FIRES IN TROPICAL DECIDUOUS FOREST, CAUSES AND CONSEQUENCES : A STUDY FROM THANE DISTRICT OF MAHARASHTRA

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INTRODUCTION:

In our country forest fires are not studied scientifically on large scale. Some attempts are made by Forest Officers, FSI and some NGO's on micro scale. Given the scale at which forest fires occur in India, their impact on the vegetation, and also given the large gap between the legal framework and the actual practices of local forest management, we think it would be timely to study the matter in greater depth at the regional level. There is need to study the theoretical relations surrounding fires with scientific methodology to discover ways of directing fire application and therefore the supply of ecosystem services. This includes understanding forest vegetation dynamics in relation to the fire regime, the role fire plays in the provision of ecosystem services, and the social background behind fire applications.

The objective of this paper is to study the spatio and temporal patterns of forest fires and to examine methods employed to control forest fires and gaps in them. The study is based on data obtained from FSI (Forest Survey of India) and from FD (Forest Department). A spatio-temporal analysis is carried out by taking into consideration the physiography, weather conditions and socio–economic factors. Field visits and interviews with FD officials and local people were carried out to get their perspectives regarding forest fires. This will help us to understand the behavior of local forest dwellers and to plans of Forest Department to prevent it.

1.1. FOREST FIRES:

A) Definition and types of forest fire:

A forest fire is defined as "any uncontrolled fire in combustible vegetation that occurs in the countryside or in a wilderness area". It is also called as wild fire, brush fire, bushfire, grass fire, hill fire, squirrel fire, etc. Forest fires are classified in to following categories:

1. Ground fires - fed by subterranean roots, litter and other buried organic matter. These fires typically burn by smoldering, and can burn slowly for number of days.

2. Crawling or surface fires - fueled by low-lying vegetation such as leaf and timber litter, grass, and low-lying shrubbery. This is the most common fire type in the Thane as well as in India.

3. Crown, **canopy**, **or aerial fires** - burn suspended material at the canopy level, such as tall trees, vines, and mosses. The ignition of a crown fire is dependent on the canopy height, canopy continuity, and sufficient surface as ladder in order to reach the tree crowns.

B) Causes of forest fires:

a) Natural causes: The four major natural causes of forest fire ignition are lightning, volcanic eruption, sparks from rock falls, and spontaneous combustion.

b) Anthropogenic causes: Majority of forest fires in India are man-made and the important causes are:

1. Conversion of forestland to agriculture as well as traditional slash and burn agriculture practices.
2. Promotion of early flushing of grass for grazing livestock, at the onset of the monsoon
3. Burning the under storey to clear the forest floor and enable collection of Mahua flowers, honey, Sal seeds, tendu leaves, shed antlers and other products easily.
4. Forest/human habitation interface e.g. during burning of agricultural wastes in adjoining cultivated areas fire spreads to surrounding forest.
5. Facilitation of hunting of wild herbivores early in the monsoon season.
6. Conflicts over the land right claims and an attempt to encroach on forest lands.
7. Negligence while commuting with local fire torches at night.
8. Sparks from electricity transmission lines during strong gusty winds.
9. Burning of forests in and around their villages by locals to kill snakes and other pests, and to destroy their habitat.
10. Poverty and lack of adequate employment among the forest dwellers.
11. Some kind of animosity towards FD

C) Characteristics of Forest Fires:

1. Forest fire generates where there is an occurrence of ignition source, combustible material and an adequate supply of oxygen.
2. Evergreen or dense forests usually provide more shade, resulting in lower temperatures and greater humidity, and are therefore less susceptible to forest fires than deciduous forests
3. Plants continuously lose water by evapotranspiration, but water loss is usually balanced by water absorbed from the soil, humidity, or rain. When this balance is not maintained, a plant dries out and becomes more fire prone and flammable.
4. Forest fires have a rapid forward rate of spread. They can move as fast as 11 kms per hour in forests and 22 kms per hour in grasslands.
5. On the sloping land fire moves faster towards the upward slopes than down slope.
7. Heat waves, droughts, cyclical climate changes such as El Niño, and regional weather patterns such as high-pressure ridges can increase the risk and alter the behavior of forest fires dramatically.
8. Fire intensity increases during daytime. Burn rates of smoldering logs are up to five times greater during the day due to lower humidity, increased temperatures, and increased wind speeds.
9. Forest fires are fanned by mountain and valley winds and often follow the air currents over hills and through valleys.

1.2. FOREST FIRES IN INDIA:

Forest vegetation in India varies from tropical evergreen forests on the west coast and in the northeast to alpine forests in the Himalayas in the north. In between the two extremes, there are varieties of forests in the country. As per the FSI State of Forest Report-1995, about 53% of India's forests are prone to fire; of this 9% of forest area is affected by frequent fires. More than 95% of the forest fire incidents in India are anthropogenic, the main fire starters being the

grazers and minor forest product collectors. Forest fires are a driving factor in shaping forest vegetation and landscape in the country.

In India forest fires are significant and one of the increasing contributory factors in the degradation process, although the extent of total damage is widely disputed. According to the study by Srivastava (1987), during the sixth five year plan (1980-85) 17,852 fires were reported affecting an area of 5.7 million ha(Hectares). Data collected by the FSI indicates that forest area affected by annual fires may be as high as 37 million ha (Ministry of Environment & Forests, 1987). Out of total area affected by fire, 50% of it is in the North Eastern states. In other states like Maharashtra, Madhya Pradesh, Orissa, Chhattisgarh and Karnataka forests are prone to fires.

India is among the top 10 countries, globally, in terms of area under forest and tree cover, but due to its large population size, the per capita availability of forest area is only 0.06 ha per person against a world average of 0.6 ha per person. The problem is further accentuated by the low average productivity of forests in India. Forests meet nearly 40% of the country's total energy needs and about 30% of all fodder needs. It is estimated that about 270 million tons of fuel wood and 280 million tones of fodder are extracted from India's forests every year. In addition, a large number of non-timber forest products (NTFP) are also harvested by millions of people who live in and around forests. These figures highlight the tremendous biotic pressure on our forests. (Speech delivered by Mr. S. Reghupathy, Minister of State for Environment and Forest, During National Workshop on Forest Fires, 2007 - New Delhi.)

Table-01 shows crucial forest fire periods in the States and Union Territories of India for the year 2006-2007.

Sr. No	State	Forest Area in Kms ^{2}	No of Forest Fires Spots		Crucial Period of Forest Fires	
			Nov2005-June 2006	Nov2006-June 2007	From	To
1	Andhra Pradesh	45102	1855	1569	2- Feb	16 -May
2	Arunachal Pradesh	67353	593	474	11- Feb	7 - May
3	Assam	27692	881	1344	28-Feb	2- May
4	Bihar	6804	84	147	23 -Feb	9- April
5	Chhattisgarh	55870	1738	792	22 - Feb	2 -May
6	Goa	2151	1	8	6- Feb	23 -April
7	Gujarat	14620	92	200	4 – Feb	21 -May
8	Haryana	1594	14	11	28 -Feb	10- June
9	Himachal Pradesh	14668	43	12	5- May	10- June
10	Jammu and Kashmir	22686	92	78	30- May	11 -June
11	Jharkhand	22894	140	548	23 Feb	6 -May
12	Karnataka	36190	324	541	2 Feb	5 -April
13	Kerala	17324	120	48	9- Feb	31- March
14	Madhya Pradesh	77700	838	1066	3- Feb	14- May
15	Maharashtra	50650	1244	947	17- March	8 - May
16	Manipur	17280	1213	1654	1 –March	2- May
17	Meghalaya	17321	507	1285	28- Feb	3 - April
18	Mizoram	19240	2830	4467	28- Feb	30 - April

19	Nagaland	13464	767	1132	2 - Feb	11 April
20	Odisha	48855	1457	1646	23- Feb	8 - May
21	Punjab	1664	18	33	3- March	16 - June
22	Rajasthan	16036	53	47	22 -Feb	26- May
23	Sikkim	3357	0	2	14- Feb	6- March
24	Tamil Nadu	23338	122	107	2 - Feb	10 -June
25	Tripura	8073	738	1421	17 March	3- April
26	Uttarakhand	24495	221	170	1 – Feb	9- June
27	Uttar Pradesh	14341	297	242	2 - April	14 - April
28	West Bengal	12994	6	164	23 -Feb	26 - May
Total		**6,83,756**	**16,288**	**20,155**	February	May

Table-01, Source: National Forest Fire Monitoring by Forest Survey of India – 2007

The policy towards fire in India has been one of strict suppression for at least the past century. An early formal rule of this is to be found in the 1927 Forest Act, which made setting of fires, whether deliberately, or inadvertently, a punishable offence, and also mandated participation in fire prevention and control by any persons exercising rights in forests, or receiving government emoluments. This has since been reiterated in several ways. For example, the National Forest Policy of 1988 emphasizes forest protection against fires and also stresses the use of improved and modern fire management practices; this is echoed in various forest protection schemes and guidelines that have been issued subsequently.

1.3. FOREST FIRES IN MAHARASHTRA:

Maharashtra has 61939 sq. km. of recorded forest area, constituting about 20 % of the geographical area. According to satellite data, actual forest cover is 50650 sq. km. which is 16.46% of the state's geographical area. Large part of Maharashtra's forest falls in tropical deciduous forest which is highly prone to fires. Table 02 shows details of forest fires in Maharashtra.

Statement of forest fires registered in Maharashtra

Year	**2005-06**		**2006-07**		**2007-08**		**2008-09**		**2009-2010**	
Origin of Fire	**No. of Fires**	**Area burned (in ha)**	**No. of Fires**	**Area burned (in ha)**	**No. of Fires**	**Area burned (in ha)**	**No. of Fires**	**Area burned (in ha)**	**No. of Fires**	**Area burned (in ha)**
Natural	445	4649	518	4266	510	4321	673	5585	434	3676
Accidental	750	7023	887	9429	1245	13075	1317	18746	848	6663
Intentional	257	3040	97	1758	225	3167	417	6009	261	6323
Unknown	550	16122	1183	20228	1273	26397	1446	29285	875	14097
Total	**2002**	**308.34**	**2685**	**356.81**	**3253**	**469.60**	**3853**	**596.25**	**2418**	**307.59**
% of area burned to total forest	--	0.61		0.70		0.73		1.18		0.61

Table-2, *Source: Annual Administrative Report -2009-10, Forest Department of Maharashtra*

As per the records of FD, in Maharashtra on an average 2842 fires occur every year. Average area burned by these fires is more than 400 sq. kms. This area is less than 1% of the total forest area of the state, but in spite of it the role of these fires is very significant. The recorded fires increased in the state from the year 2006 to 2009, but thereafter the number declined substantially. On an average 14

hectares of forest land are burnt during each fire. Eastern and Northern Western part of part of Maharashtra is prone to forest fires.

FSI records much lower number of fires as compared to FD of the state. FD records fires that are quite small in size that probably cannot be detected by satellites. But it is also a fact that FD officers cannot report each and every fire which takes place for short duration. So the fire affected areas and loses by it can be of greater intensity than recorded by government agencies. Fires constitute a major threat to the forests in Maharashtra as most of the forests fall in dry and deciduous category, particularly in the dry season from February to June. Forest fire prevention is an important function of the FD and Village Forest Protection Committees.

1.4. FOREST FIRES IN THANE DISTRICT:

A) Geography of Thane's Forest: Thane district is the northernmost part of the Konkan lowlands of Maharashtra and it has a geographical area of 9558 km². As per the 2011 census it is the most populated district in India. The district is situated between 18°42' and 20°20' North latitude and 72°45' and 73°48' East longitude. Fig. 01 shows month wise precipitation and potential evapotranspiration in Thane district. During the fire season there is a substantial amount of evapotranspiration in the district and there is no precipitation.

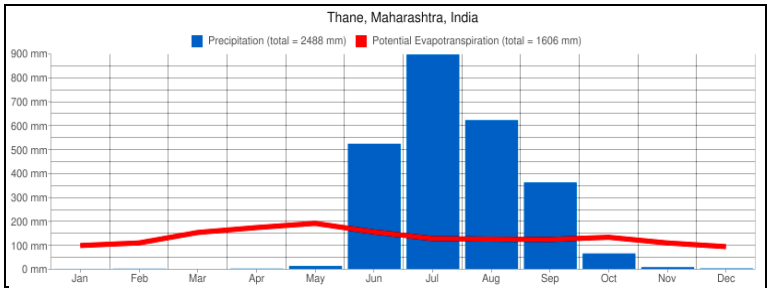


Fig.-1, Source: FAO Web LocClim.

In the district average annual range of temperature is between 27 ^{0} C and 37 ^{0} C. The average annual rainfall in the district is 230 cms and it increases from west to east. The northern hilly part of the district is thickly forested. The district has 40.2 % of its geographical area under forest. More than 90 % of the forests of Thane district fall under the type 'tropical moist (mixed) deciduous forests'. Important species in the district are *teak*, *ain, khair, hed, bibla, shisham, sawar* etc. The minor forest produce in the district includes *apta* leaves, *mohuwa* flowers, palm leaves, bamboo, hirada, *shikakai,* honey and gum. Forests are unevenly distributed in the district.

B. Patterns of Forest Fires:

a) Yearly variation: Fig. - 02 shows recorded forest fires by FSI. A reported fire in Thane varies between 23 in 2005 to 75 in 2010. There is gradual increase in number of fire incidences in the district till 2010 after which (2011) there appears to be a decline in the incidence of fire. This shows a perplexing trend and the researcher was unable to determine the cause behind this sharp decline in number of fires. The gradual increase in number of fires up to 2010 can be related to increase in population of the district.

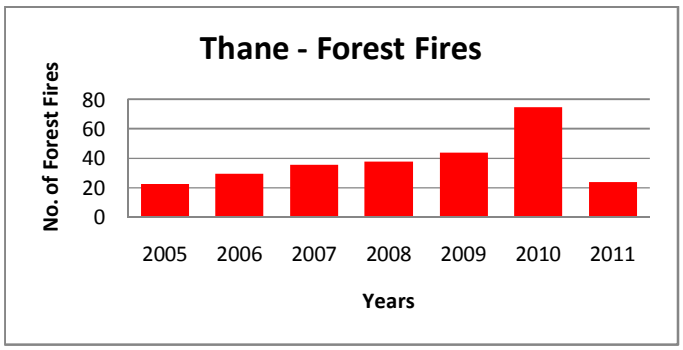


Fig:-02, Source: Forest Survey of India Web Site - 2011

b) Month wise variation: 'Fire season' in Thane starts during late winter. The grass and ground remains moist up to December and hence the number of fire incidences till December are very few (Fig. - 03). Fire number increases in the month of January as the ground cover of grass starts getting dry and gradually there is a rise in temperature during the day accompanied by a decline in the humidity. The maximum number of fires in the district is recorded in the month of March. In this month fires are due to availability of huge amount of dry biomass, high temperature, low humidity and high wind speed. The number of fire incidences falls gradually after April as sufficient dry biomass is not available.

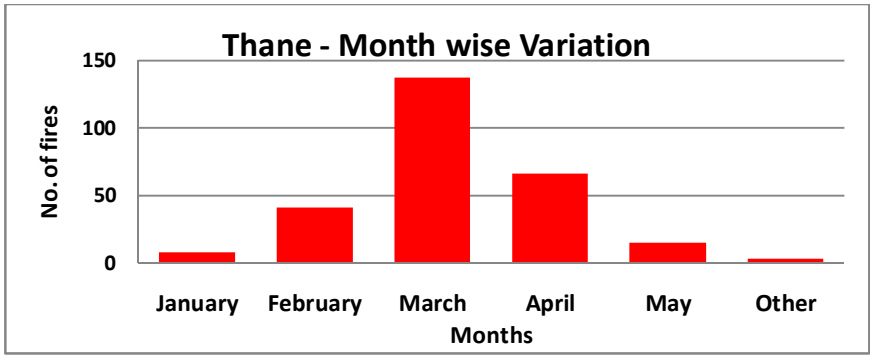
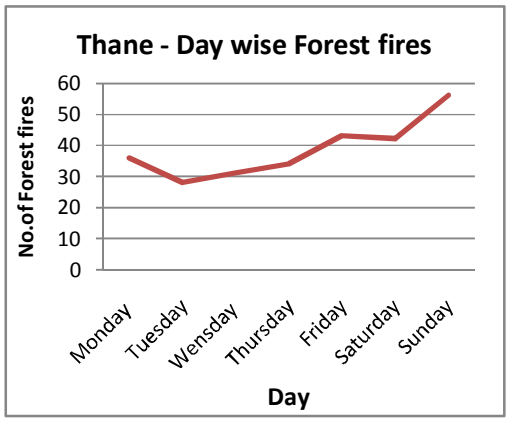


Fig-03: Source: Forest Survey of India

c) Day and holiday wise variation: When a correlation of working days with forest fires, and holidays with forest fires, was carried out, it was observed that maximum incidence of forest fires took place on Sundays and a day before and after public holidays (Fig-04 and 05).



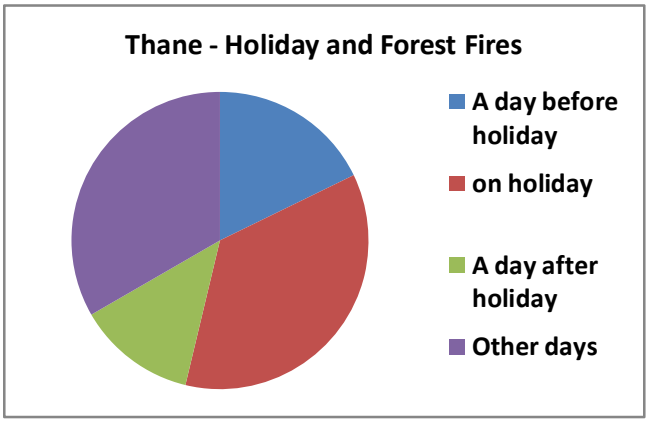


Fig 04 and 05: Source: Forest Survey of India

Poaching is the most important reason behind setting fires in forests by *Katkari* tribes in Thane. They set fire at the base of gently sloping hills, and put traps on uphill to get wild pig, rat, rabbit and other small herbivorous animals which try to escape from the fire below and run uphill. Fires thus set by people spread in forests as they never try to put it off after poaching. These types of fire incidences are maximum on the holidays due to less number or absence of forest guards.

d) Festivals and forest fires: No relation is found between specific festivals and fire incidences. Even on the day of *Holi* very few or no forest fires are observed in the district. When a comparison is made between *Shukla Paksha* and *Krishna Paksha,* it has been observed that 57 % of forest fire incidences take place during *Krishna Paksha* when visibility is lesser.

e) Spatial distribution of forest fires: When forest fire incidences of last seven years are located on Google Earth imagery with the help of latitudes and longitudes, we get the spatial distribution pattern of forest fires in the district (Fig- 06). Forest fire incidences of the district can be grouped into the following clusters;

1. Major concentration around Tansa dam- The forest in this belt is of dry deciduous mixed jungle category. Teak is the most important plant species in this forest. A major concentration of forest fires is seen around Tansa dam and particularly in Tansa wildlife sanctuary. The forests near Khodala, Vada, Khardi and Aasangoan burn regularly in each fire season. The main causes behind these fires are clearing forests for satisfying demands due to population pressure, for collection of minor forest products, negligence by tourists and vehicle drivers and poaching by *Katkaris* and others.

2. Major concentration around Barvi dam – This belt is located between Titwala, Asangoan, Murbad and Badlapur towns. Here the major concentration of fires is around Barvi dam. Increasing urbanisation, population pressure, encroachment on forest land, poaching and collection of minor products are the reasons behind forest fires in this area. In this belt also forest is deciduous and prone to forest fires in the dry season.

3. A minor concentration North of Bhiwandi town – Forest areas north of Bhiwandi town show a minor concentration of forest fires around village Depoli, Bhinar and Navghar. Here the forest is open mixed jungle with large patches of grassland. In dry months the grasslands are prone to fires.

4. A minor concentration around NH-08 – A minor concentration of forest fires is seen along NH-08, around Navghar, Kasa, Andhari Fort, Tungar hills, etc. Here the forest is open mixed jungle. Most of the fires in this belt start from the national highway and spread to surrounding forests. Here fires may be mainly due to negligence by the motorist.

Surprisingly in spite of good forest cover in Jawhar, Mokhada, Vikramgad and in Eastern part of Murbad and Shahapur tehsils, forest fire incidences are very less in number. This may be due to less population pressure and inaccessibility of forest.

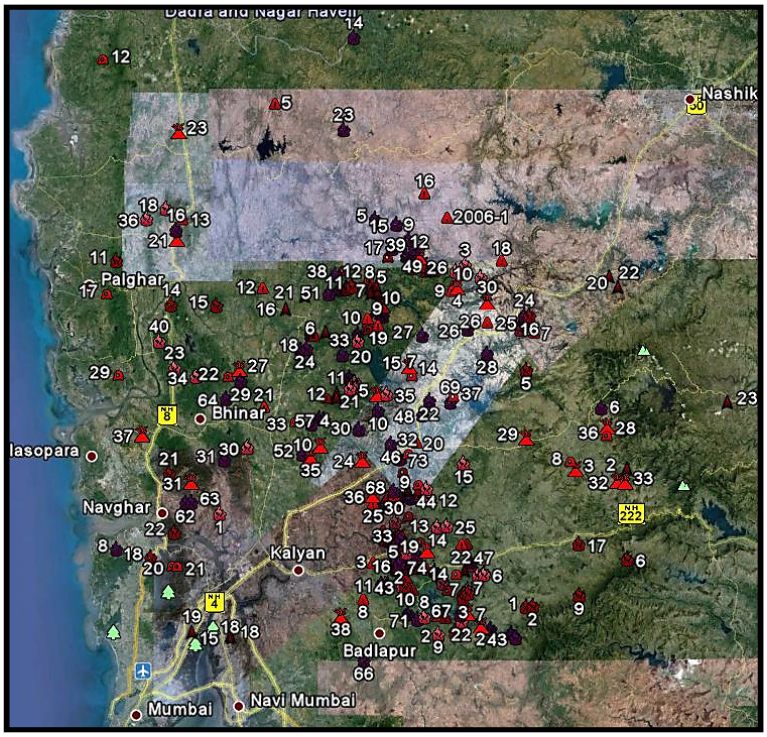


Fig. - 06: Source: Google Earth and FSI data- 2011

F) Impact of Forest Fires: Table - 03 shows details of fire incidences in Thane Forest Circle in year 2009-2010. These figures are not tallying with FSI records. In year 2009-10 there were 314 fires in Thane Circle which includes Thane and Raigad districts. As per the FD department total damage by these fires was of more than Rs. 3 lakhs which is less than UNDP estimates (Rs.9000/ ha for year 1987). This figure is the value of only timber and firewood; it does not include the loss suffered in the form of biodiversity, nutrient soil moisture and other intangible benefits. Total burned area by these fires was 2,227 ha which not even 1% of total forest area. As per the records most of the fires in the district are of surface nature and average burned area is 7 ha as compared to 14 ha of state average.

Sr. No	Fire cause	No. of Fires	Fire Type	Area burned in ha	Value of damage in Rs.	Estimated cost of fire suppression
1	Due to lightning	03	Surface	11	1500	--
2	Due to other natural reasons	77	Surface & ground	753	86,800	--
3	Unintentional or Accidental mainly due to carelessness by passers , labour camps	234	Surface	1463	2,28,200	21000
4	Deliberate or intentional for poaching, grazing, minor forest products	--	--	--	--	--
		314		2,227	3,16,500	21,000

Table-3, Source- Annual Administrative Report, Thane Forest Circle - 2009-10, Abstract of form -119

Following are some of the common environmental problems associated with forest fires:

1. Forest fires, either natural or manmade, play a significant role in ecosystem dynamics. The study revealed that uncontrolled forest fires result in significant loss of biodiversity, loss of forest regeneration, burning of biomass, and destruction of micro-organisms necessary for essential forest ecological processes.

2. The recurrent fires adversely affect natural regeneration and lead to the slow death of the forest. Simultaneously, vegetation present in the grassland also disappears. To a certain extent, regular fires converted the forest into grassland.

3. Forest fires also increase erosion and alter the physical and chemical properties of the soil, converting organic ground cover to soluble ash and modify the micro-climate through the removal of overhead foliage.

4. Biomass burning is an important source of atmospheric bromine in the form of methyl bromine. Bromine leads to the chemical destruction of ozone in the stratosphere and is about 40 times more efficient in the process than is chlorine on a molecule-to-molecule basis (Gupta and Yunus 1998).

5. Forest burning enhances emissions of nitric oxide and nitrous oxide from soil. Biomass burning affects the reflectivity and emissivity of the earth's surface as well as hydrological cycle by changing rates of land evaporation and water runoff (Gupta and Yunus 1998).

6. Biomass burning is an important source of greenhouse gas (GHG) emissions and is the largest source of air pollution (Crutzen and Andreae 1990, Crutzen and Carmichael 1993, Kaufman et al. 1998, Streets et al. 2003). Globally, biomass burning is estimated to produce 40% of the carbon dioxide, 32 % of the carbon monoxide, 20% of the particulates and 50% of the highly carcinogenic polyaromatic hydrocarbons produced by all sources (Levine 2000).

7. The burning of forest also destroys an important sink for atmospheric carbon dioxide. Hence, burning has a significant role in the world's carbon dioxide budget (P. Soni, M. M. Kimothi, A. K. Tripathi and H. B. Vasistha, Forest Fire Workshop-2007).

9. Severe burns such as those caused by forest fires can result in nearly complete destruction of organic matter and bring about changes in the physical, chemical and biological properties of the upper layers of mineral soil. This makes the trees more susceptible to insect attack.

10. Repeated fires in forest ecosystems decreased tree densities and species diversity, and concomitant changes in species composition and forest structure. Evidence for such effects has been reported from tropical dry deciduous forests in India (Saha and Howe 2003).

G) Forest Fire Management in Thane: Forest fire management in Thane is carried out by the FD. Some of the common methods of fire management are:

1. The conventional method to control forest fire is the creation and maintenance of a network of fire lines. Fire lines are cut and burnt annually between the periods of 15 November to 15 February. But they need to be swept continuously as leaves continue to shed even after 15 February. Table-04 shows the fire lines and forest fire management for the year 2009-10 in Thane district:

Forest Division	Length of fire control line (in kms)				Expenditure on fire control line (in lakhs)				Expenditure on fire lines (in lakhs)	No. of fire watchers	Amount spent on fire watchers (in lakhs)
	15 MTS	12 MTS	6 MTS	3 MTS	15 MTS	12 MTS	6 MTS	3 MTS			
Shahapur	197	0	133	1557	1.81	0	0.55	4.73	7.09	21	0.5
Thane	0	746	104	200	0	5.08	0.43	0.61	6.12	20	1.68
Dahanu	0	99	143	981	0	0.68	0.57	2.9	4.15	0	0
Jawhar	505	190	0	1315	4.33	0.92	0	3.82	9.07	0	0
Total	**702**	**1035**	**380**	**4053**	**6.14**	**6.68**	**1.55**	**12.06**	**26.43**	**41**	**2.18**

Table-4, Source: Annual Administrative Report 2009-2010, Thane Circle.

2. Patrolling the area by forest staff and temporary appointment of fire watchers during fire season.

3. Setting up few watch towers at ideal location for early detection of fires in the forest.

4. Involving local villagers to support FD staff to suppress the fire after the fire incidence is reported.

5. Carrying out the *panchnama* of the fire affected area, calculation of value of damage, and registration of fire at range office for further investigation.

By the present management system it is very difficult to protect forests from fires as maximum fires are anthropogenic in origin. For example as per FD, 193 fire incidences were recorded in Thane District during year 2009-10. The total burned area was more than 2500 ha. In more than 95 % fire incidences, cause of fire remained unrevealed or undetected and so no case was registered or no punishment given and so there was no recovery of losses.

H) Suggestions for better management:

1. Fire protection camps/squads should be set up during fire season at strategic locations along with regular patrolling and reporting and on-the-ground verification of satellite information.

2. Basic training is required for the temporarily appointed fire watchers, fire suppression squads and members of JFM.

2. The Moderate Resolution Imaging Specter-Radiometers (MODIS) data can be replaced by Indian Remote-Sensing Satellite (IRS) data, which is of higher spatial resolution. Latest technology should be employed for early detection of fire and warning about forest fires should be given to the forest guards with the high rank Forest Officers.

3. Separate machinery is required to take care of private forests during the time of disasters like fire.

4. There is need to create public awareness through public meetings, street plays, religious and political leaders in forested villages. A fire awareness week should be organized annually. Local NGOs, NSS volunteers, Scouts, Home-guards and other organizations should be involved in awareness drive as well as for fire suppression.

5. There is need for greater coordination between FD, FSI, ISRO, IMD and Revenue Department in order to generate a national forest fire danger rating system, based on the national-level database on forest fires, vegetation and land cover maps, and real-time weather predictions.

6. During the time of afforestation programme, care should be taken to plant non-flammable species in fire prone areas.

7. Forest Protection communities, JFM Committees, and civil society should be involved in stewardship including fire prevention, detection and management in accordance with existing policies and guidelines.

8. Essential and modern equipment for fire suppression, including hand tools, fire resistant clothing, mechanized equipment, and water tenders, especially for protected areas, should be provided on a priority basis.

9. There are very few detailed studies in the country to get exact idea about the losses that takes place by forest fires. More detailed ecological and socio-economic impact studies are required at regional, state and national level.

10. Strict implementation of fire control rules and regulation and rapid disposals of cases related to forest fires should be followed. Sufficient publicity must be given to forest fire cases to create public awareness.

Conclusion: More than 50% of the forest in the country has threat of forest fires every year. We need the proper planning strategy to reduce number and impact of forest fire. Most of the resources seem to be allocated to fire suppression, whereas increased efforts toward prevention could have a greater impact. Further development of early warning and fire danger rating systems, and development of satellite derived products for operational use appear essential for effective fire management. Effective involvement of local people through JFM can provide reasonable solution to this annual disaster.

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