# Forest Fire
# Risk Mitigation and Management

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## Abstract

*Forests are expected to face significant challenges of fire incidences over the coming years. The importance of forests cannot be underestimated as our survival depends on the forests. Forest have been a natural safety net for the communities. They play a vital role in reducing the disaster risks primarily caused due to floods, landslides and cyclones by maintaining environmental stability. Forest fire has become a regular phenomenon in India, especially in the months of March to June which causes loss of forest cover, biodiversity, environment, and resources of native livelihoods. The presentstudy provides an illustrative review of the forest distribution in India, causes of forest fires, its classification, causes & impacts and initiatives taken by the government. The paper also represents suggestions which can be adopted for forest fire risk mitigation and management.*

## 1. Introduction

Forest is one of the most essential terrestrial ecosystems that help to maintain environmental balance (Jha, Jana, Negi, & Negi, 2018) of different cycles functioning in an ecosystem. The Food and Agriculture Organisation of the United Nations (FAO) defines forest as land with a tree canopy cover of more than 10 per cent and an area of more than 0.5 ha.Forestplays a vital role as a shield in combating disasters such as landslides flash floods, tsunamis and snow avalanches etc. Other than this, it also helps toreduce pollution and global carbon emissions. Forestry makes several direct contributions, to sustained human welfare such as wood, food, medicines, fodder, fibre, and organic fertilizers as well as indirect and attributable benefits such as enhancing

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soil fertility and conservation of underground water. Hundreds of millions of people around the world depend directly on forest resources for their livelihoods. Increasing climate variations and extreme weather events are somehow increasing the frequency and intensity of forest fires all around the globe. Ultimately in today's modern world, the increasing number of forest fires represents a significant hazard to forest ecosystems and human well-being. Forest fires have severe consequences for human health and wellbeing, biodiversity, and the economy.

A recent report of the Forest Survey of India indicates that a number of forest fires/ wildfires represent a significant hazard to forest ecosystems and human well-being. Around 95% of forest fires occurred due to anthropogenic activities, which can be by mistake or deliberately. More than 60% of Indian states are highly prone to forest fire events. Over the previous two decades, Andhra Pradesh, Assam, Chhattisgarh, Odisha, Maharashtra, Madhya Pradesh, Manipur, Mizoram, Nagaland, and Uttarakhand have all seen severe forest fires (Mithal, 2022) and Nearly 36% of the country's forests are prone to fires. While total forest cover has grown by 1.12%, forest fire occurrences have increased by 52%. It is observed that forest cover is increasing but forest fire is a major threat to that. According to Global Forest Watch statistics utilizing Visible Infrared Imaging Radiometer Suite (VIIRS) alerts, the nation recorded 43,031 warnings during 2020. In every summer season, some parts of the forest witness forest fire and receive a huge loss of forest cover, ecosystem, environment, and resources of native livelihoods.

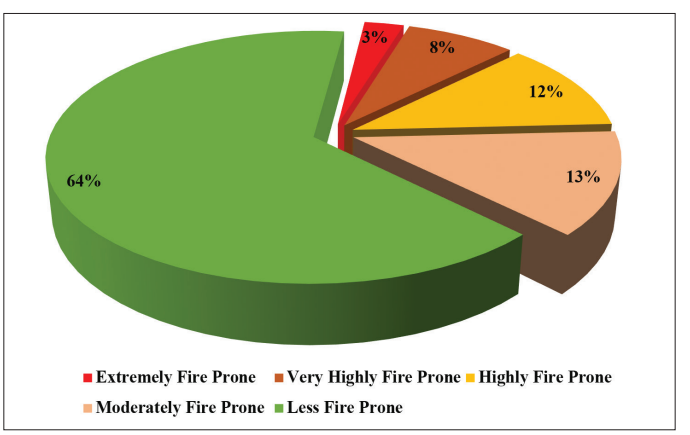



**Figure 1: Forest fire Prone areas in India**

India is having the second largest population in the world and 27% of the total population is directly or indirectly dependent on forest resources for their livelihoods and a wide range of non-timber forest products (CSE, 2012). Forest Fires cause wide-ranging adverse ecological, economic, and social impacts (V.K. Bahuguna, 1999). A few of them are mentioned below:

- Depletion of carbon sinks due to loss of timber resources and increase of carbon dioxide in the atmosphere
- Loss of water sources due to degradation of water catchment areas
- Loss of ecological balance and bio-diversity causing the extinction of many endangered species
- Soil erosion in the mountain slopes and nearby runoff zones due to the absence of tree roots.
- Forest fire causes loss of livelihood and houses for the tribals

## Methodology:

This paper is based on various literature review and secondary data which are relevant to the topic. After review of different reports, publications and research papers it has been examined and relevant information has been extracted according to the usability of the paper. Following that, the data is represented structurally for easier comprehension. A few of the approaches and mitigating measures that were assessed and are currently being used in various sections of the country are also discussed.

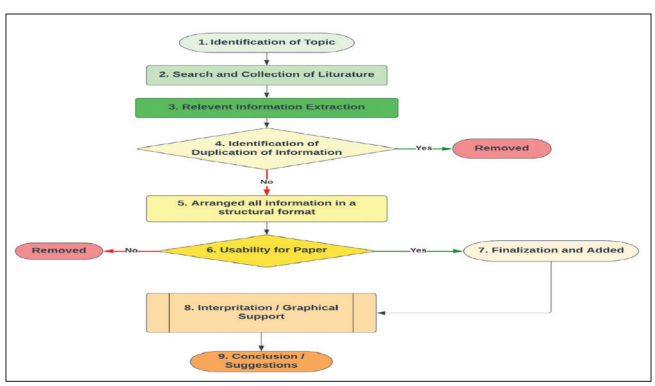



**Figure 2: Methodology**

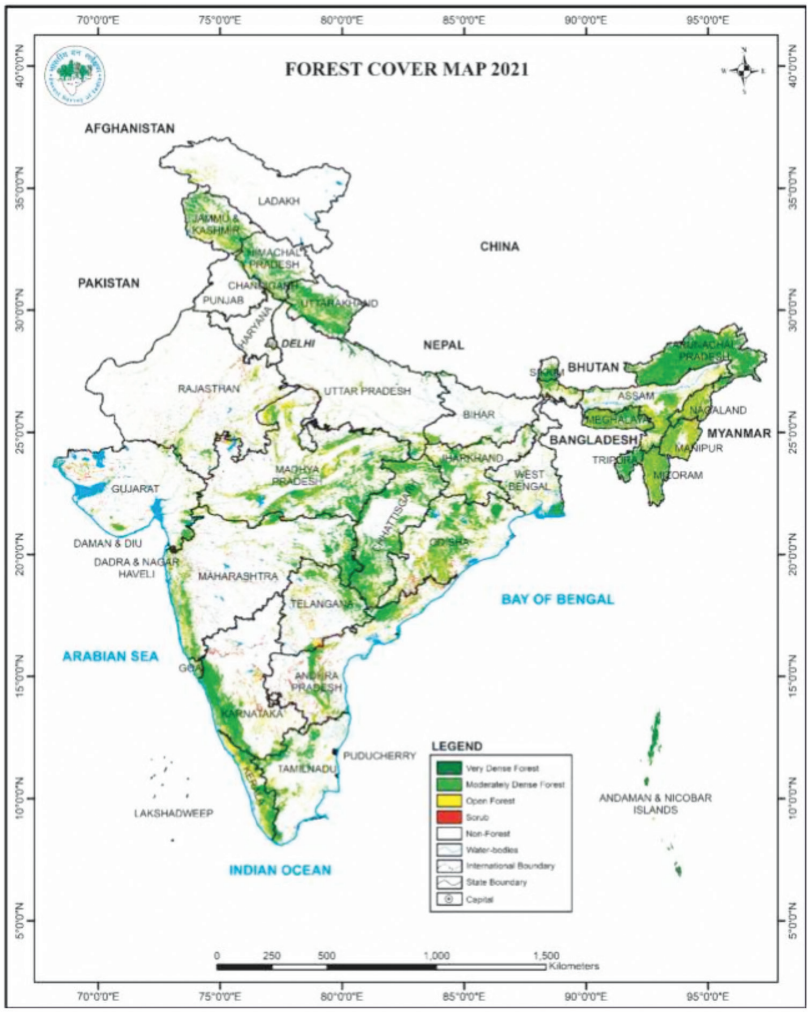
## Forest - An Essential Natural Resource:

Forest is a sophisticated ecosystem that mostly consists of trees and bushes and has a closed canopy. A wide range of life forms, including plants, mammals, birds, insects, and reptiles, among others, can be found in forests. According to the Forest Survey of India (2021), the country's forest and tree covers are spread over 80.9 million hectares or24.62 per cent of its overall geographical area.

**Table1: Forest cover in India**

| Year | Very Dense Forest Area (sq. Km.) | % of Total Area | Moderately Dense Forest Area (sq. Km.) | % of Total Area | Open Forest Area (sq. Km.) | % of Total Area | Total Area |
|---|---|---|---|---|---|---|---|
| 2003 | 51285 | 7.56 | 339279 | 50.02 | 287769 | 42.42 | 678333 |
| 2005 | 54569 | 8.06 | 332647 | 49.13 | 289872 | 42.81 | 677088 |
| 2009 | 83510 | 12.09 | 319012 | 46.17 | 288377 | 41.74 | 690899 |
| 2011 | 83471 | 12.06 | 320736 | 46.35 | 287820 | 41.59 | 692027 |
| 2013 | 83502 | 11.96 | 318745 | 45.67 | 295651 | 42.36 | 697898 |
| 2015 | 85904 | 12.24 | 315374 | 44.95 | 300395 | 42.81 | 701673 |
| 2017 | 98158 | 13.86 | 308318 | 43.53 | 301797 | 42.61 | 708273 |
| 2019 | 99278 | 13.94 | 308472 | 43.31 | 304499 | 42.75 | 712249 |
| 2021 | 99779 | 13.98 | 360890 | 50.56 | 307120 | 43.03 | 713789 |

(Source: Forest Survey of India, 2022)




Map1: (Source: India Forest Report 2021)

## Government Initiatives for Forest Fire Risk Mitigation

1. Ministry of Environment, Forest and Climate Change launched National Action Plan on Forest Fires in 2018 after consultation with different states and Union territories to minimize forest fires by informing, enabling, and empowering forest fringe communities and incentivizing them to work with the State Forest Departments (SFDs). The plan

aims to enhance the capabilities of forest personnel and institutions in fighting fires and swift recovery subsequent to fire incidences. The components of the action plan are as given below:

a. *Forest Risk Zonation and Mapping:* This is a scientific method for categorization of different areas on the basis of management interventions, allocating resources to priority areas and monitoring the effectiveness of measures to control fire risk.

b. *Community Awareness:* Every state forest department should spend a satisfactory amount of money for sensitization of the state in general and the community in particular.

c. *Framework for biomass management:* This is for SFDs which says, "Collection of dry woods, fallen pine needles should be encouraged to mitigate the surface fire." Women SHGs should also be promoted for entrepreneurship generated by forest floor biomass.

d. *Digitization of forest boundaries, promoting greater adoption* of the Forest Fire Alert System, Improving Ground-based Detection, Dedicated phone line and Monitoring and evaluation are some technological enhancement methods suggested in the framework for the action plan.

e. MoEFCC is the monitoring and policy-making agency whereas SDFs will function as action authority (National Action Plan on Forest Fires, 2018).

f. *Coordination between Disaster Management Authorities & State Forest Departments:* Forest fires of disastrous proportions already come under the purview of the **National Disaster Management Authority (NDMA)** and the Disaster Management Authorities at the state and district levels and institutional mechanisms for combating forest fires at disaster scale have already been formalized for incorporation in the **National, State, and District level disaster management plans.** The institutionalization of close coordination with relevant institutions is thus already a reality but it needs to be strengthened further. For this purpose, there are existing procedures developed by the Disaster Management Authorities at all levels and the State Forest Departments may take urgent steps to update, upgrade and integrate their systems with those of the DMAs.

g. *Mobilization of Financial Resources:* SFDs should make sufficient financial resources available at district, range and local levels well in advance of fire season with enough money for ensuring that lack of money does not hamper emergent fire management works. Mainstream forest fire management initiatives into ongoing schemes such as MNREGA and community development/welfare programs which are aimed at generating employment. Funding given for ICT promotion of the use of Information and Communication Technology (ICT) should be used for forest fire detection and protection activities.

h. *Role of the State Forest Department:* Functioning of the Crisis Management Groups for Forest Fires at all levels may be reviewed to ensure that Standard Operating Procedures (SOPs) are in place related to command and control, a compilation of availability of extent and location of resources required in case of occurrence of fires and for monitoring its spread. Other than this Organizing Joint training and mock drills, Assistance of Defense agencies should also be performed. MoEFCC may need to coordinate at the Ministerial level with the Ministry of Defense to obtain suitable directions and an escalation matrix may be developed at the state level by the SFDs in consultation with the SDMA.

2. A Centrally Sponsored Scheme on Forest Fire Prevention and Management (FPM) 2017 has been dedicated specifically to assisting the states in dealing with forest fires. At central level, forest protection division (Ministry of Environment, Forest and Climate Change) can utilise this fund and involve central institutes such as Forest Survey of India, Indian Institute of Forest management etc. At state level, the scheme will be implemented by Forest Departments of the concerned states / UT's.

3. National Disaster Management Plan (2019): Based on the recommendations of National Action Plan on Forest Fires (MoEFCC) NDMP 2019 has included a chapter on forest fire hazards. The chapter provides an action plan to be undertaken by the state and other agencies on various activities such as:

   a. Understanding Risk
   b. Inter-Agency Coordination
   c. Investing in DRR – Structural Measures
   d. Investing in DRR – Non-Structural Measures
   e. Capacity Development
   f. Climate Change Risk Management

g. **Community Involvement Practices:** Involvement of communities is extremely important for reducing the forest fire incidences and to inculcate early response. The Joint Forest Management (JFM) scheme is one of its own kind of initiative, which was initiated to involve people from the grassroots level in forest protection and conservation. Currently, India has a total of 36,165 communities spread over an area of more than 10.24 million hectares that are engaged in active JFM programs (Goldammer, et al., 2001). Such initiatives should be used for fire risk mitigation and management. Some of the possible methods and Initiatives.

1. **Van-Panchayat:** Van Panchayats in Uttarakhand is an autonomous local institution with legally demarcated village forests. They have the right to fine the person who is irresponsibly violating the rules created for the forest. During forest fire scenarios they help the department by informing them about it and also helping them in combating and controlling it.

2. **Van Prahari:** The major role of Prahari is alerting about fire information and providing necessary local support and help during the need. They are mainly appointed for the 3 months in the summer season (April-June) when there are more chances of the occurrence of forest fires. For forest people, it is a 3-month income source and they are paid for their services.

3. **Community-Level Work:** Creating a trench line by digging long drains and clearing the surface fuels such as dry leaves, grasses, woods etc. is a good method for the prevention of surface and ground forest fire. Local communities can play a vital role to help reduce the risk of forest fires.

4. **Agroforestry:** It is a long-standing technique in the North East in which agronomy, forestry, and animal husbandry will assist to reduce soil erosion, saving moisture, boosting infiltration rate, reducing evaporation from the soil, and balancing nutritional status, all of which will contribute to land remaining productive for longer (Shangpliang, 2019).

**Technological Ad-on:**

1. **Unnaed Aerial Vehicles:** The use of UAVs as a technique for forest fire prevention is a new concept eliminating the use of piloted aircraft. UAVs can generate early

warning systems and prevent wildfires to spread. (Dea, et al., 2019).UAVs also help to provide continuous and remote observation of already occurring forest fire incidents by giving elevated information such as source identification, intensity, spread capacities, and more (Sudhakar, et al., 2020). Using the UAV technology provides a reasonable alternative for fire detection, prevention, and real-time support to firefighters.

2. **Forest Fire Apps:** The already existing technologies we are using such as mobile phones, to turn into an efficient tool for forest fire prediction practice, various forest fire apps have been developed. One of the major objectives of these apps are to decrease the flight path of data to get real-time alerts, finding out the initial hotspot and its co-relation to FSI. They are designed for easy wildfire detection and also includes socio-economic and geographical perspectives.

**Table 2: Different Forest Fire Apps**

| S.No. | State | EWS for Forest Fire (App and Web Based) |
|---|---|---|
| 1 | Forest Survey of India | Fire Alert System (FAST) 3.0 |
| 2 | Uttarakhand | Forest Fire Rudraprayag |
| 3 | Meghalaya | Forrest Fire (NESAC) App |
| 4 | Orissa | Smart app |
| 6 | Madhya Pradesh | Fire Alert and Messaging System (FAMS) |
| 7 | e-Forest Fire App | Arunanchal Pradesh |

3. **Use of IoT / LoRaWAN Technology:**During any fire incident, the emission of carbon

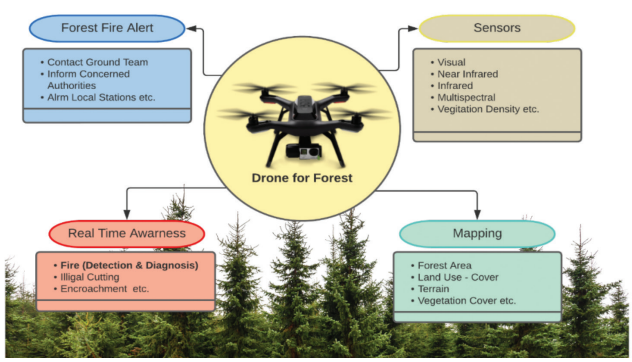



**Figure 3: Drone for Forest**

dioxide is no exception. When a forest is burning it emits a large volume of $CO_2$ and with the use of IoT $CO_2$ sensors, it is possible to calculate the amount of $CO_2$ and temperate of the air. It can check the set threshold values and inform the concerned authorities about the situation. Modern IoT devices can work alongside satellite and optical detection systems to observe a larger area by identifying infrared signatures. Most of the IoT - $CO_2$ sensor devices are powered by battery or solar energy and can provide coverage of inaccessible areas by using LoRa-WAN and satellite communications.

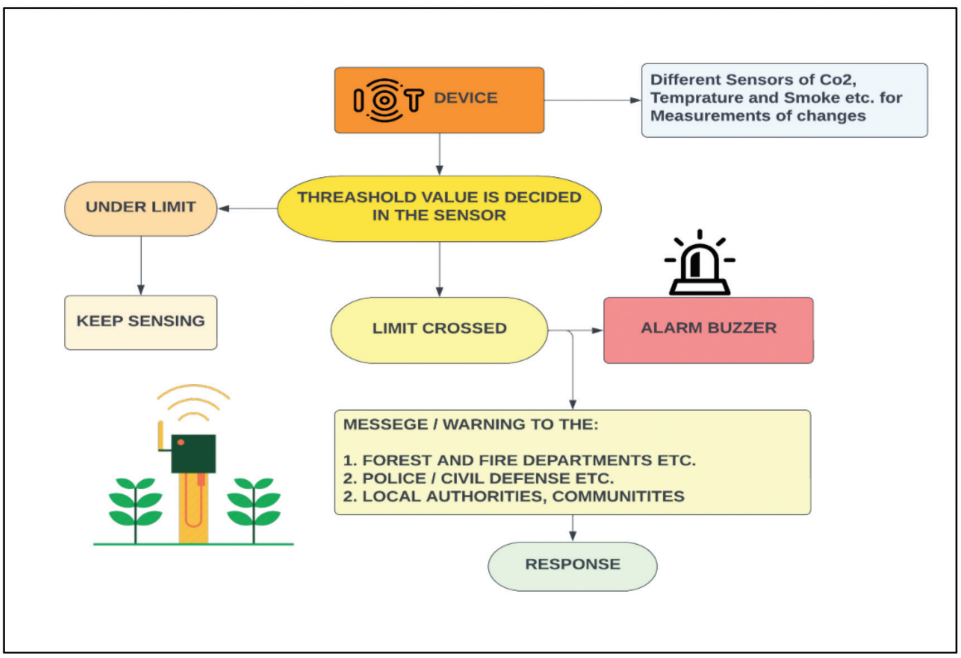



**Figure 4: Cycle of Forest Fire Prevention**

4. **Fire and Smoke Detection from Geostationary Satellites**:Fire and Smoke detection from Geostationary satellites is not new. By using the modern Himawari-8 weather satellite used by the Japan Meteorological Agency provides a higher quality of radiometric, spectral, and spatial resolution than its predecessor.

**Table 3: Satellite Detected Forest Fire in India**

| Year | MODIS Detection | SNPP-VIIRS Detection | Total Detection |
|---|---|---|---|
| 2018-2019 | 29547 | 210286 | 239833 |
| 2019-2020 | 22447 | 124473 | 146920 |
| 2020-2021 | 52785 | 345989 | 398774 |
| 2022(Till April) | 2434 | 17067 | 19,501 |

Source: https://fsi.nic.in/isfr2017/isfr-forest-fire-2017.pdf

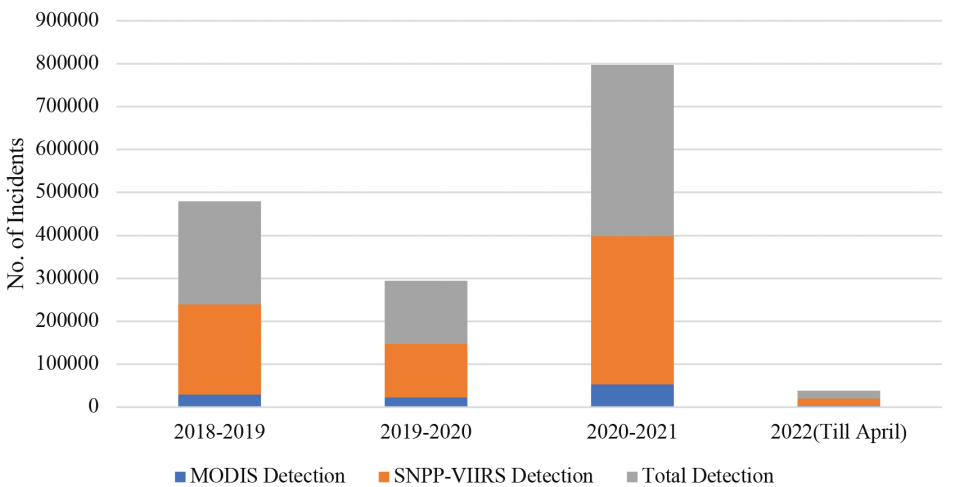



**Figure 4: Sattelite Detected Forest Fire in India**

## Suggestions for Forest Fire Risk Management:

- **In Disaster Management Phases:** Disaster Management Cycle have four basic phases i.e. Prevention, Mitigation, Response and Recovery. The strategy for Forest Fire Risk Management can be divided into these phases (refer Table 2 and Figure 5). Monitoring, Early Warning Systems using different mobile application-based solutions,geospatial tools, and electronic messages are a few new technological advancements which help us in both early warning and detection. Other than this, community awareness, the establishment of adequate forest watch stations and the creation of fire linesareother methods of preparedness and mitigation.

**Table 5: Forest Fire Risk Management in various phases**

| Sl. No. | Phases | Activities |
|---|---|---|
| 1. | Mitigation & Prevention | • Surveillance/ Watching on forest<br>• Early detection of Forest Fire<br>• Establishing preventive measures such as watchtower, equipment, community teams, etc. to control the situations<br>• Use of indigenous knowledge and methods for fire prevention<br>• DM Planning (unit level to state-level)<br>• Usage of IoT devices/GPS/Drone technology and Application based models |
| 2. | Preparedness | • Awareness generation<br>• Emergency response & logistics planning<br>• Early warning systems and communications to concerned departments, and authorities.<br>• Constitution of Community/ Volunteer teams and their training in forest fire management |
| 3. | Response | • Activation of fire control methods<br>• Manpower support for large areas of fire<br>• Affected person evacuation<br>• Search & rescue, evacuation and First-aid<br>• Shelter management<br>• Relief camp management |
| 4. | Recovery | • Afforestation Activities<br>• Managing and taking care of the forest. |


**Figure 5: Forest Fire Mitigation and Management Strategies**

Early detection of forest fire is necessary to keep it under control otherwise it would be difficult to manage. During the reaction phase, fast response units and local communities must be mobilised for assistance and cooperation. Finally, post-fire management includes human and animal rehabilitation. Activities that promote reforestation are also essential.

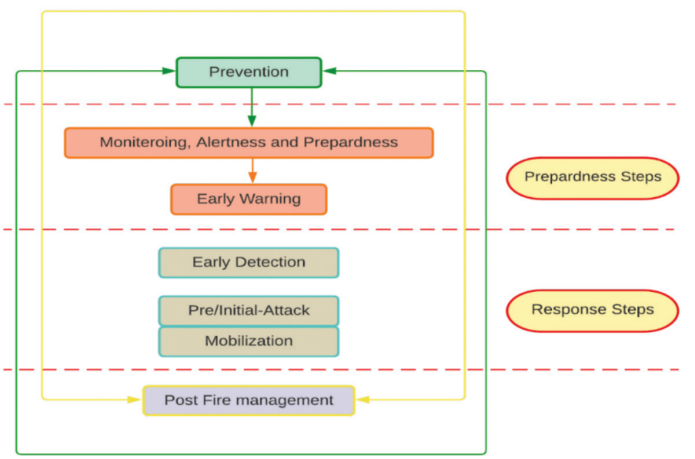



**Figure 6: Cycle of Forest Fire Risk Management**

## Conclusion

Forests are essential to our survival and also have a critical role to play in climate change. Their significance cannot be underestimated. Forest fires have a direct or indirect influence on socioeconomic and livelihood problems. Since humans are almost always to blame for a forest fire, it is imperative that those who live there or nearby should be aware of the consequences ofthe forest fire. Local communities should be encouraged to participate and promote actions associated with forest fire mitigation and management. The communities may also be rewarded financially, socially, with favouritism in government programmes, or in other ways for their assistance in fire prevention and control efforts. Other than community involvement country needs to adopt new technological innovations needed to sustain a systematic forest fire management programme. Geospatial tools, IoT devices Drones etc. can play an important role in this field. Strategic fire centres, inter-ministerial coordination, finance arrangements, human resource development, new research and development, fire management, and extension programmes are all much necessary for forest fire risk mitigation and management.

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