Yes
10	Himachal Pradesh	Beat	No
11	Jammu & Kashmir	Range	Yes
12	Jharkhand	Beat	No
13	Karnataka	Beat	No
14	Kerala	Range	No
15	Madhya Pradesh	Beat	Yes
16	Maharashtra	Beat	No
17	Manipur	Beat	No

Sl. No.	State/UT	Alert Level	RFA details included in alerts (Yes/No)
18	Meghalaya	Block	No
19	Mizoram	Beat	No
20	Nagaland	District	No
21	Odisha	Beat	Yes
22	Punjab	Beat	No
23	Rajasthan	Range	No
24	Sikkim	District	No
25	Tamil Nadu	Beat	Yes
26	Telangana	Beat	Yes
27	Tripura	Beat	No
28	Uttar Pradesh	Beat	No
29	Uttarakhand	Beat	Yes
30	West Bengal	Beat	Yes
31	Andaman & Nicobar Islands	District	No
32	Chandigarh	District	No
33	Dadra & Nagar Haveli and Daman & Diu	District	No
34	Ladakh	District	No
35	Lakshadweep	District	No
36	Puducherry	District	No

5.2.1.1 Analysis of number of forest fire detected using MODIS & SNPP-VIIRS sensors for fire seasons 2019-2020 and 2020-2021

During the forest fire season 2019-2020, the number of hotspots detected by MODIS sensor were 22,447 & by SNPP-VIIRS sensor were 1,24,473. In fire season 2020-2021, the total hotspots detected by MODIS sensor were 52,785 & by SNPP-VIIRS sensor were 3,45,989. State wise details of number of forest fires detected by FSI using MODIS & SNPP-VIIRS sensors for fire season 2019-2020 and 2020-2021 are given in Table 5.4. This includes large, continuous and repeated forest fires.

Map showing MODIS and SNPP-VIIRS hot spots detected during 2020-2021 forest fire season are given in Figure 5.3 & Figure 5.4 respectively. Graphical depiction of month-wise forest fire detection from MODIS and SNPP-VIIRS sensors, for the entire country for the fire season 2019-20 and 2020-2021 is presented in Figure 5.5.

The SNPP-VIIRS forest fire data for the 2020-2021 season was analysed for assessing the top 10 States (Table 5.5) and top 20 districts (Table 5.6) of the country w.r.t forest fire incidences. The following observations were made:

- Amongst States, maximum number of fire detections were observed in Odisha (51,968) followed by Madhya Pradesh (47,795) and Chhattisgarh (38,106).
- Amongst districts, maximum number of SNPP-VIIRS forest fire detections were observed in Gadchiroli in Maharashtra (10,577) followed by Kandhamal in Odisha (6,156) and Bijapur in Chhattisgarh (5,499).

Sl. No	State/UT	MODIS Detections		SNPP-VIIRS Detections	
		Nov 2019 to Jun 2020	Nov 2020 to Jun 2021	Nov 2019 to Jun 2020	Nov 2020 to Jun 2021
1	Andhra Pradesh	1,080	2,888	9,996	19,328
2	Arunachal Pradesh	660	1,109	1,786	3,914
3	Assam	3,000	3,387	8,924	10,718
4	Bihar	50	537	614	5,179
5	Chhattisgarh	416	3,112	6,360	38,106
6	Delhi	3	5	21	14
7	Goa	4	10	47	45
8	Gujarat	202	422	2,770	3,803
9	Haryana	39	25	68	152
10	Himachal Pradesh	80	533	536	4,110
11	Jammu & Kashmir*	62	131	438	1,098
12	Jharkhand	101	1,563	2,613	21,713
13	Karnataka	538	932	4,232	5,784
14	Kerala	142	51	864	296
15	Madhya Pradesh	1,383	7,103	9,537	47,795
16	Maharashtra	1,102	4,297	14,018	34,025
17	Manipur	2,475	3,252	8,800	10,457
18	Meghalaya	1,826	2,052	6,762	7,658
19	Mizoram	2,816	4,345	7,361	12,846
20	Nagaland	1,248	1,726	2,905	4,975
21	Odisha	1,326	5,307	10,602	51,968
22	Punjab	52	171	153	635
23	Rajasthan	420	447	3,461	3,402
24	Sikkim	5	17	47	63
25	Tamil Nadu	187	202	1,368	1,220
26	Telangana	1,042	2,566	12,132	18,237
27	Tripura	1,467	1,664	4,369	5,015
28	Uttar Pradesh	396	1,667	1,548	8,608
29	Uttarakhand	167	2,710	759	21,487
30	West Bengal	141	548	1,320	3,287
31	Andaman & Nicobar Islands	15	2	39	16
32	Chandigarh	0	0	2	0
33	Dadra & Nagar Haveli	1	3	21	33
34	Daman & Diu	0	0	0	1
35	Lakshadweep	0	0	0	0
36	Puducherry	1	1	0	1
	Total	**22,447**	**52,785**	**1,24,473**	**3,45,989**

**Combined figures of Jammu & Kashmir and Ladakh*

Table 5.4 Number of forest fire detected by FSI using MODIS & SNPP-VIIRS sensors (This includes large, continuous and repeated forest fires) for fire season 2019-2020 and 2020-2021.

Figure 5.3
Map showing MODIS based hot spots detected during 2020-2021 forest fire season

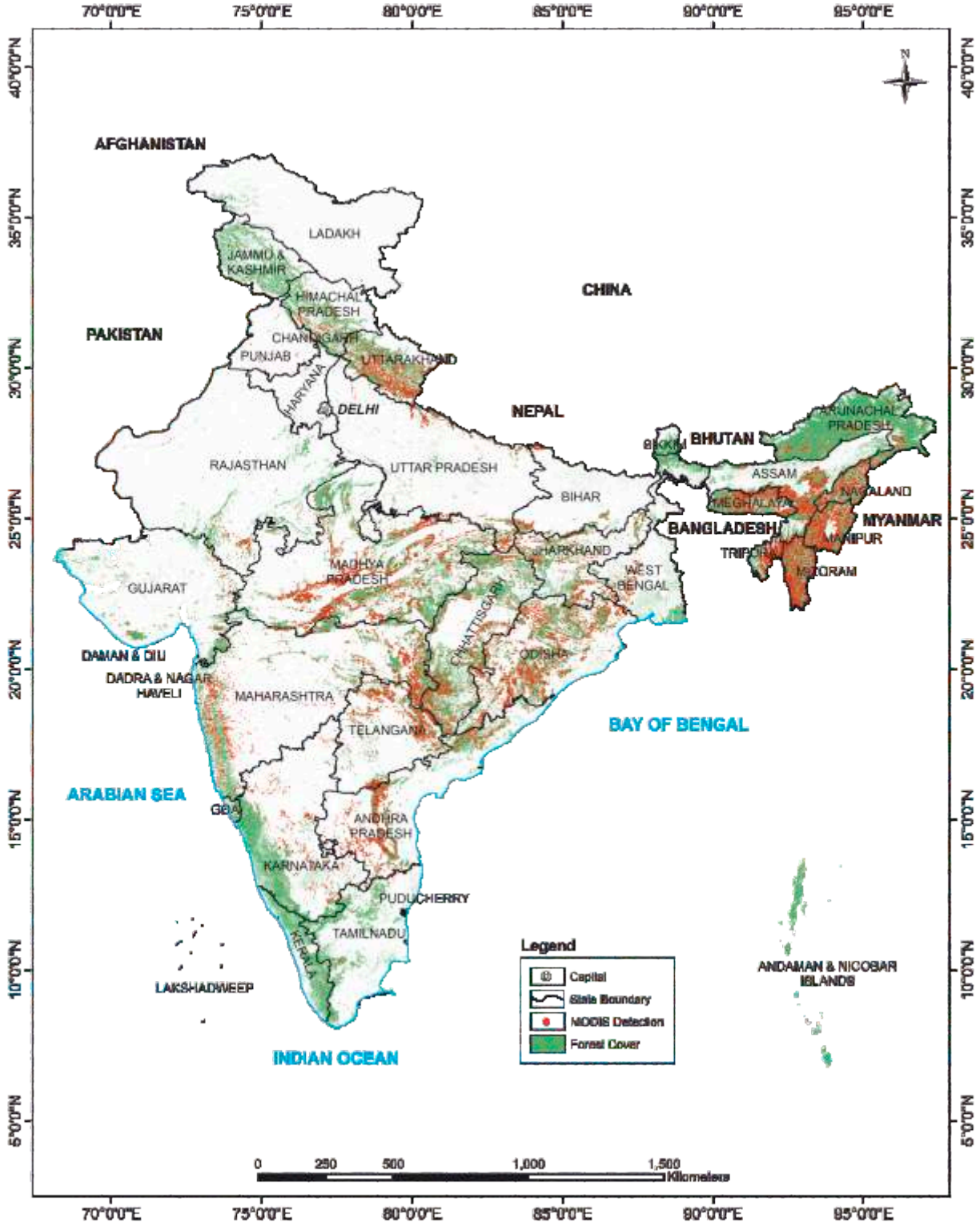


Figure 5.4
Map showing SNPP-VIIRS based hot spots detected during 2020-2021 forest fire season

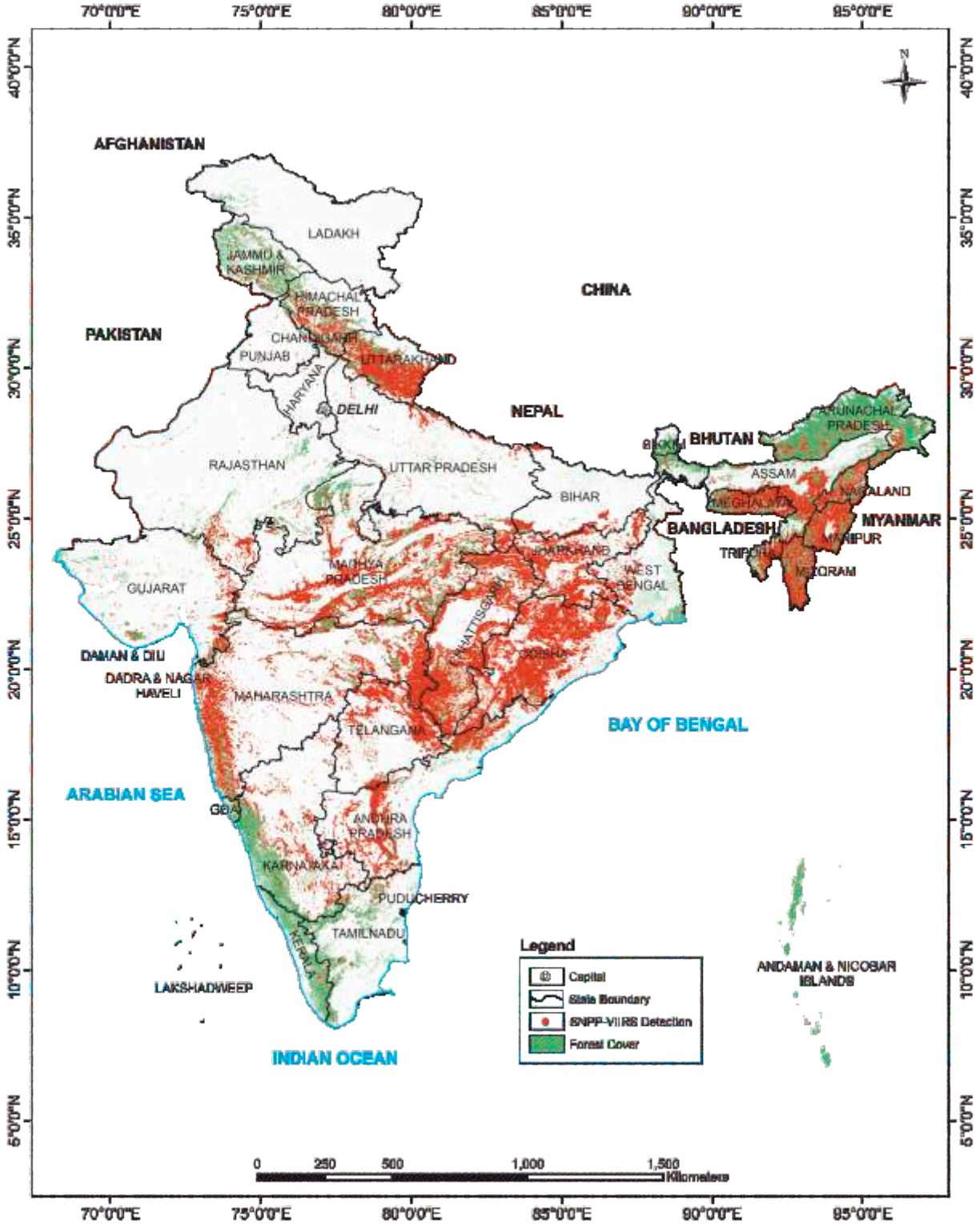
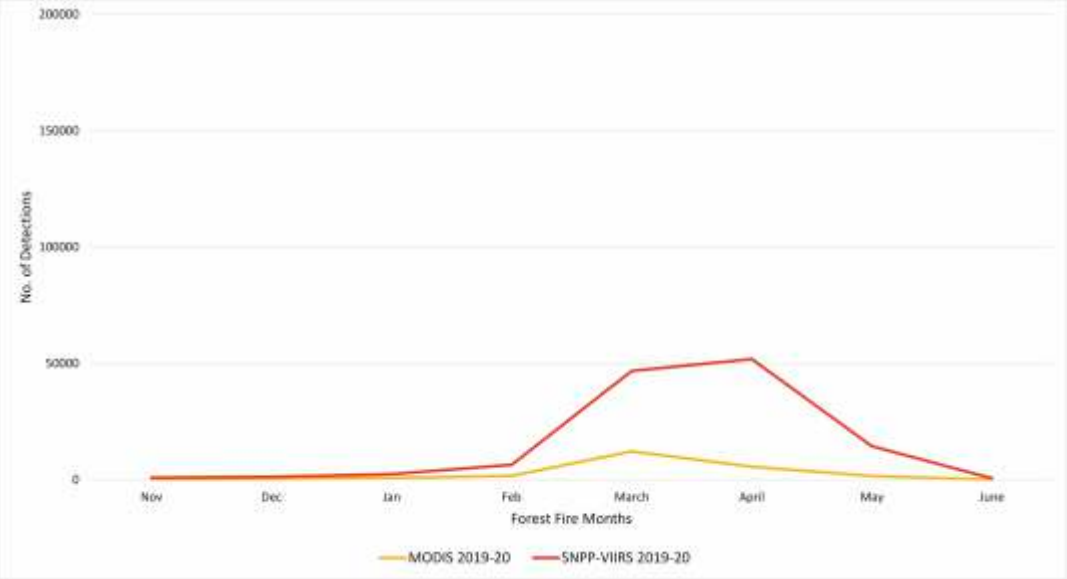


Figure 5.5 Comparative graph showing month-wise number of detections by MODIS and SNPP-VIIRS during the mentioned forest fire season



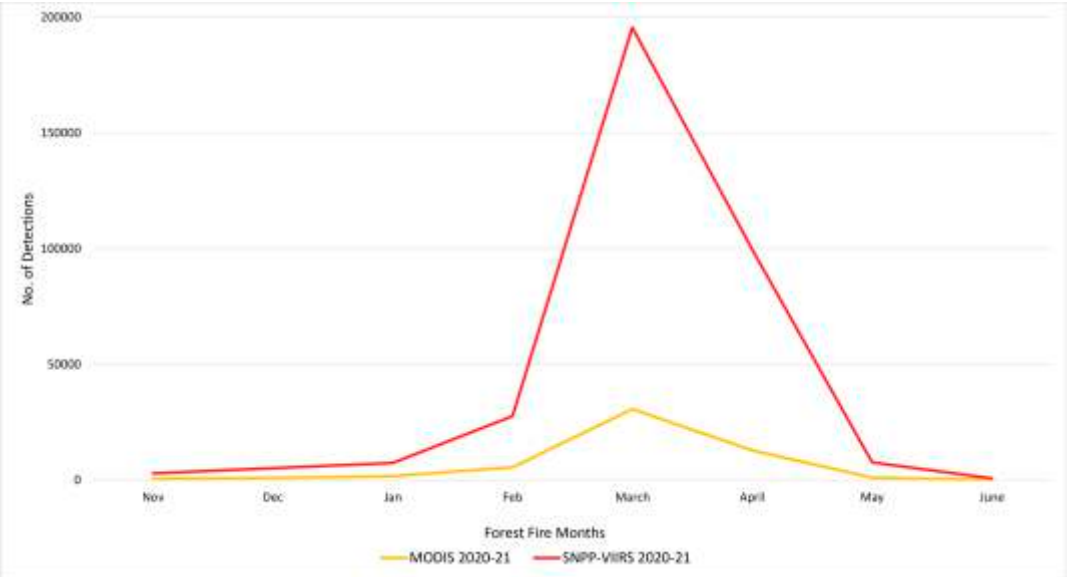


Table 5.5 Top ten states according to number of forest fire detected by FSI using SNPP-VIIRS sensors (This includes large, continuous and repeated forest fires)

Sl. No	State	Nov 2020 - June 2021
1	Odisha	51,968
2	Madhya Pradesh	47,795
3	Chhattisgarh	38,106
4	Maharashtra	34,025
5	Jharkhand	21,713
6	Uttarakhand	21,487
7	Andhra Pradesh	19,328
8	Telangana	18,237
9	Mizoram	12,846
10	Assam	10,718

Sl. No	District	State	Nov 2020 - June 2021
1	Gadchiroli	Maharashtra	10,577
2	Kandhamal	Odisha	6,156
3	Bijapur	Chhattisgarh	5,499
4	Karbi Anglong	Assam	4,881
5	Kadapa	Andhra Pradesh	4,872
6	West Singhbhum	Jharkhand	4,553
7	Pauri Garhwal	Uttarakhand	4,512
8	East Nimar	Madhya Pradesh	4,210
9	Mayurbhanj	Odisha	4,073
10	Sundargarh	Odisha	3,940
11	Nainital	Uttarakhand	3,802
12	Raisen	Madhya Pradesh	3,713
13	Kalahandi	Odisha	3,555
14	Chhindwara	Madhya Pradesh	3,535
15	Narayanpur	Chhattisgarh	3,510
16	Bhupalpally	Telangana	3,477
17	Aizawl	Mizoram	3,336
18	Kendujhar	Odisha	3,194
19	Dima Hasao	Assam	3,188
20	Rayagada	Odisha	3,172

Table 5.6 Top 20 districts according to number of forest fire detected by FSI using SNPP-VIIRS sensors (This includes large, continuous and repeated forest fires)

Subscription for FSI Forest Fire Alert System 5.2.1.2

Forest fire alert service of FSI is provided to all subscribers who have registered for receiving this service. Any individual can subscribe to this service, as it is open to public also. User can register from the link https://fsiforestfire.gov.in/registration.php and subscribe for at most three administrative levels and up to Beat level depending upon the availability.

From a subscriber base of 66,870 at the end of forest fire season 2018-2019, the number of subscribers has risen to 1,31,102 at the end of forest fire season 2020-2021. Details of user subscriptions across different levels of administrative hierarchy is given in Figure 5.6. State wise status of SMS subscriptions is given in Table 5.7. Himachal Pradesh has the maximum subscribers to the FSI forest fire alert service followed by Telangana and Maharashtra. In the forest fire season 2020-2021, approximately 79,55,749 SMS were disseminated to the subscribers.

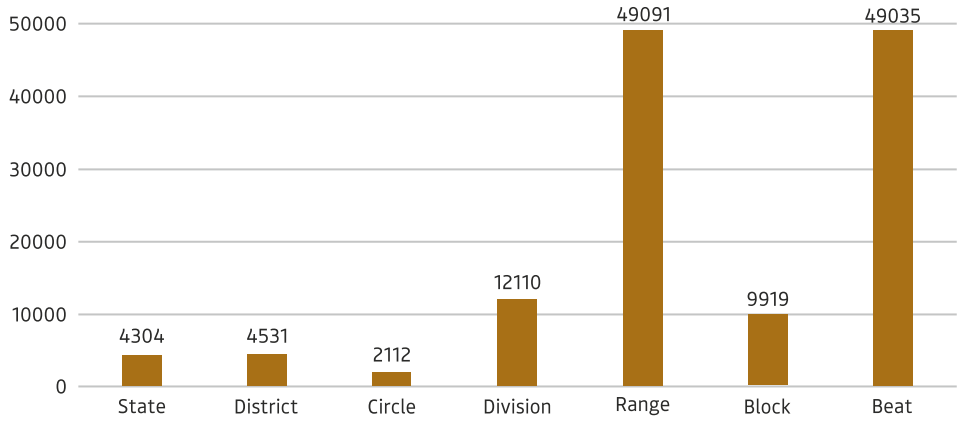


Figure 5.6 User subscriptions across different levels of Administrative hierarchy

Table 5.7 State-wise SMS subscriptions at different administrative levels.

State/UT	State	District	Circle	Division	Range	Block	Beat	Total
Andhra Pradesh	78	64	49	261	648	292	901	2,293
Arunachal Pradesh	9	10	0	0	0	0	0	19
Assam	18	12	0	0	0	0	0	30
Bihar	29	20	8	42	67	7	85	258
Chhattisgarh	92	45	70	358	3,085	31	2,162	5,843
Delhi	22	5	0	0	0	0	0	27
Goa	473	7	4	5	13	0	0	502
Gujarat	100	83	34	241	455	474	952	2,339
Haryana	52	36	6	94	173	109	151	621
Himachal Pradesh	249	375	125	1,871	22,664	3,698	19,479	48,461
Jammu & Kashmir*	70	43	23	147	1,341	1	0	1,625
Jharkhand	45	31	21	203	242	17	340	899
Karnataka	197	56	211	725	2,342	224	684	4,439
Kerala	333	235	212	945	3,500	1	3	5,229
Madhya Pradesh	171	164	168	937	3,098	283	2,159	6,980
Maharashtra	658	54	426	1,507	2,926	1,949	4,904	12,424
Manipur	79	68	11	389	332	65	55	999
Meghalaya	8	0	0	15	3	39	0	65
Mizoram	10	4	7	15	93	0	0	129
Nagaland	12	4	0	0	0	0	0	16
Odisha	127	171	83	1,769	954	500	183	3,787
Punjab	63	8	6	113	235	230	718	1,373
Rajasthan	235	643	47	464	2,218	11	0	3,618
Sikkim	8	1	0	0	0	0	0	9
Tamil Nadu	484	304	437	870	956	107	444	3,602
Telangana	101	143	51	579	1,936	1,819	13,224	17,853
Tripura	7	5	0	30	45	0	19	106
Uttar Pradesh	143	1,655	22	135	167	44	77	2,243
Uttarakhand	156	74	89	199	1,397	16	2,042	3,973
West Bengal	36	27	2	194	199	2	453	913
Andaman & Nicobar Islands	217	177	0	2	2	0	0	398
Chandigarh	4	2	0	0	0	0	0	6
Dadra & Nagar Haveli	9	3	0	0	0	0	0	12
Daman & Diu	4	0	0	0	0	0	0	4
Lakshadweep	1	0	0	0	0	0	0	1
Puducherry	4	2	0	0	0	0	0	6
Total	**4,304**	**4,531**	**2,112**	**12,110**	**49,091**	**9,919**	**49,035**	**1,31,102**

**Combined figures of Jammu & Kashmir and Ladakh*

Large Forest Fire (LFF) Monitoring 5.2.2

Forest fires, if undetected and not extinguished on time, may turn into large forest fires that cause wide spread destruction. Such fires require extensive resources in terms of firefighting force, materials, equipment and other logistical support for containment. Timely information and tracking of such large fire events helps in devising strategies for planning, resource mobilization for their effective containment, thereby minimizing losses to forests.

To assist the SFDs in effective management of large forest fire (LFF) events, a satellite based automated system of monitoring LFF was developed and launched in 2019. The objectives of this programme are given below:

i. Continuous monitoring and tracking of large forest fires in near real-time.
ii. Timely containment of such fires by SFDs.
iii. Escalation of alerts to higher level for timely additional support from agencies such as District Administration, SDMA, NDMA, Armed forces etc.
iv. Development of a National Large Forest Fire Database for future planning especially in development of State Crisis Management Plans and Working Plans.
v. For planning of burnt area restoration programmes.

The LFF programme uses the SNPP-VIIRS sensor (375 m X 375 m resolution) fire hotspot data. The application identifies a candidate large fire through an automated algorithm, which identifies large fire comprising of at least three contiguous VIIRS pixels in any geometry as shown in Figure 5.7. Once the candidate large fire is detected, it is continuously monitored using data from subsequent satellite passes as long as the fire is active. The continuous tracking of the identified event is achieved by monitoring the estimated fire boundary, which is also continuously updated as per the changes in direction of the fire event. The program scans the area for additional three days after its inactivity to detect dormant fires, if any, restarting in the same area again.

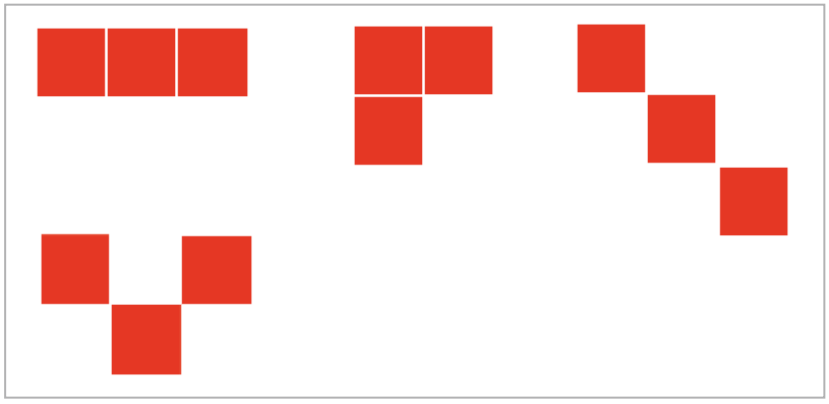


Figure 5.7 Candidate Large Forest Fire

Information on the number of fire affected active pixels, total number of fire affected pixels, administrative and management boundary, KMZ file and web-linked *.png map of the fire location etc. are provided to the subscribers through SMS. The LFF alerts are being sent as e-mail to the Principal Chief Conservator of Forests (Head of Forest Force) & Nodal Officer of SFD and as SMS to all the registered subscribers.

State-wise details of LFF events detected during fire season 2020-2021 (Nov 2020 to June 2021) is given in Table 5.8. Maps showing Large Forest Fire Events based on the number of days for which the LFF was active (viz. ≤ 5 days, between 6 to 10 days and >10 days) are given in Figure 5.8. From Table 5.8, it is seen that during the fire season 21,142 LFF events were detected and tracked by FSI. Out of this about 59.43% LFF were extinguished or contained within 24 hours, 37.72% of LFF were active for one to five days, 2.70% were active for six to ten days and only 32 LFF (0.15%) continued

to burn for more than eleven to fifteen days. The LFF (Gobardaha-1) detected in the State of Bihar (Nepal- Bihar border) was active for fifteen days.

Since the commencement of the LFF monitoring programme in 2019, FSI is preparing a database of all the LFF events detected. A unique system for naming the large forest fire events has been developed. In every fire season, individual LFF event is recorded by the name of the Range of the

Table 5.8 State-wise number of large forest fire events detected during fire season 2020-2021 (Nov 2020 to June 2021)

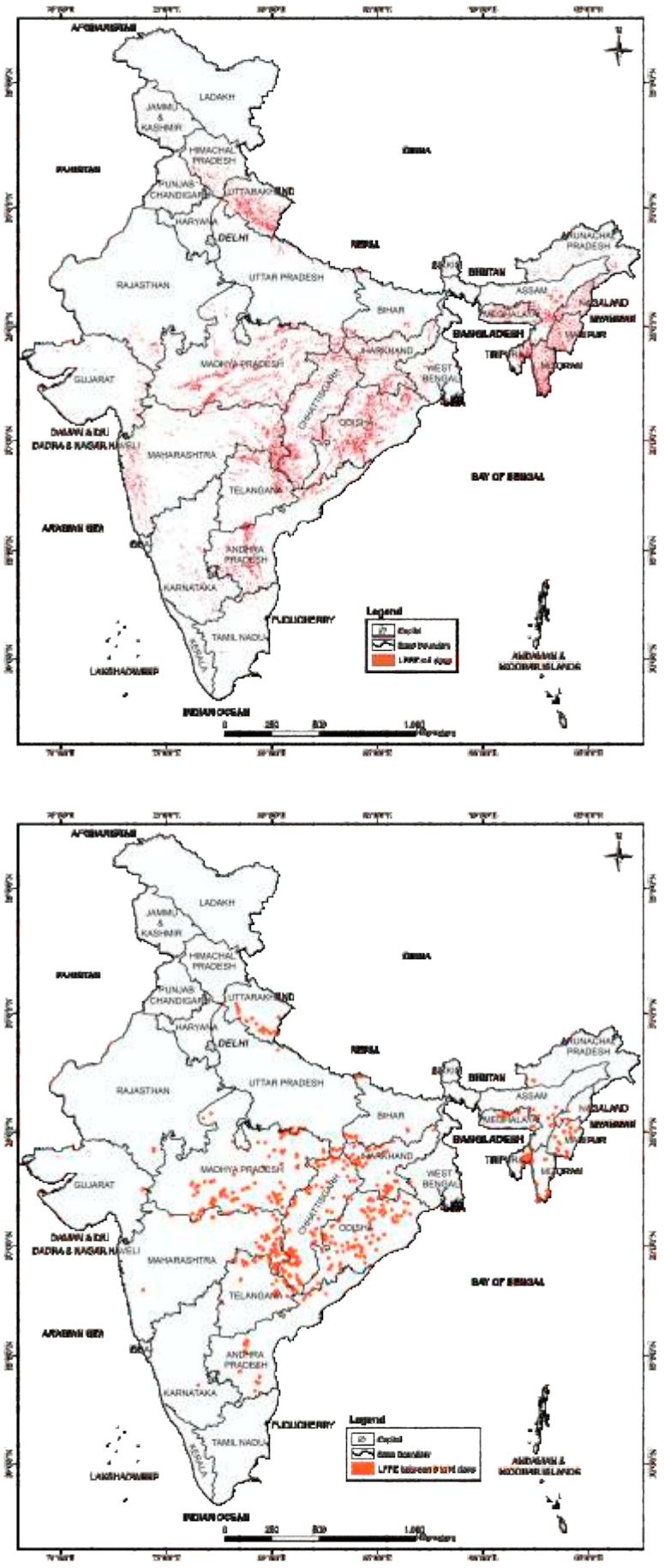
State/UT	Number of active Days for LFF					
	< 24 Hrs	1	2	3	4	5
Andhra Pradesh	834	235	112	72	28	16
Arunachal Pradesh	222	27	17	4	5	1
Assam	448	91	60	48	17	10
Bihar	122	62	37	18	15	6
Chhattisgarh	1,027	385	221	181	97	51
Delhi	0	0	0	0	0	0
Goa	2	1	0	0	0	0
Gujarat	151	34	9	10	5	1
Haryana	4	4	1	0	0	0
Himachal Pradesh	194	47	13	8	3	0
Jammu & Kashmir*	48	11	9	2	0	0
Jharkhand	519	247	118	69	47	33
Karnataka	349	34	12	9	2	0
Kerala	15	1	1	0	0	1
Madhya Pradesh	1,727	519	243	218	108	55
Maharashtra	1,456	320	154	120	54	36
Manipur	537	97	57	46	10	15
Meghalaya	283	58	31	32	10	13
Mizoram	508	158	73	49	18	9
Nagaland	317	53	18	10	5	3
Odisha	1,571	670	321	204	112	75
Punjab	24	4	4	3	1	0
Rajasthan	150	28	17	7	4	4
Sikkim	5	1	0	0	0	0
Tamil Nadu	74	15	2	1	0	1
Telangana	551	216	102	83	39	24
Tripura	228	40	58	28	13	9
Uttar Pradesh	280	63	46	21	23	17
Uttarakhand	798	250	127	80	44	17
West Bengal	119	25	9	17	6	2
Andaman & Nicobar Islands	0	1	0	0	0	0
Chandigarh	0	0	0	0	0	0
Dadra & Nagar Haveli	3	0	0	0	0	0
Daman & Diu	0	0	0	0	0	0
Lakshadweep	0	0	0	0	0	0
Puducherry	0	0	0	0	0	0
Total	**12,566**	**3,697**	**1,872**	**1,340**	**666**	**399**

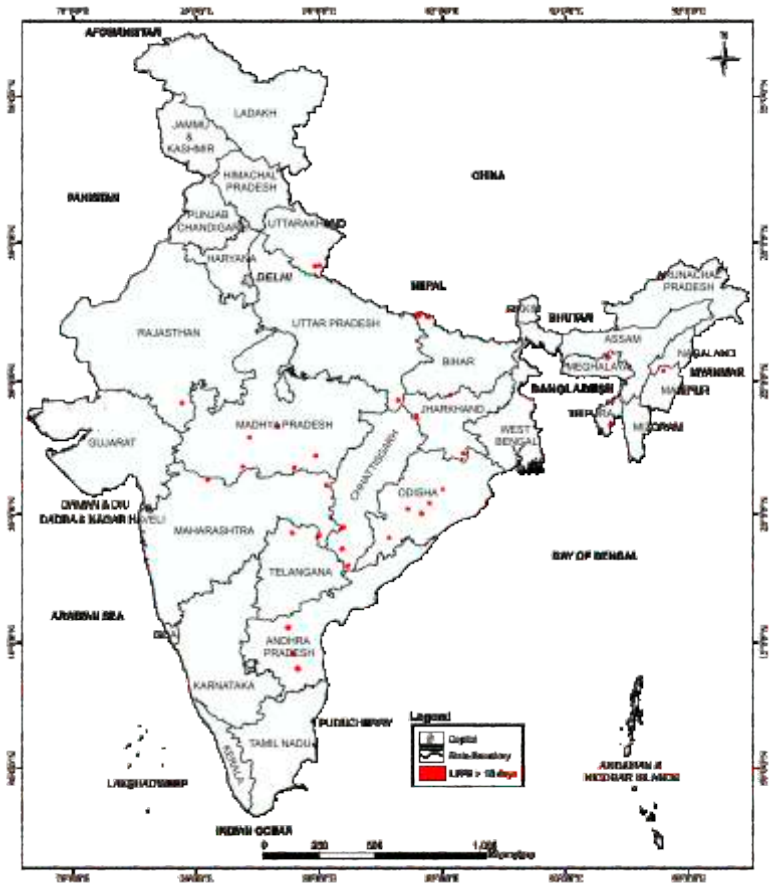
**Combined figures of Jammu & Kashmir and Ladakh*

State Forest Department where it was first detected. If the State has not provided the administrative boundary, the LFF event is recorded after the name of the District. In cases, where multiple LFF events are detected in the same Range, the numerical numbering is suffixed after the name of the Range. For example, if 4th LFF event is detected in Range Paukhal, then this LFF event will be recorded as Paukhal - 4 in the large forest fire database.

Number of active Days for LFF										
6	7	8	9	10	11	12	13	14	15	Total
9	6	2	1	1	0	2	0	1	0	**1,319**
1	0	0	0	1	0	0	0	0	0	**278**
7	2	1	4	0	0	0	0	0	0	**688**
8	4	0	0	0	0	0	1	0	1	**274**
51	21	12	5	3	3	0	0	0	0	**2,057**
0	0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	0	**3**
0	1	0	0	0	0	0	0	0	0	**211**
0	0	0	0	0	0	0	0	0	0	**9**
0	0	0	0	0	0	0	0	0	0	**265**
0	0	0	0	0	0	0	0	0	0	**70**
18	20	5	2	1	1	0	1	1	0	**1,082**
0	1	0	0	0	0	0	0	0	0	**407**
0	0	0	0	0	0	0	0	0	0	**18**
45	24	14	8	4	4	1	0	0	0	**2,970**
28	11	7	7	5	1	1	1	0	0	**2,201**
11	6	4	0	0	0	1	0	0	0	**784**
10	5	3	0	0	1	0	0	0	0	**446**
5	4	1	1	0	0	0	0	0	0	**826**
2	1	0	1	0	0	0	0	0	0	**410**
44	21	15	4	2	3	2	0	0	0	**3,044**
0	0	0	0	0	0	0	0	0	0	**36**
2	0	0	0	0	1	0	0	0	0	**213**
0	0	0	0	0	0	0	0	0	0	**6**
0	0	0	0	0	0	0	0	0	0	**93**
14	7	8	4	3	1	0	0	0	0	**1,052**
6	6	1	1	2	1	0	0	0	0	**393**
4	4	3	1	2	0	1	0	0	0	**465**
10	5	4	2	0	1	0	1	0	0	**1,339**
0	0	1	0	0	0	0	0	0	0	**179**
0	0	0	0	0	0	0	0	0	0	**1**
0	0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	0	**3**
0	0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	0	**0**
275	**149**	**81**	**41**	**24**	**17**	**8**	**4**	**2**	**1**	**21,142**

Figure 5.8
Map showing Large Forest Fire detections based on the number of active days of LFF





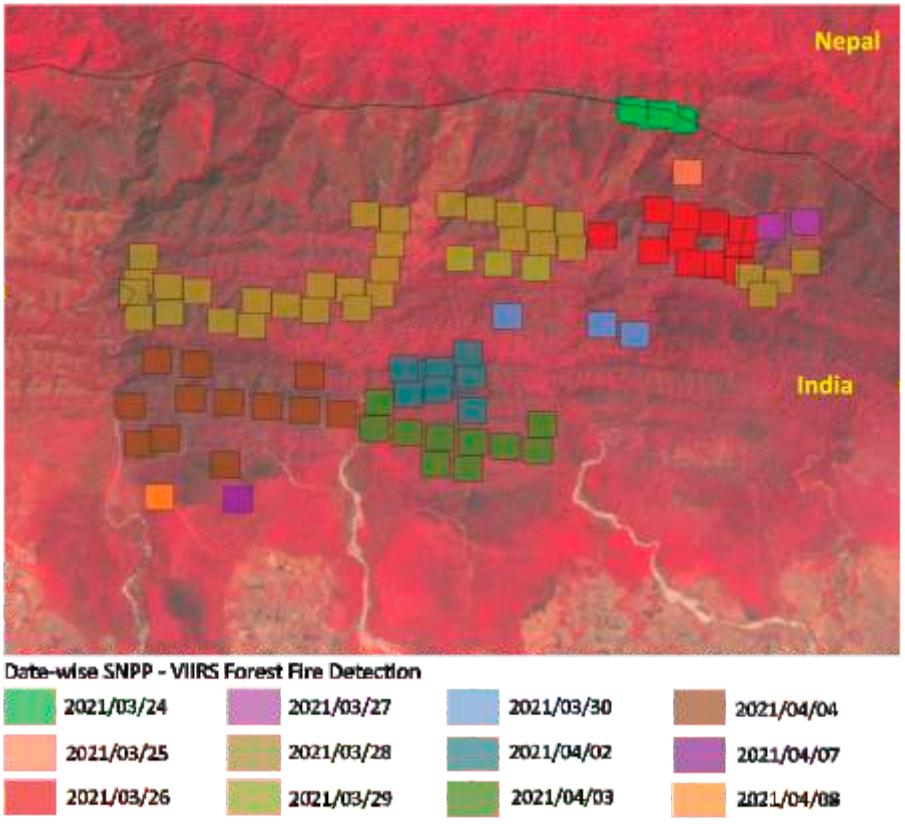
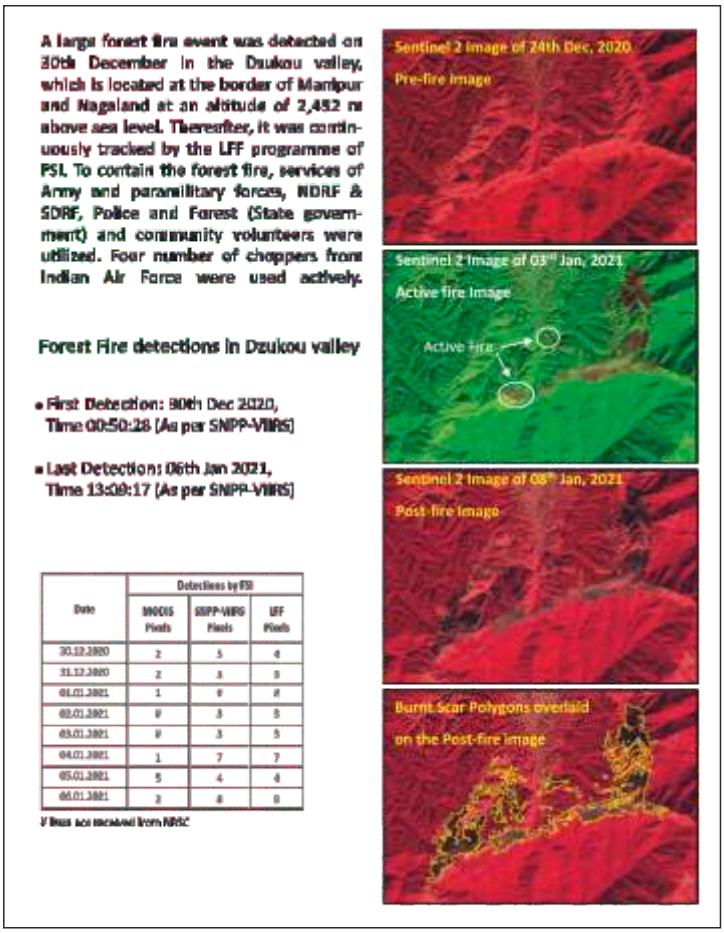


Figure 5.9
Tracking of Large Forest Fire Event in Gobardaha-1 in the State of Bihar

Box 5.1
Monitoring Large Forest Fire in Dzukou Valley (Manipur-Nagaland)



5.2.3 Early-Warning Alert based on Forest Fire Danger Rating

Early Warnings about potential forest fire situation in an area are useful in deciding upon timely preventive measures to avoid their occurrence and related losses. Since 2016, FSI is working on developing danger rating system based on daily weather data, forest fuel load conditions and terrain conditions.

FSI is currently working on a system similar to Canadian Forest Fire Danger Rating System (CFFDRS), based on Fire Weather Index (FWI) for fire danger rating in India. Additionally Forest Type Layer information and Forest Fire Archival information are also being used to generate Forest Fire Danger Rating. The parameters are quantified and overlaid on grids of 5 km X 5 km.

FWI consists of six components that account for the effects of fuel moisture and weather conditions on fire behaviour. The first three components are fuel moisture codes, which are numeric ratings of the moisture content of the forest floor and other dead organic matter. Their values rise as the moisture content decreases. The remaining three components are fire behaviour indices, which represent the rate of fire spread, the fuel available for combustion, and the frontal fire intensity; these three values rise as the fire danger increases. All information regarding FWI is downloadable from GEOS-5 daily data from NASA's GFWED database, which is satellite calibrated weather data. The FWI values from GEOS-5 daily database from NASA's GFWED database are downloaded and thresholds are customized for different physiographic zones of the country using past archive data on a weekly basis. The Fire Danger Rating is categorized into five classes as Extreme Risk, Very High Risk, High Risk, Moderate Risk and Low Risk and uploaded as Web Map Service (WMS) in the Van Agni Geo-portal of FSI (http://vanagniportal.fsiforestfire.gov.in/fsi_fire/fire.html).

During Fire season, the Extreme Risk and Very High Risk categories of Forest Fire Danger Rating based on FWI values are disseminated as Early-warning Alerts (EWA) on every Thursday of the week to SFDs. EWA's are disseminated through e-mail as KML (Keyhole Markup Language) file, which is Google Earth compatible file, to Principal Chief Conservator of Forests (Head of Forest Force) and Forest Fire Nodal Officer of the SFD. Maps showing weekly detailed EWA disseminated to States and UTs are shown in Figure 5.10.

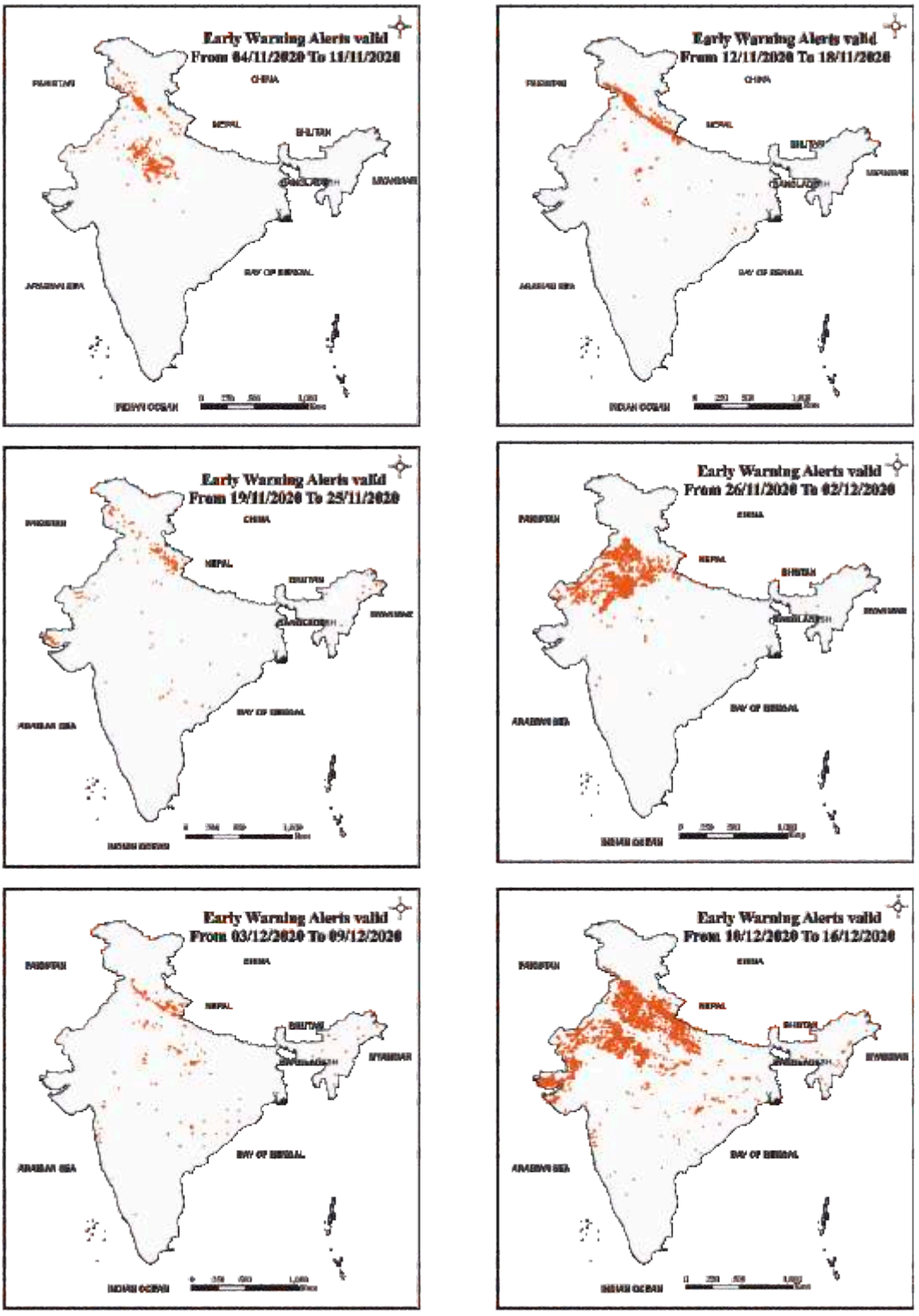
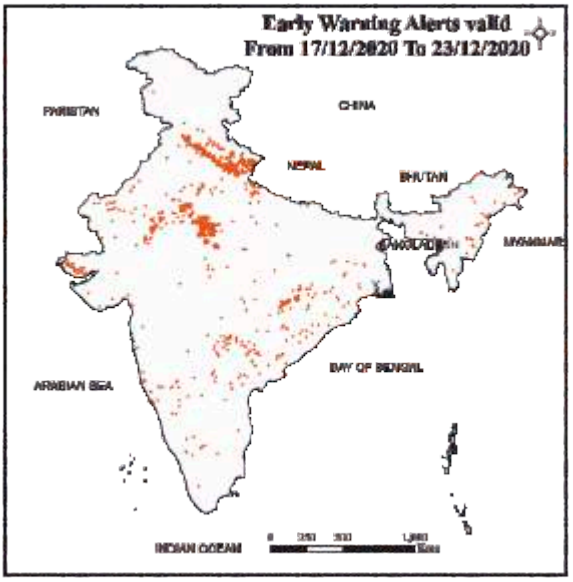


Figure 5.10 Weekly Early Warning Alerts disseminated in the fire season Nov 2020 - Jun 2021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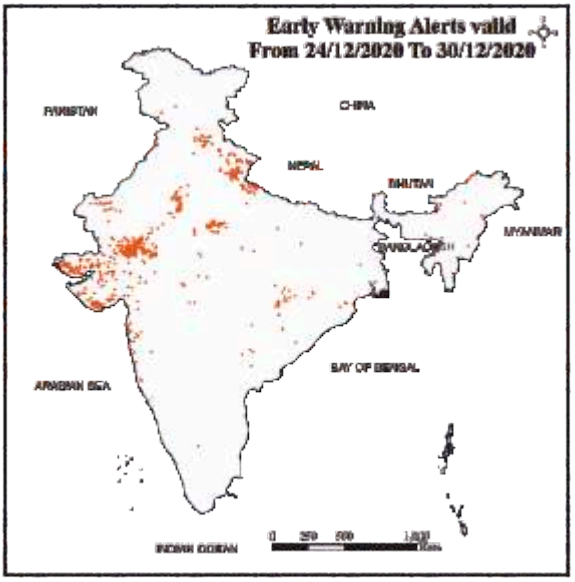
INDIAN OCEAN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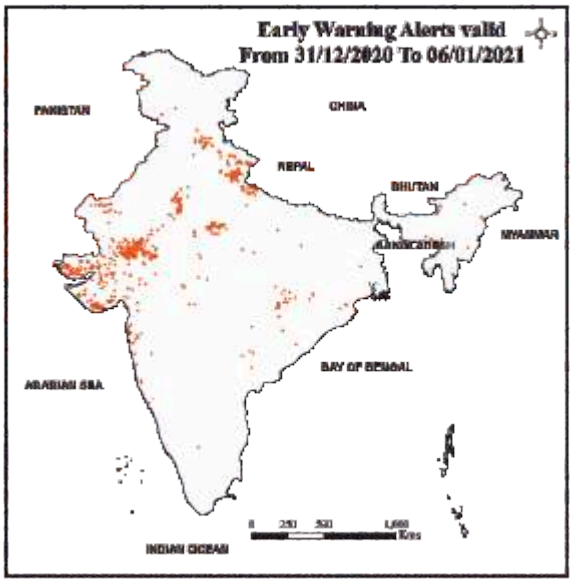
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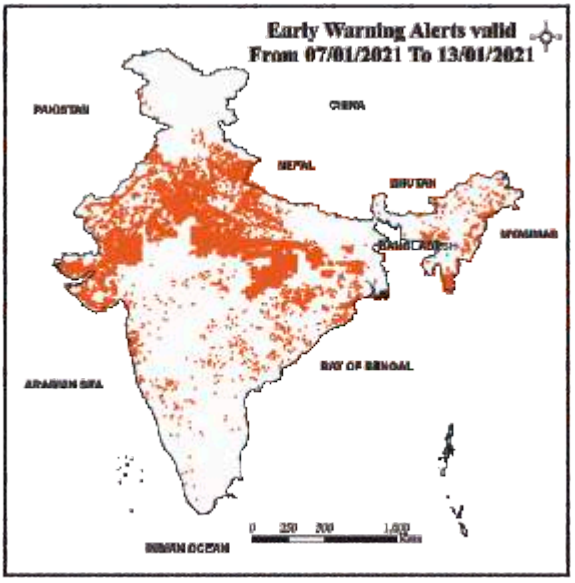
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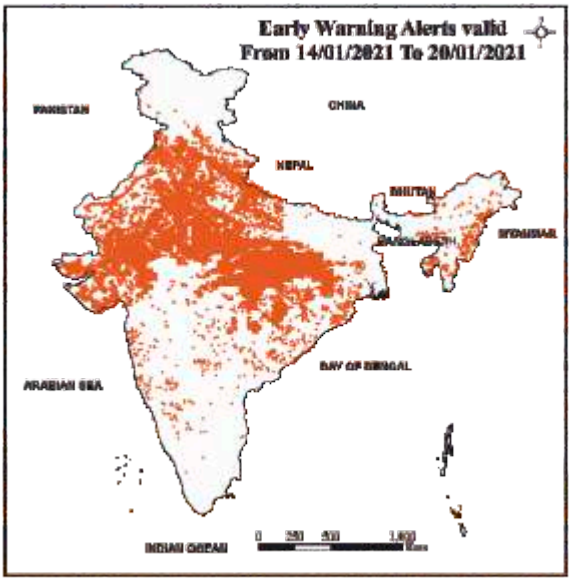
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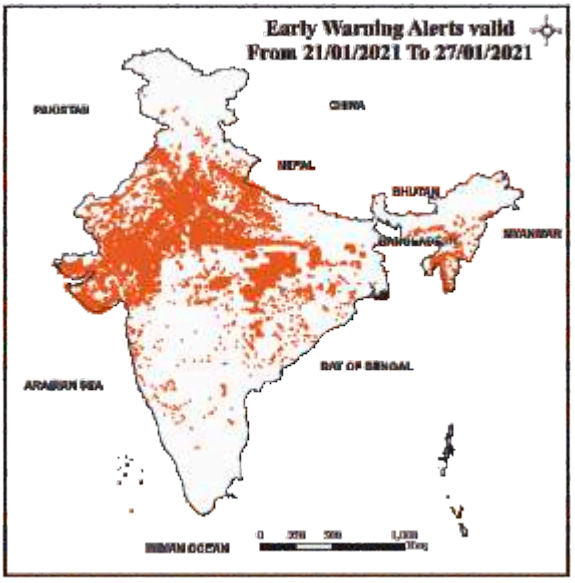
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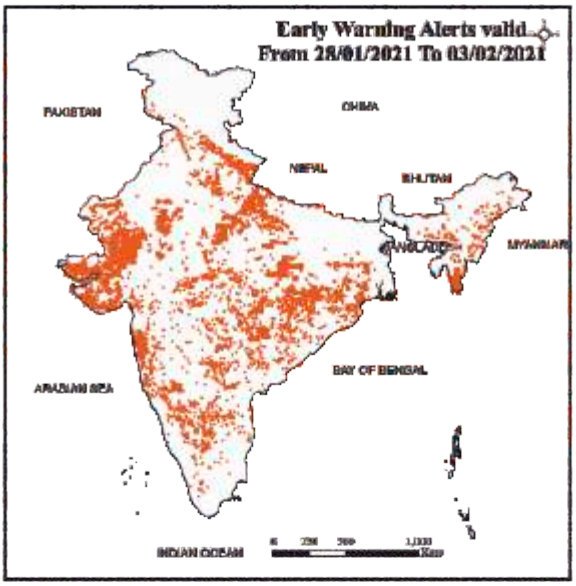
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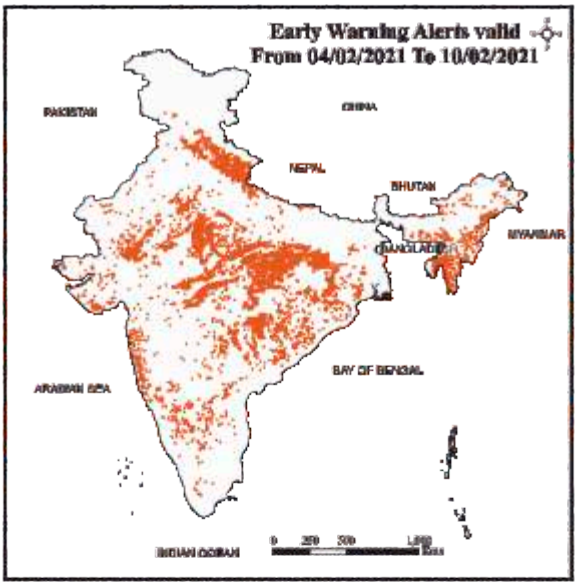
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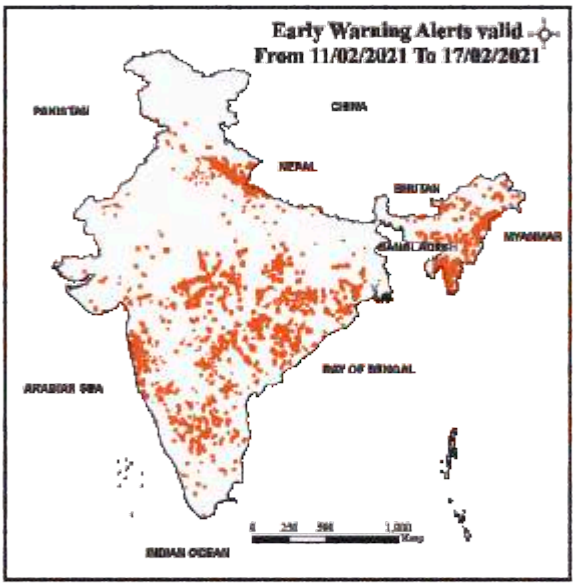
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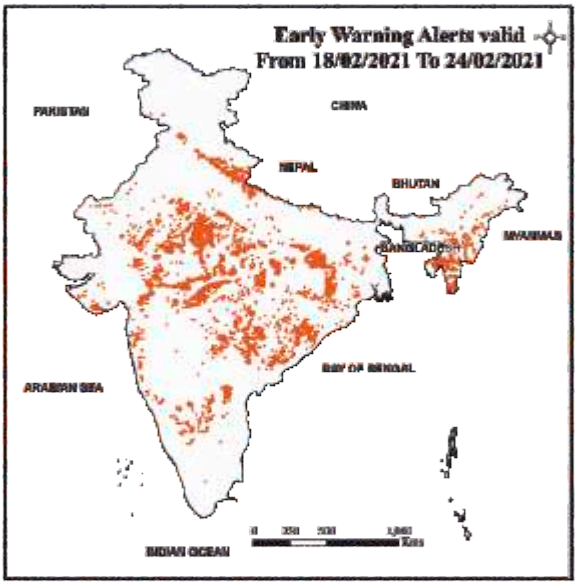
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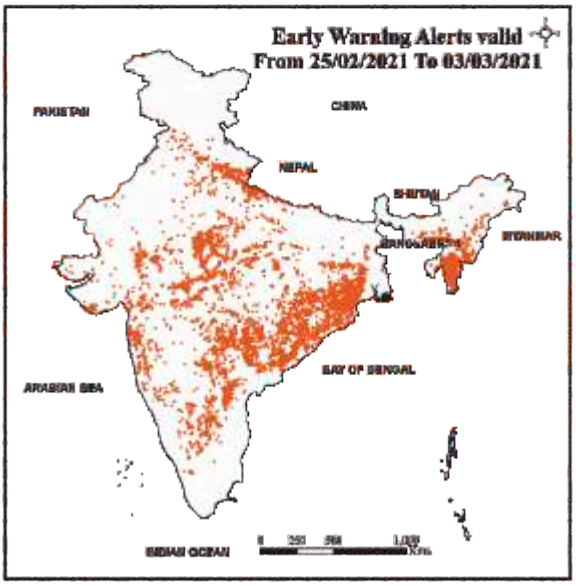
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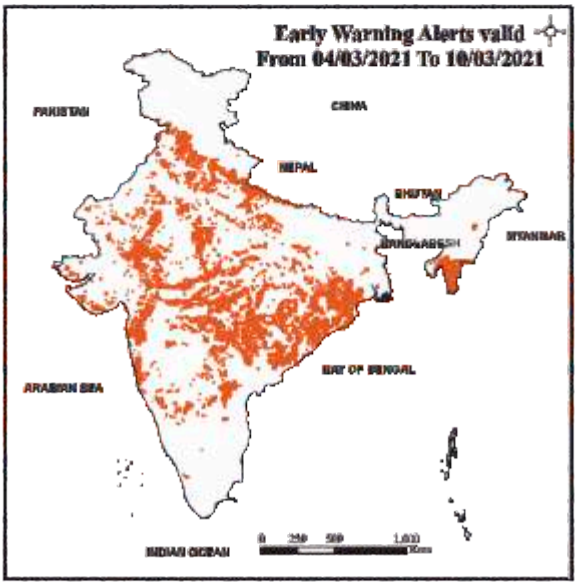
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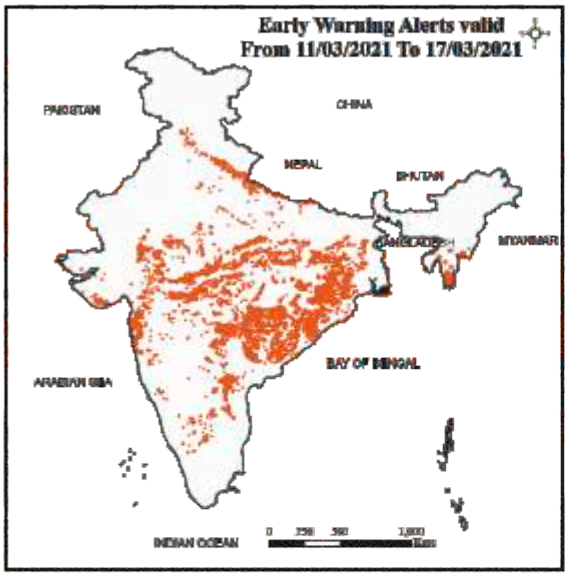
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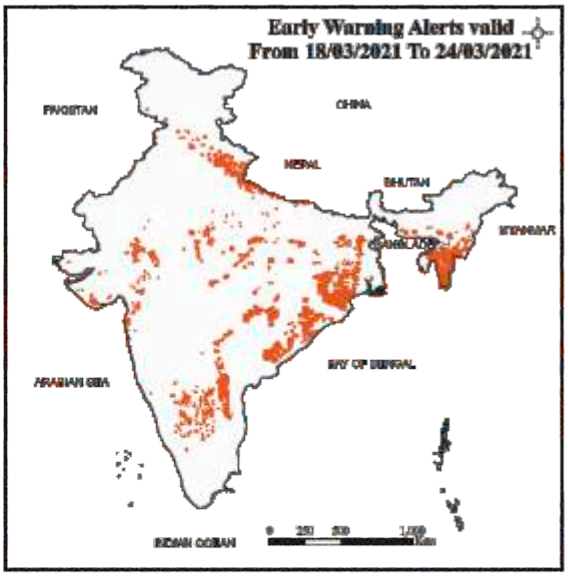
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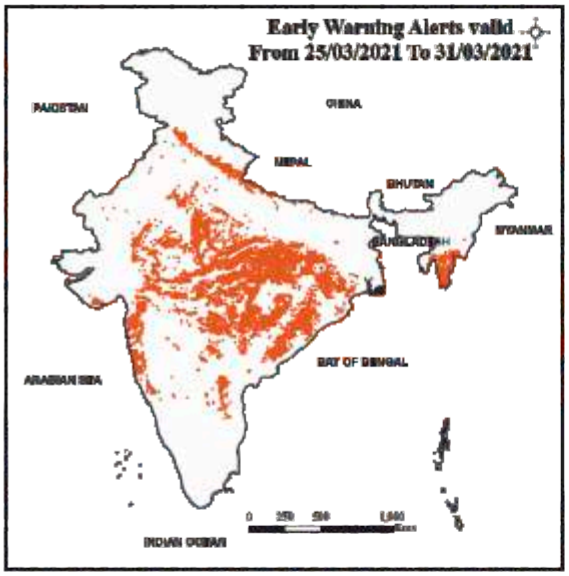
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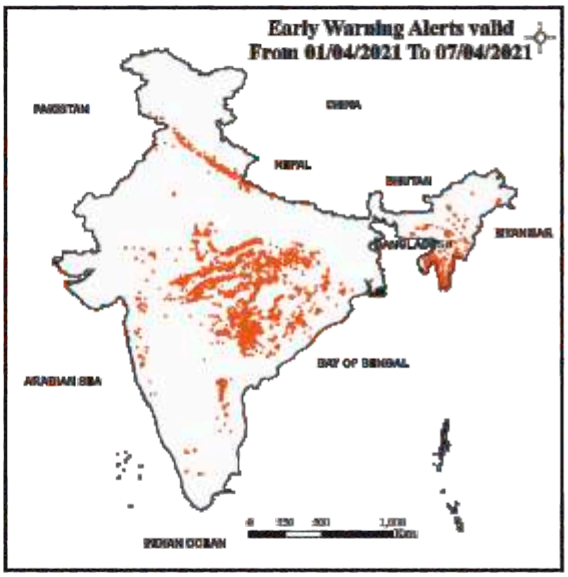
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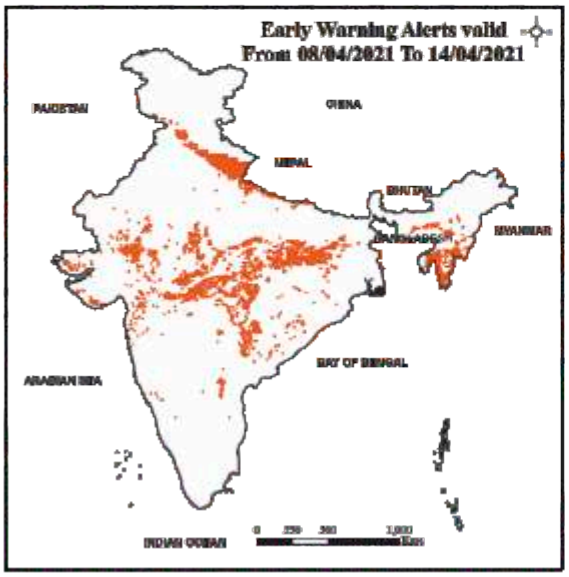
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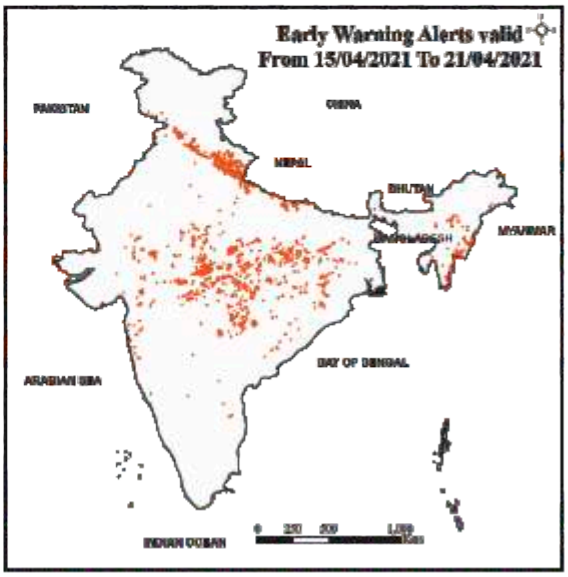
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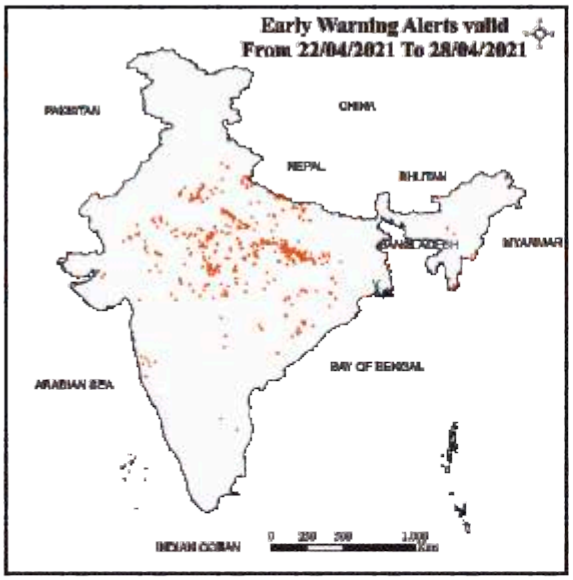
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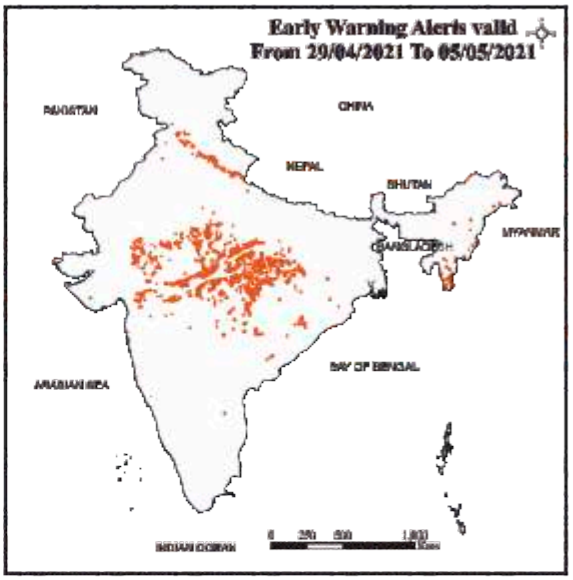
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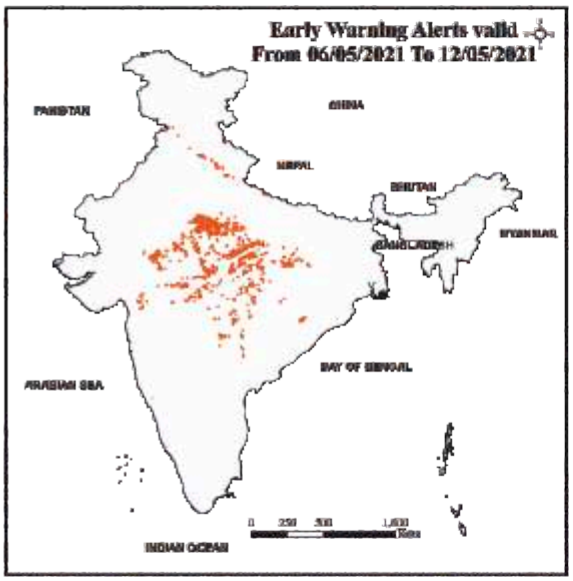
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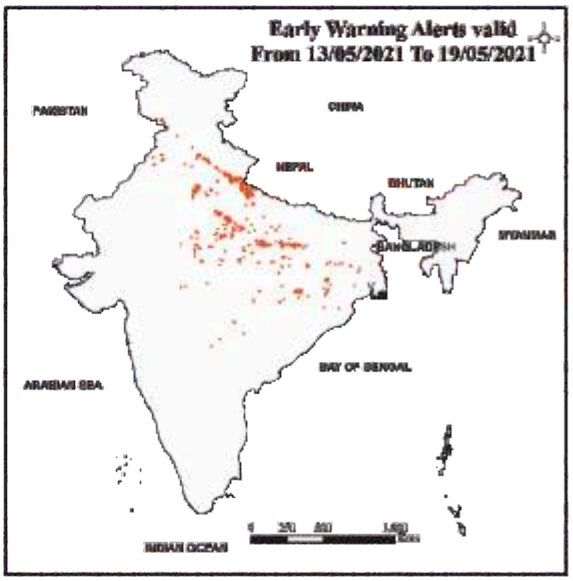
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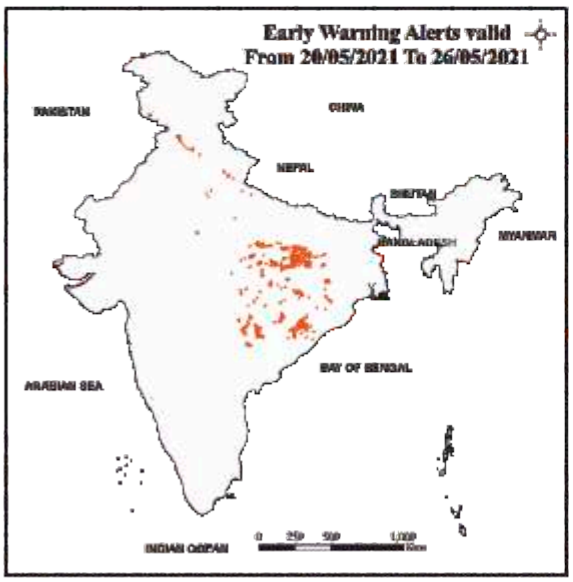
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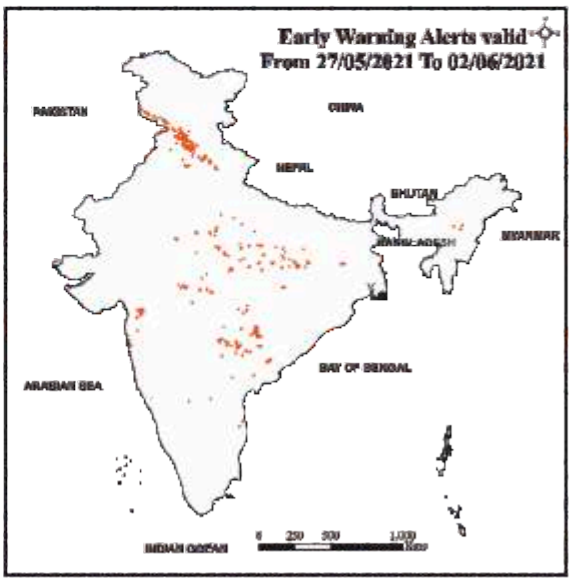
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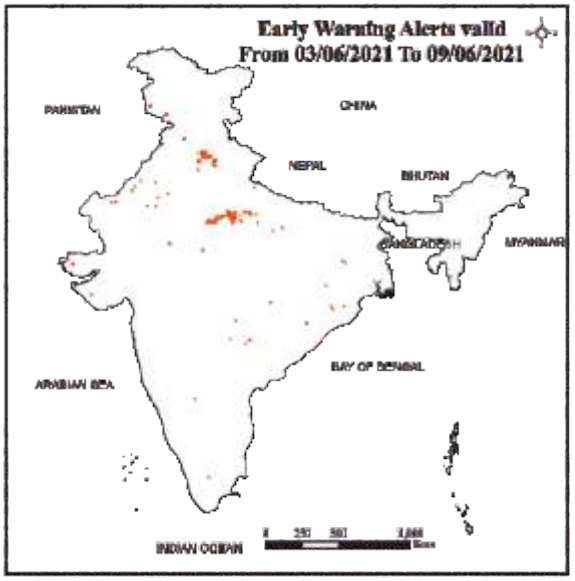
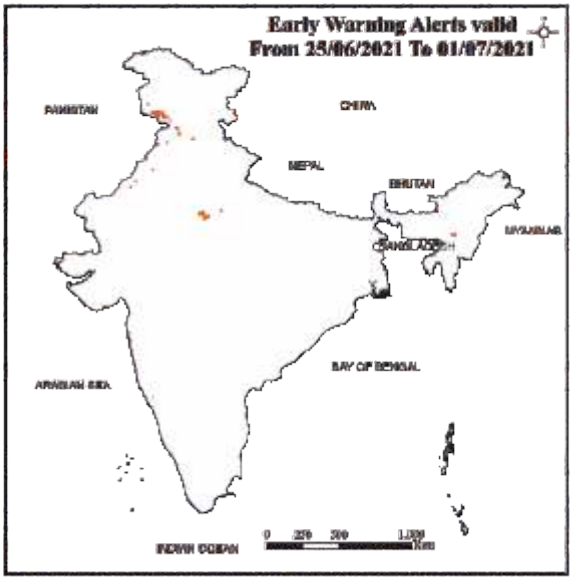
INDIAN OCEAN





5.2.4 FSI Van Agni Geo-portal

FSI Forest Fire Geo-portal, VAN AGNI 2.0 (http://vanagniportal.fsiforestfire.gov.in/fsi_fire/fire.html) is an in-house development of FSI, which was launched in 2019. It has been created using Open source Softwares viz. MapServer 7.0.7 & GeoMOOSE 2.9. The portal provides user-friendly interactive viewing where the user can view forest fire related data (forest fires, large forest fire events tracking etc. along with other thematic layers such as Forest administrative boundaries, Forest cover, Forest type, Fire prone forest area and FWI based fire danger rating etc.) pertaining to area of interest. Therefore, FSI Van Agni Geo-portal serves as a single point source for the information related to forest fires in India. A user can visualise Near Real-Time forest fire detected using MODIS & SNPP-VIIRS sensor of last three days in the portal. Besides this, Large Forest Fire Events showing active and inactive pixels and Forest Fire Danger Rating are available on the portal. This information is uploaded every Thursday of the fire season and is valid for the ensuing week.

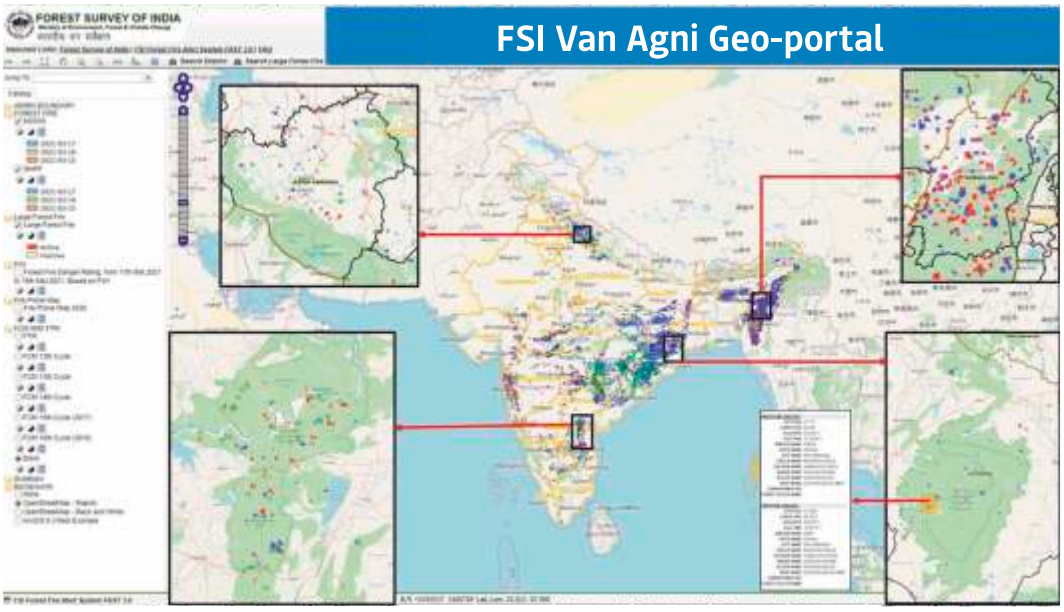


Figure 5.11
FSI Van Agni Geo-portal

Identification of Fire Prone Forest Areas 5.2.5

FSI has carried out a study based on spatial analysis of forest fire points detected by FSI in the last 17 years (2004-2021) to identify fire prone forest areas in the country. Extent of forest cover under different fire prone classes has also been determined for each State/UT.

Frequency of detected forest fires in an area over a period of time indicates proneness of the area to forest fires. Maps showing forest area in different classes of fire proneness can be an effective management tool for controlling forest fires. Such maps 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 the 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 carried out for the whole country.

Details of Forest cover under different fire prone classes is given in Table 5.9. Map showing fire prone forest areas in the country under different categories is presented as Figure 5.12. State/UT wise details of forest cover under different fire proneness categories is presented in Table 5.10.

Highlights of the study 5.2.5.1

- As per the long-term trend analysis performed by FSI, nearly 10.66% area of Forest Cover in India is under extremely to very highly fire prone zone.
- States under North-Eastern Region, showed the highest tendency of forest fire, and these states fall under extremely to very highly forest fire zone.
- States like Mizoram, Tripura, Meghalaya, and Manipur in North-Eastern Part of India exhibit the highest forest fire probability in terms of its frequency of event occurrence.
- Parts of Western Maharashtra, Southern part of Chhattisgarh, Central part of Odisha and few parts of Andhra Pradesh, Telangana and Karnataka are showing patches of extremely and very highly fire prone zones.

Based on robust data of a fairly long period, the identification of fire prone forest areas of the country presents credible spatial data, which can be effectively utilized for policy formulation, planning and strategizing forest fire mitigation measures by the SFDs.

Table 5.9 Forest cover in different fire prone classes

Sl. No.	Category	Forest cover (in sq km)	% of Total forest cover
1.	Extremely Fire Prone	20,074.47	2.81
2.	Very Highly Fire Prone	56,049.35	7.85
3.	Highly Fire Prone	82,900.17	11.61
4.	Moderately Fire Prone	94,126.68	13.19
5.	Less Fire Prone	4,60,638.36	64.54
	Total	**7,13,789.03**	**100.00**

5.2.6 Sharing of WMS and WFS service

FSI creates and shares Web Map Service (WMS) and Web Feature Service (WFS) of near real-time monitoring of forest fires, large forest fires and FWI based danger rating on demand basis to the State Forest Department. States such as Uttarakhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Telangana etc. are consuming these services effectively. North Eastern Space Applications Centre (NESAC), Shillong is also using these service for entire North-Eastern States.

The Open Geospatial Consortium Web Feature Service (WFS) Interface Standard provides an interface, which allows requests for geographical features across the web, using platform-independent calls. One can think of geographical features as the "source code" behind a map,

Table 5.10 Forest cover of State & UTs under different fire prone classes

Sl.No.	State/ UT	Extremely Fire Prone		Very Highly Fire Prone	
		Forest cover (in sq km)	% of total Forest cover	Forest cover (in sq km)	% of total Forest cover
1.	Andhra Pradesh	1,150.13	3.86	3,832.50	12.87
2.	Arunachal Pradesh	35.16	0.05	959.78	1.44
3.	Assam	3,166.11	11.18	4,871.05	17.20
4.	Bihar	24.38	0.33	471.89	6.39
5.	Chhattisgarh	1,935.04	3.47	3,655.58	6.56
6.	Delhi	0.00	0.00	0.00	0.00
7.	Goa	0.00	0.00	0.00	0.00
8.	Gujarat	8.08	0.05	384.42	2.58
9.	Haryana	0.00	0.00	20.40	1.27
10.	Himachal Pradesh	0.00	0.00	6.81	0.04
11.	Jammu & Kashmir	0.00	0.00	17.90	0.08
12.	Jharkhand	47.36	0.20	480.45	2.03
13.	Karnataka	71.58	0.18	930.93	2.40
14.	Kerala	0.00	0.00	54.79	0.26
15.	Madhya Pradesh	336.52	0.43	4,730.92	6.10
16.	Maharashtra	470.68	0.93	3,585.37	7.06
17.	Manipur	1,636.46	9.85	6,167.06	37.16
18.	Meghalaya	1,588.24	9.32	3,505.49	20.56
19.	Mizoram	4,683.50	26.28	8,862.58	49.73
20.	Nagaland	352.24	2.88	3,129.20	25.54
21.	Odisha	1,226.66	2.35	3,930.36	7.54
22.	Punjab	0.00	0.00	53.86	2.92
23.	Rajasthan	0.00	0.00	197.33	1.18
24.	Sikkim	0.00	0.00	0.00	0.00
25.	Tamil Nadu	0.00	0.00	38.78	0.15
26.	Telangana	571.87	2.70	2,970.26	14.00

whereas the WMS interface returns only an image, which end-users cannot edit or spatially analyse.[7]

The WMS/ WFS of near real-time monitoring of forest fire consists of the layers of MODIS and SNPP-VIIRS sensor detections for last three days (including current day), represented by different legends. The WMS/WFS of large forest fire events consists of incidents of large forest fire of the current fire season. The WMS of the FWI based danger rating consists of different categories of danger rating which is applicable for ensuing week.

Highly Fire Prone		Moderately Fire Prone		Less Fire Prone	
Forest cover (in sq km)	% of total Forest cover cover	Forest cover (in sq km)	% of total Forest Cover	Forest cover (in sq km)	% of total Forest cover
4,915.11	16.50	4,153.69	13.95	15,732.57	52.82
2,744.51	4.13	4,459.73	6.71	58,231.82	87.67
3,400.46	12.01	2,653.93	9.37	14,220.45	50.24
984.48	13.34	1,173.58	15.90	4,726.67	64.04
8,159.70	14.64	11,275.57	20.24	30,691.11	55.09
0.00	0.00	0.00	0.00	195.00	100.00
0.00	0.00	0.00	0.00	2,244.00	100.00
523.32	3.51	975.10	6.53	13,035.08	87.33
66.81	4.17	154.50	9.64	1,361.29	84.92
305.56	1.98	999.03	6.47	14,131.60	91.51
321.68	1.50	857.95	4.01	20,189.47	94.41
2,159.16	9.10	4,227.02	17.82	16,807.01	70.85
2,506.25	6.47	2,989.30	7.72	32,231.94	83.23
461.06	2.17	1,266.42	5.96	19,470.73	91.61
10,889.70	14.05	15,231.85	19.66	46,304.01	59.76
8,540.70	16.81	9,377.92	18.46	28,823.33	56.74
5,423.48	32.68	2,096.16	12.63	1,274.84	7.68
3,716.73	21.80	2,900.24	17.02	5,335.30	31.30
3,369.82	18.91	543.28	3.05	360.82	2.03
4,849.90	39.59	2,477.96	20.23	1,441.70	11.76
7,634.76	14.64	10,086.77	19.34	29,277.45	56.13
254.95	13.80	375.30	20.32	1,162.89	62.96
366.57	2.20	705.56	4.24	15,385.54	92.38
0.00	0.00	25.30	0.76	3,315.70	99.24
470.00	1.78	1,910.94	7.23	23,999.28	90.84
3,920.18	18.48	3,522.07	16.60	10,229.62	48.22

[7] https://en.wikipedia.org/wiki/Web_Feature_Service

Sl.No.	State/ UT	Extremely Fire Prone		Very Highly Fire Prone	
		Forest cover (in sq km)	% of total Forest cover	Forest cover (in sq km)	% of total Forest cover
27.	Tripura	2,491.90	32.27	1,249.76	16.18
28.	Uttar Pradesh	209.30	1.41	1,043.54	7.04
29.	Uttarakhand	49.21	0.20	757.92	3.12
30.	West Bengal	20.05	0.12	120.03	0.71
31.	Andaman & Nicobar Islands	0.00	0.00	20.39	0.30
32.	Chandigarh	0.00	0.00	0.00	0.00
33.	Dadra & Nagar Haveli and Daman & Diu	0.00	0.00	0.00	0.00
34.	Ladakh	0.00	0.00	0.00	0.00
35.	Lakshadweep	0.00	0.00	0.00	0.00
36.	Puducherry	0.00	0.00	0.00	0.00
	Total	**20,074.47**	**2.81**	**56,049.35**	**7.85**

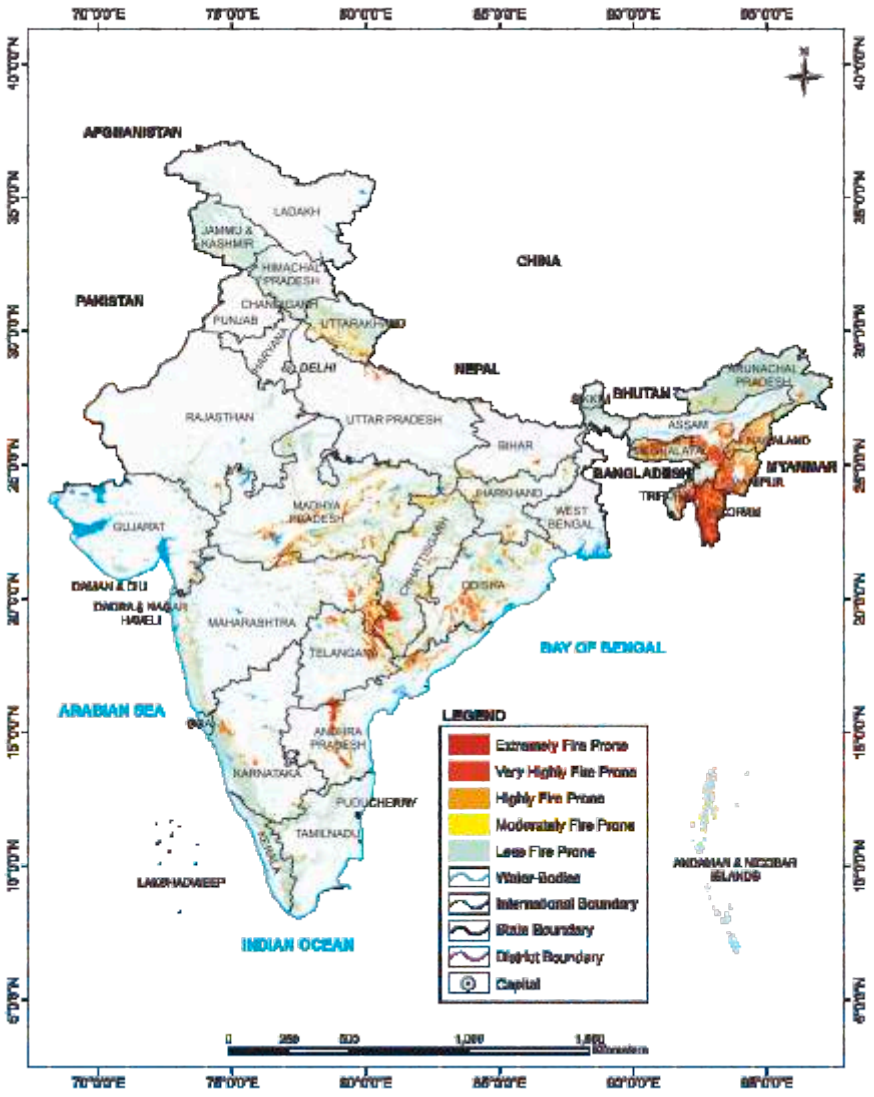


Figure 5.12
Map showing forest areas under different fire prone classes

Highly Fire Prone		Moderately Fire Prone		Less Fire Prone	
Forest cover (in sq km)	% of total Forest cover cover	Forest cover (in sq km)	% of total Forest Cover	Forest cover (in sq km)	% of total Forest cover
812.80	10.53	641.61	8.31	2,525.93	32.71
1,555.38	10.50	2,070.29	13.97	9,939.49	67.08
4,070.09	16.75	5,887.70	24.22	13,540.08	55.71
425.63	2.53	1,050.42	6.24	15,215.87	90.40
51.38	0.76	37.49	0.56	6,634.74	98.38
0.00	0.00	0.00	0.00	22.88	100.00
0.00	0.00	0.00	0.00	227.75	100.00
0.00	0.00	0.00	0.00	2,272.00	100.00
0.00	0.00	0.00	0.00	27.10	100.00
0.00	0.00	0.00	0.00	53.30	100.00
82,900.17	**11.61**	**94,126.68**	**13.19**	**4,60,638.36**	**64.54**

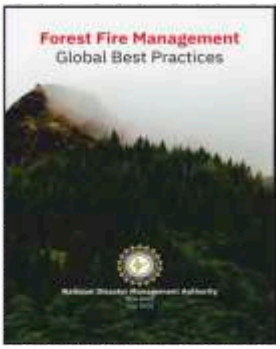
National Disaster Management Authority (NDMA), under Ministry of Home Affairs, is the apex body mandated to lay down the policies, plans and guidelines for Disaster Management. India envisions the development of an ethos of Prevention, Mitigation, Preparedness and Response.

Following are some of the important initiatives taken by National Disaster Management Authority (NDMA) towards coordinating the work related to mitigation and management of Forest fires:

- **Common Alert Protocol (CAP):** Under NDMA, CAP is being implemented. Under CAP, a standard message format which contains all the relevant details like type of hazard, intensity, duration, area of impact and actions to be taken are clearly defined. CAP compliant systems and devices like the GSM network, Radio, Television etc. can plug and play with a CAP based alerting system. Forest fire alerts are proposed to be added to CAP.

- **Awareness Generation:** A list of do's and don'ts has been prepared by NDMA and has been shared with all the forest fire prone states. These do's and don'ts are being widely circulated on various official social media handles of NDMA like Facebook, Twitter etc.

- **Research on Forest Fire:**



1. NDMA has undertaken studies to understand forest fire management within India as well as globally. A report was compiled on international best practices on forest fire management across the globe. The report is available on NDMA's website www.ndma.gov.in under the link Resources -> Reports and Studies -> Forest Fire Management Global Best Practices.
2. A study to document indigenous forest fire management practices across India has been initiated in collaboration with Forest Research Institute.

- **Management of Active Forest Fire:** The massive forest fire break outs often cover multiple states. In order to contain/ manage these forest fires, the National Disaster Recovery Force (NDRF) was engaged in dousing the active fires. In the forest fire in Dzukou Valley in Manipur & Nagaland and in Uttarakhand in 2021, NDRF along with other armed forces and State agencies, played an active role in limiting the spread of fire as well as in search and rescue where required.

Box 5.2 Initiatives by National Disaster Management Authority on Forest Fire