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Forest fires are considered as one of the most widespread hazards in a forested landscape. Fires have played an important role in shaping forest dynamics since ancient times. Fire can act as a stabilizing or destabilizing force in tree communities in the forests by approximate maintenance of species composition and abundance and community structure over time. Foresters use fire as a tool for scientific forest management since many species regenerate and establish well under light fire conditions. Fire can play a vital role in healthy forests, recycling nutrients, helping tree species regenerate, removing invasive weeds and pathogens, and maintaining habitat for some wildlife. Occasional fires can also keep down fuel loads that feed larger, more destructive conflagrations. However, as populations and demands on forest resources have grown, the cycle of fire has spun out of balance and these uncontrolled and repeated fires at short succession are one of the major causes behind forest degradation since forest resources and carbon stocked in the biomass is lost due to fire every year adversely impacting the flow of benefits and services from the forests.

Forest fires have now become an increasing global concern. Forest fires are a challenge across many countries as wildfires are burning larger areas, and fire seasons are growing longer due to a warming climate. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, annual carbon emissions from forest fires are in the range of 2.5 billion to 4.0 billion tons of CO2, and smoke exposure from landscape fires (including forest fires) is estimated to cause 260,000 to 600,000 premature deaths annually. Moreover, forest fires result in the loss of forest goods such as timber, fuelwood, fodder, and non-timber forest products, and consequently, the loss of livelihoods for people directly dependent on forests, loss of natural habitat for wildlife, and soil erosion and damage to water supply.

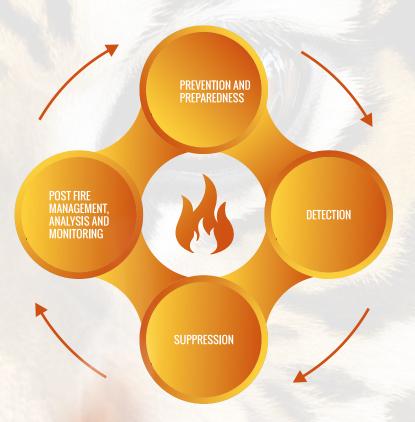
Impact of uncontrolled fires on wildlife is also detrimental. Besides killing a large number of smaller animals, they do harm micro fauna and flora of the habitat, destroy the organic matter, which contributes to the humus content of the substratum. Fire changes the abundance and composition of wildlife communities drastically, and a general ecological effect of fire is to reverse the natural succession. The fire also destroys the eggs of a number of ground-nesting birds and reptiles. Fire compels animal and bird population to abandon the habitat and disperse, often disturbing the spatio-temporal utilization of a habitat. Many seeds and several plant species are completely destroyed by fire and their regeneration is affected adversely.

Forest fires are a regular phenomenon in India often observed during the fire season. A number of 37,059 fires were detected by Forest Survey of India (FSI) in year 2018 using MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor data. Every year large areas of forests are affected by fires of varying intensity and extent. Based on the forest inventory records of FSI, 54.40% of forests in India are exposed to occasional fires, 7.49% to moderately frequent fires and 2.405% to high incidence levels while 35.71% of India's forests have not yet been exposed to fires of any real significance. Forest fires are often caused intentionally by communities to increase fodder (grass) growth, clear areas for shifting cultivation, clearing of areas for NTFP collection, hunting and encroachment. Unintentional fires from casually discarded match sticks, cigarette/bidi butts sometime may cause havoc if not noticed at an early stage.

Tiger Reserves, being key sites for 'source populations' of tigers, are cornerstones for tiger and biodiversity conservation in India. Besides poaching driven by an illegal international market for tiger parts and products, loss of habitats and prey depletion have remained major threats for tiger populations in India. All India tiger estimation 2018 has demonstrated that many Tiger Reserves in the country support low density of tigers and need substantial management interventions in terms of habitat development/amelioration and prey augmentation. National Tiger Conservation Authority (NTCA) has also issued several guidelines for protection and habitat management of the Tiger Reserves, which inter alia form part of the Tiger Conservation Plans (TCP). While majority of the Tiger Reserves are investing their efforts in accordance to these guidelines to develop habitats for prey and tiger: forest fire remains a paramount unsurmountable management challenge for most of them. It also adversely impacts India's ambitious plan (under National Action Plan on Climate Change) to increase forest and tree cover by 5 million hectares and to improve the quality of forest on another 5 million hectares thereby creating additional sinks of 2.5 billion to 3 billion tons' worth of CO2 stored in its forests by 2030. National legislations also strictly forbid setting fire in forests. Sections 26 and 33 of the Indian Forest Act of 1927 make it a criminal offense to burn or to allow a fire to remain burning in reserved and protected forests. Section 30 of the Wild Life (Protection) Act of 1972 further prohibits setting fire in wildlife sanctuaries. It is, therefore, important that a protocol for auditing and monitoring fire incidents in the Tiger Reserves and other forests be developed to understand the magnitude of the threat and evaluate the efforts being put forward by the management in its mitigation.

NATIONAL TIGER CONSERVATION AUTHORITY

The Fire Audit Protocol is developed largely based on The World Bank's 2018 assessment report for Ministry of Environment, Forest and Climate Change. Effective forest fire prevention and management system (FFPM) entails a continual management process, as illustrated in Figure 1. The stages of this process include prevention and preparedness, detection, suppression, and post-fire management, analysis and monitoring. Prevention is the beginning and most critical stage of the process. At the end of the process, after a fire is extinguished, post-fire management and introspection should aim to inform and improve future prevention activities, hence the cycle. These constitute the broad framework of fire audit protocol which are further sub-divided into 20 indicators (Table 1). Each Indicator has four possible answers, 'poor', 'fair', 'good' and 'very good' based on a score assigned from 2.5 to 10, a score of 2.5 represents the worst status and rated as 'poor'; a score of 5 represents average status and rated as 'fair'; a score of 7.5 represents the below optimal effectiveness and rated as 'good', whereas a score of 10 represents the optimal scenario and rated as 'very good'. The scores of all 20 indicators need to be pooled together and a percentage rating will be calculated for each Tiger Reserve. The aim for quantifying the indicators is to ensure their potential amalgamation with the Management Effectiveness Evaluation framework.



## Figure 1: The Forest Fire Prevention and Management (FFPM) Cycle (modified from MOEFCC and World Bank Joint Report, 2018) which constitutes the broad framework for fire audit protocol

### FRAMEWORK & INDICATORS FOR FIRE AUDIT

Table 1: Framework for fire auditing protocol in Tiger Reserves

Framework	Indicators	
Prevention and preparedness (11 indicators)	Fire lines Road side cleaning Controlled burning Early warning and fire alert system	
	Financial resources Firefighting infrastructures Water availability Ecological assessment and restoration Mapping and sensitivity analysis Capacity building of forest staff Awareness raising	
Detection (3 indicators)	Satellite and technology based detection systems Ground level detection by staff	
Suppression (4 indicators)	Infrastructures for ground level detection Human resource deployment Fire control room Involvement of local communities Coordination with other relevant agencies	
Post-fire management, analysis and monitoring (2 indicators)	Collection of data and record keeping mechanism Ecological assessment and restoration	

The assessment criteria for each indicator under the aforementioned frameworks are as follows:

#### PREVENTION AND PREPAREDNESS

#### FIRE LINES 1.

Poor	Fair	Good	Very good
Cleaning and maintenance of fire lines not done	Upto half of the fire lines prescribed in TCP appropriately cleaned and maintained	Majority (51-80%) of fire lines prescribed in TCP appropriately cleaned and maintained	Majority (51-80%) of fire lines prescribed in TCP appropriately cleaned and maintained

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

The percentage extent of fire lines to be determined based on their length (km) approved in the TCP and length (km) for which cleaning and maintenance have been achieved. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### ROAD SIDE CLEANING 2.

Poor	Fair	Good	Very good
No cleaning or cleaning upto 25% of the fire prone areas	Road sides cleaned for 26-50% of the fire prone area	Road sides cleaned for 51-80% of the fire prone area	Road side cleaned for 81-100% of the fire prone area

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

The percentage extent of road side cleaning to be determined based on their area extent compared to the total fire prone area in the Tiger Reserve. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### CONTROLLED BURNING

3.

Poor	Fair	Good	Very good
No controlled burning as per prescribed in the TCP	Extent of controlled burning to an extent of half the area as prescribed in TCP	Extent of controlled burning to an extent of 50-80% of the area as prescribed in TCP	Controlled burning as prescribed in the TCP

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

The extent of controlled burning to be determined based on area under which it has been executed compared to the total extent prescribed in the TCP. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### EARLY WARNING AND FIRE ALERT SYSTEMS

Poor	Fair	Good	Very good
No early warning /	Some initial thoughts	Fire alert systems are	Fully implementing
alert system in place	have taken place but yet to be translated into action	in place but implementations are ad hoc	fire alert and early warning systems

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

This includes Forest Fire Alert System (FAST) developed by Forest Survey of India or any other agencies such as IT Wing of State Forest Departments or State Governments. There is little integration between alert systems developed by FSI and state governments which need to be established. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

# FOREST FIRE AUDIT PROTOCOL FOR TIGER RESERVES

#### 5. FINANCIAL RESOURCES

Poor	Fair	Good	Very good
Upto 25% availability of the budgetary requirement for FFPM	26-50% availability of the budgetary requirement for FFPM	51-80% availability of the budgetary requirement for FFPM	81-100% availability of the budgetary requirement for FFPM

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

This includes availability, timely mobilization and utilization of fund under different Centrally Sponsored Schemes for forest management such as Project Tiger (CSS-PT), National Afforestation Programme (NAP), National Mission for Green India (GIM), CAMPA etc. or any other funding from state governments. Provisions made in the APO should be mentioned. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### FIREFIGHTING INFRASTRUCTURES 6.

Poor	Fair	Good	Very good
No infrastructure available	Little infrastructure available (like only manual hand tools such as axe, spade, rake, hoe, beaters etc.)	Availability of manual hand tools, mechanized hand tools (such as leaf blower) and dousing equipment (such as lightweight fire extinguishers, water tanker, portable sprinklers etc.)	In addition to above mentioned infrastructures, availability of safety equipment and fire resistant clothing for staff, boots, helmets, dedicated vehicles, first aid kit, communication tools and GPS.

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### WATER AVAILABILITY

Poor	Fair	Good	Very good
25% of the waterholes as per the TCP are maintained	26-50% of the waterholes as per the TCP are maintained	51-80% of the waterholes as per the TCP are maintained	81-100% of the waterholes as per the TCP are maintained

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

Additional availability of water (such as water tankers procured from outside forest) should also be factored in under this criterion. Number of waterholes which are active should be mapped from waterhole management feature under M-STrIPES patrol module. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### MAPPING AND SENSITIVITY ANALYSIS 8.

Poor	Fair	Good	Very good
No mapping of fire prone sites	Mapping has been done but not shared with all divisions, ranges, beats	Risk mapping done and shared with all concerned stakeholders	Risk mapping along with necessary sensitivity analysis models understanding spatio- temporal patterns of fire occurrences

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

Data on fire incidents such as slope, aspect, ruggedness, precipitation, land cover type, nearest road, nearest human habitation etc. need to be analysed for mapping fire hot spots and preparing risk maps based on predictive modelling. Artificial intelligence based algorithms may be used for this purpose. Such exercise may also be extended for fire incidents in the landscape outside the designated Tiger Reserve boundaries. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

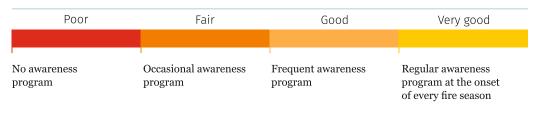
#### TRAINING AND CAPACITY BUILDING OF FOREST STAFF 9.

Poor	Fair	Good	Very good
No training and capacity building for staff, 0-25% staff are trained	Occasional training and capacity building for staff, 25-50% staff are trained	Frequent training and capacity building for staff, 50-80% staff are trained	Regular training and capacity building for staff, 80-100% staff are trained

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### PUBLIC OUTREACH AND AWARENESS RAISING 10.

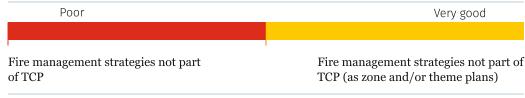


<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

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#### 11. FIRE PREVENTION MANAGEMENT PLAN



Score: Poor: 2.5; Very Good: 10.

In case of poor category, the reason(s) behind it may need to be furnished as Remarks.

#### **B. DETECTION**

#### 1. SATELLITE AND TECHNOLOGY BASED DETECTION SYSTEMS

Poor	Fair	Good	Very good
No system in place	Some initial thoughts have taken place but yet to be translated into action	Technological aid such as drones, real time monitoring wide ranging cameras with 360° PTZ being used, but no satellite or remote sensing infrastructures being used for detection	Both satellite and remote sensing based detection systems and technologies used for fire detection

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

This should be examined in relation to average time to extinguish fires, extent of burnt area etc. at a temporal scale (comparison across the years) to understand the rate of efficacy of such early detection systems. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### 2. GROUND LEVEL DETECTION BY STAFF

Poor	Fair	Good	Very good
o-25% deployment of forest watchers against approved/required strength	26-50% deployment of forest watchers against approved/required strength	51-80% deployment of forest watchers against approved/required strength	81-100% deployment of forest watchers against approved/required strength

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

This should accompany budgetary requirement and availability for deploying such manpower and provisions made in APO or any other source. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### INFRASTRUCTURES FOR GROUND LEVEL DETECTION 3.

Poor	Fair	Good	Very good	
No fire watch tower	A few fire watch towers as against approved in TCP	Presence of fire watch towers in accordance with TCP, but not appropriately maintained	Presence of well maintained, good network of fire watch towers in accordance with TCP	

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### SUPPRESSION C

#### HUMAN RESOURCE DEPLOYMENT 1

Poor	Fair	Good	Very good
0-25% deployment of trained manpower against requirement	26-50% deployment of trained manpower against requirement	51-80% deployment of trained manpower against requirement	81-100% deployment of trained manpower against requirement

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### FIRE CONTROL ROOM

Poor	Fair	Good	Very good
No fire control	Fire control room	Presence of fire	Presence of a well-
room at division level	proposed at division level, but not yet implemented	control room at equipped	equipped fire control room at division level

<sup>\*</sup>Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

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#### 3. INVOLVEMENT OF LOCAL COMMUNITIES

Poor	Fair	Good	Very good	
Local communities are hostile and not involved	Some community members are engaged on daily labour's wage	JFMCs, EDCs, Van Panchayat members sporadically involved	Community members including JFMCs, EDCs, Van Panchayat members are regularly engaged and provided with appropriate incentives, awards etc.	

\*Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

This should again be examined in relation to average time to extinguish fires, extent of burnt area etc. in relation to engaging community members compared to not involving community members. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### 4. COORDINATION WITH OTHER RELEVANT AGENCIES

Poor	Fair	Good	Very good	
No coordination	Occasional coordination	Frequent coordination	Regular coordination	

\*Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

The relevant agencies include National Disaster Management Authority, State and District level disaster management authorities, state disaster response forces, army, police, fire departments and other supporting agencies. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.



## NATIONAL TIGER CONSERVATION AUTHORITY

#### POST-FIRE MANAGEMENT, ANALYSIS AND MONITORING D.

#### COLLECTION OF DATA AND RECORD KEEPING MECHANISM 1.

Poor	Fair	Good	Very good	
No systematic data collection or inventory	Ad hoc data collection and maintenance of inventory	Systematic data collection but no inventorization	Systematic data collection and appropriate inventorization	

\*Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

Post-fire data collection includes the gathering of information on fire incidents via field reporting as well as use of remote sensing. Field reporting is typically done at the forest guard level. The minimum requirements for fire reports should include:

- · Location of fire
- · Date and time of fire incident
- Cause of fire
- · Person(s) responsible for causing fire, if identified
- · Witnesses, if any
- · Extent of burnt area
- Forest type and tree species affected by fire
- Damage to wildlife
- · Action taken to extinguish fire
- Date and time when fire was completely extinguished

This may be developed as a separate section or stand-alone module under M-STrIPES. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.

#### ECOLOGICAL ASSESSMENT AND RESTORATION

Poor	Fair	Good Very good			
No ecological assessment or restoration post fire	Ad hoc ecological assessment but no restoration	Robust scientific ecological assessment but no restoration in place	Ecological restoration by forest department based on robust scientific ecological assessment		

\*Score: Poor: 2.5; Fair: 5; Good: 7.5; Very Good: 10.

Tiger Reserves should regularly get the ecological and economic impacts of forest fires evaluated by involving scientific agencies such as ICFRE, FSI, IIFM, FRI, IIRS etc. Ecological restorations of the affected areas have to be planned, if required, based on findings of such studies. In case of poor and fair categories, the reason(s) behind it may need to be furnished as Remarks.



FOREST FIRE AUDIT PROTOCOL FOR TIGER RESERVES

Framework	Number of indicator (a)	Maximum score per indicator (b)	Total (c) (c= a x b)	Score secured for the framework (d)	% age of score for the framework (d/c) x 100	Overall Audit Score and % age (e)(e = ? d/200) x 100
Prevention and preparedness	11	10	110			
Detection	03	10	30			
Suppression	04	10	40			
Post-fire management, analysis and monitoring	02	10	20			
Total	20		200			

For framework wise and overall audit score <=40% of the total score rated as 'Poor'; 41-59% of the total score rated as 'Fair'; 60-74% of the total score rated as 'Good'; >=75% of the total score rated as 'Very Good'.

### Potential indicators to track improvements in FFPM at a spatiotemporal scale

- Percentage of fires contained within 24 hours following detection
- Proportion of large fires above a certain size out of the total number of forest fires detected
- Number of trained and equipped field personnel deployed
- Number of field staff receiving fire alerts and providing field verification reports
- Reach and acceptance of fire prevention messages among the local community
- Forest regeneration in the target area versus other comparable areas
- Land degradation (specifically, deterioration or area with lack of tree cover or other vegetative cover)
- Average number of fires in project area (versus in other comparable areas)
- · Share of human-caused fires
- Area under improved fire management
- Average area of fires upon detection
- Average response time after detection
- Area under monitoring/surveillance

#### **Key useful resources for Tiger Reserves for fire monitoring and management**

- Strengthening Forest Fire Management in India. Joint report by the MoEFCC, Government of India, and the World Bank. June 2018.
- Forest Fire Disaster Management.
   National Institute of Disaster
   Management, Ministry of Home Affairs,
   Government of India. 2014.
- National Action Plan on Forest Fire.
   Forest Protection Division, MoEFCC,
   Government of India. 2018.
- Forest Fires in India: Workshop Proceedings. Pillar Human Resource Development Centre, Madurai, India. February 19 to 23, 2007.
- Operational Guideline of Forest Fire Prevention & Management Scheme.
   Forest Protection Division, Ministry of Environment, Forest & Climate Change.
   December, 2017.
- Forest Fire Alerts System 3.0. Forest Survey of India. https://fsi.nic.in/uploads/documents/tec hnical\_information\_series\_vol1\_no2.pdf and https://fsiforestfire.gov.in/.

