Combating Forest Fires

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Contents

The Forests of India

Owing to the different climatic regions, geologies, soils, etc. India has become a rich biodiversity zone. The significance of forests can be traced by following points-

- Livelihood generation
- Home for Tribal population
- Source of medicinal herbs & Gene pool
- Influence on climate and seasons
- Socio-economic as well as religious importance

Although India accounts for 1.8% of the world's forest cover, it supports more than 16% of the human population and 18% of the global cattle population.

This puts an enormous burden on the Indian forests. And further damage to the fragile ecosystem will lead to devastating effects.

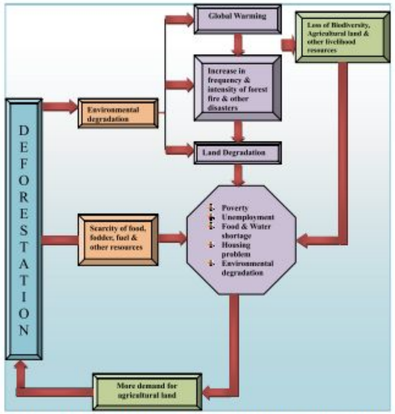


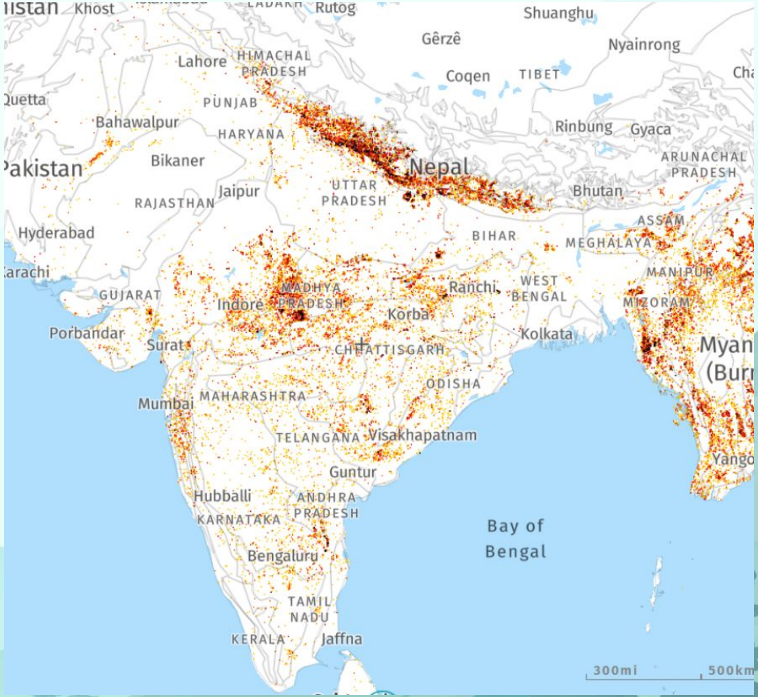
Fig.-2.4: Adverse impacts of Deforestation (Satendra, 2003)

Forest Fires

Earlier, Forest fires were a natural medium of rejuvenating the forest cycle.

However, in today's world, more than 95% of forest fires are caused either by negligence or unknowingly by human beings. The **increased Human intervention** in natural ecology has made forest fires a man-made phenomena. 43% of forest fires caused by humans are linked to imprudences (cigarette butts, garbage deposits, burning).

Though we have systems to detect Surface and Crown fires which are predicted and perceived by image processing and GIS, the Ground fires are very tough to detect as they produce no flame and little smoke. Clearly, it is an outcome of Human interventions.



Present system of Fire prediction

MODIS detection system

The current method of Identification of Forest Fires consists of monitoring forest fires across the country using a remote sensing based system : MODIS Rapid Response System. From this system, FSI collects the coordinates of the fire spots, after which FSI maps the forest fires through GIS analysis.

The coordinates are then sent to the respective State Forest Departments which further analyses the situation on ground. This method has more than 95% accuracy, though it only detects fire visible through satellite systems.

Near Real Time monitoring of forest fires

FSI has initiated Real time monitoring of forest fires in collaboration with National Remote Sensing Centre (NRSC) wherein the forest fire alerts for the active fire locations would be generated.

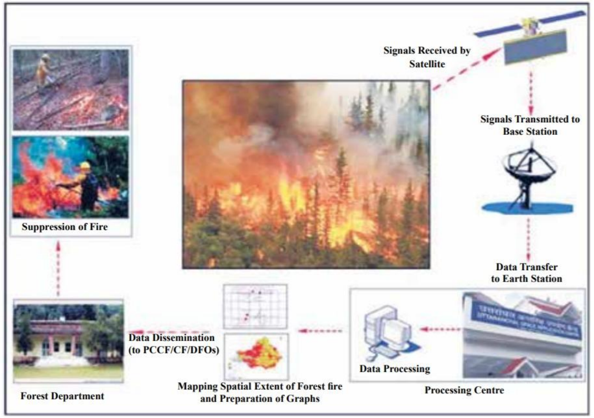


Fig.-6.1: Near Real Time monitoring of forest fires being used by FSI.

Major Drawbacks

- **Lack of appropriate policy and planning to tackle forest fire.**
- **Lack of proper institutional mechanism**
- **Emphasis on response only**
- **Lack of scientific approach to collect fire data and document it for forest fire management**
- **Not many initiatives to involve local community**
- **Poor early warning system**
- **Underreporting of data**

*"India has a **high end system** for predicting forest fires which has been restructured with time to fill the critical gaps in the system. However, the present system of dealing with this disaster can be made much more efficient.*

*The major drawbacks in the current forest management plan include **lack of well-defined institutional framework within the forest department, lack of scientific approach to collect fire data and document it for forest fire management, lack of a proper action plan for evacuation, etc.**"*

Prediction of Forest fires in India

The predication and precise evaluation of forest fire problems and decisions on solution methods can only be satisfactorily made when a fire risk zone map is plotted. For plotting the map, geographic information system (GIS) can be used effectively to combine different forest-fire-causing factors for demarcating the forest fire risk zone map.

To plot a risk map, the fire proneness of any area is assumed to depend on the following factors-

- **Vegetation Type**
- **Slope**
- **Distance from Roads**
- **Proximity to settlements**

Fire risk factor can be computed for modelling and mapping of a fire risk map. Fire risk is given as :

$$\mathbf{FR = 10F_{i=1-5} + 2H_{j=1-4} + 2R_{k=1-4} + 3S_{l=1-6}}$$

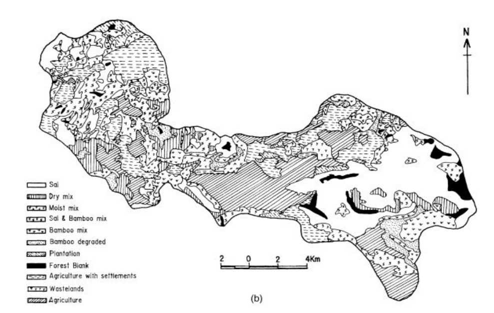
Where FR - Fire Risk , F - Vegetation Variable , H - Proximity to human Settlement
R - Road factor, S - Slope factor

Prediction of Forest fires in India

Serial no.	Variables	Class	Ratings	Fire Sensitivity
1	Vegetation Type	Very High	10	Very High
	(Weight=10)	High	8	High
		Moist	6	Medium
		Fresh-like	4	Low
		Fresh	2	Very Low
2	Habitation	Settlement	8	Very High
	(Weight=2)	<1000m corridor	7	High
		1000-2000 m	5	Medium
		2000-3000 m	2	Low
3	Road	<100 m corridor	8	Very High
	(Weight=2)	100-200m	7	High
		200-300m	5	Medium
		300-400m	3	Low
4	Slope	0–3%	2	Low
	(Weight=3)	3-5%	3	Medium
		5-10%	4	Medium
		10-15%	5	High
		15-35%	6	Very High
		>35%	10	Very High

$$FR = 10F_{i=1-5} + 2H_{j=1-4} + 2R_{k=1-4} + 3S_{l=1-6}$$

Prediction of Forest fires in India



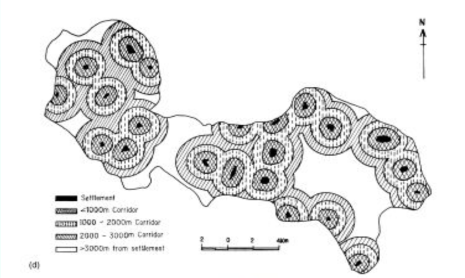
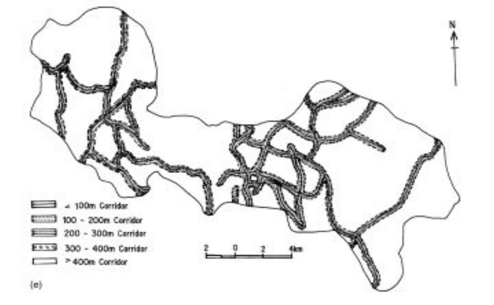
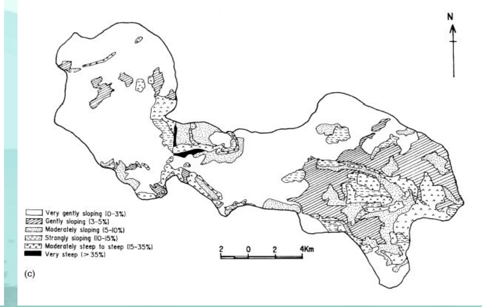


Fig. 2 (Continued).





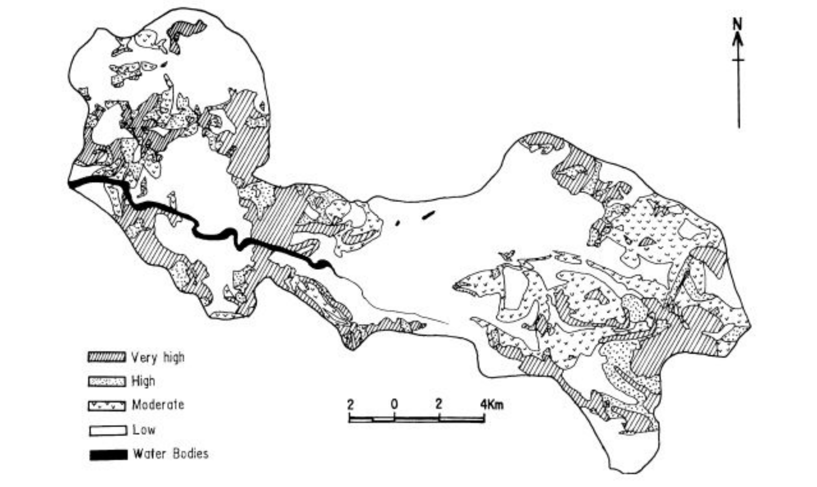


Fig. 3. Forest risk zone map of the study area.

*(Fire Risk map of **Shahdol district, MP**)*

Forest fires simulation model

Fuel Risk Zone Map

The Fuel Risk Zone map shows the different risk zones in accordance with the properties of fuel and other land features such as vegetation, aspect, slope and elevation which affect the characteristics of fuel.

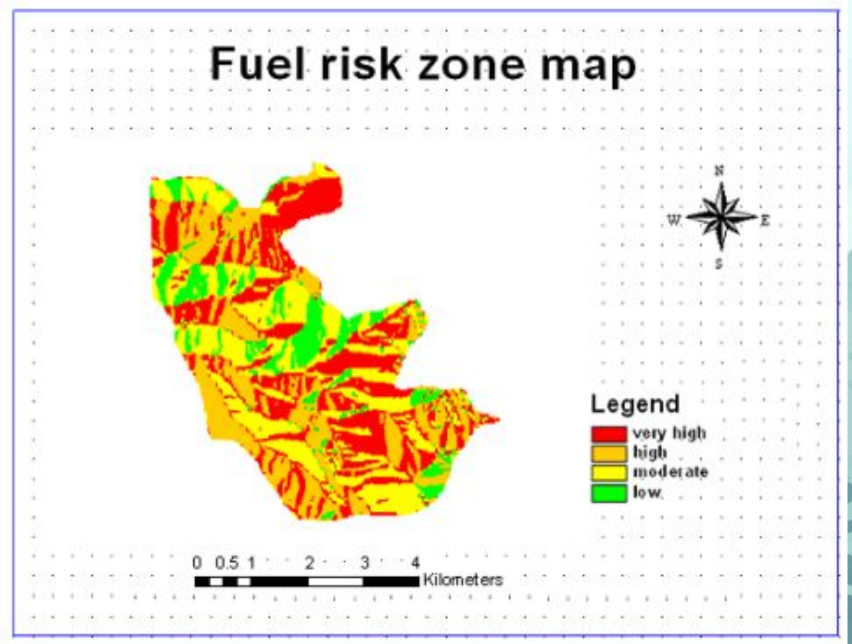
Fuel risk = F/d *0.4+S*0.3+A*0.2+E*0.1

Where F/d =Fuel type and density

S = Slope

A = Aspect

E = Elevation



*(Fuel risk map developed for the **Pauri Garhwal** region)*

Risk value	Colour	Area (Km^2)
Very high	Red	13.71
High	Orange	11.72
Moderate	Yellow	12.87
Low	Green	4.98

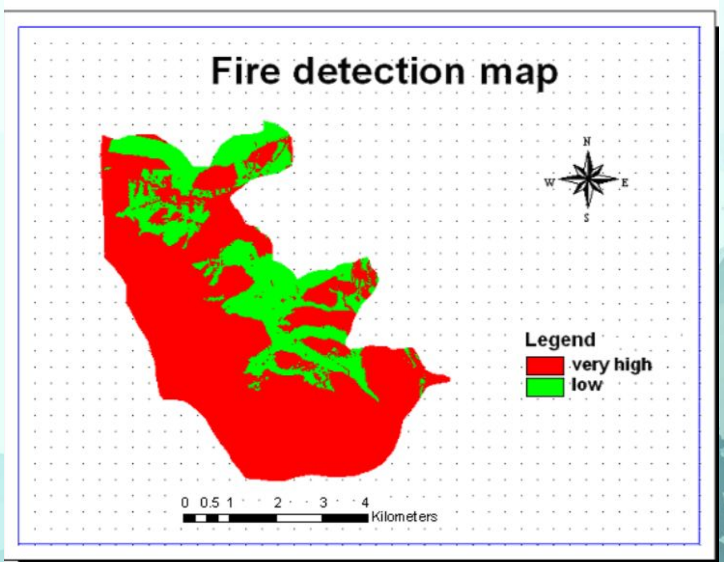
Forest fires simulation model

Fire Detection Map

Fire detection map tells us about the visibility of the fire and how easily the fire could be detected for quick response by the authorities. Therefore in this map, proximity to settlements, roads & fire stations are taken into consideration along with the elevation of the region.

Detection risk = 0.125(DEM + V) + 0.375(DEM + R) + 0.5(DEM + FS)

Where V = Village/ settlements viewshed,
R = Roads viewshed
FS = Fire station viewshed



*(Fire detection map developed for the **Pauri Garhwal** region)*

Risk value	Colour	Area (Km^2)
Very high	Red	32.38
High	Orange	
Moderate	Yellow	
Low	Green	11.19

Forest fires simulation model

Fire Response Risk Map

Response risk map takes into consideration the time taken to respond & take decisions, along with the resistance offered by different land features (manmade or natural) and also the distance of the forest fires, where both these factors depends on many features such as slope, cover type, roads and other barriers.

RS = (CO*0.57 + E *0.28 + S*0.14)

Where RS = Response Sub-model,

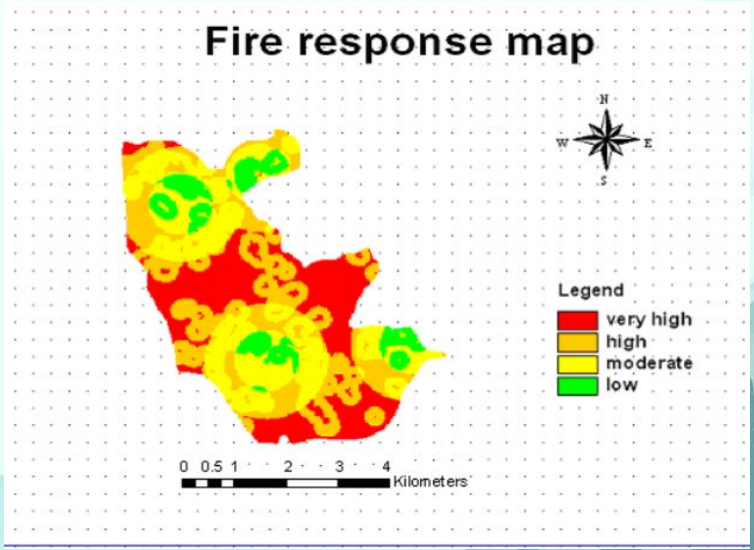
E = Elevation response, S = slope response.

CO = Cover response

CO = (N/F*0.4 + PL*0.3+ RV *0.2 + RO/V I*0.1),

N/F = Natural forests,PL = Plantation,

RO/VI = Roads/villages,RV = Rivers



(Fire Response Risk Map developed for the ***Pauri Garhwal*** *region)*

Risk value	Colour	Area (Km^2)
Very high	Red	11.66
High	Orange	13.49
Moderate	Yellow	13.61
Low	Green	4.34

Forest fires simulation model

Fire Simulated analysis

The fuel risk map, detection risk map and response risk map can be combined in an analytical manner thereby allotting appropriate weightage for each map to produce the final Fire Risk weighted parameter, which gives an analytical result regarding forest fire for a particular region; simulating various pre & post fire scenarios.

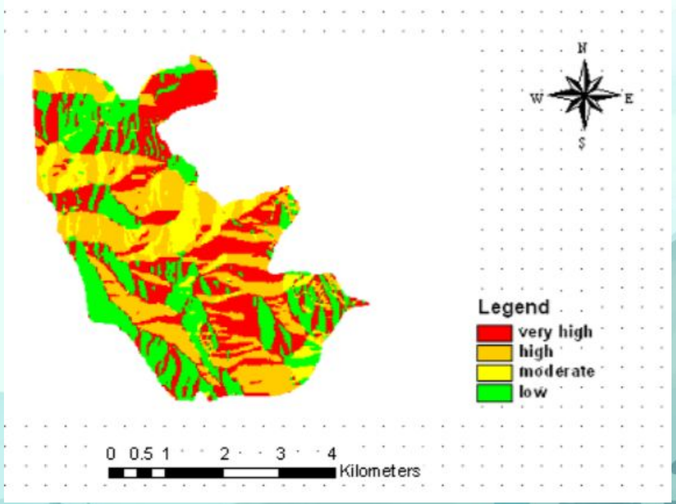
FRP = (FR *0.5+ DR * 0.375+RR *0.125)

Where, FRP = Fuel Risk Parameter

FR = Fuel risk map(Sub-model Parameter),

DR = Detection risk map(Sub-model Parameter),

RR = Response risk map(Sub-model Parameter)



(Fire risk analytical map developed for the ***Pauri Garhwal*** *region)*

Table 4-9: Risk values for various Sub-models

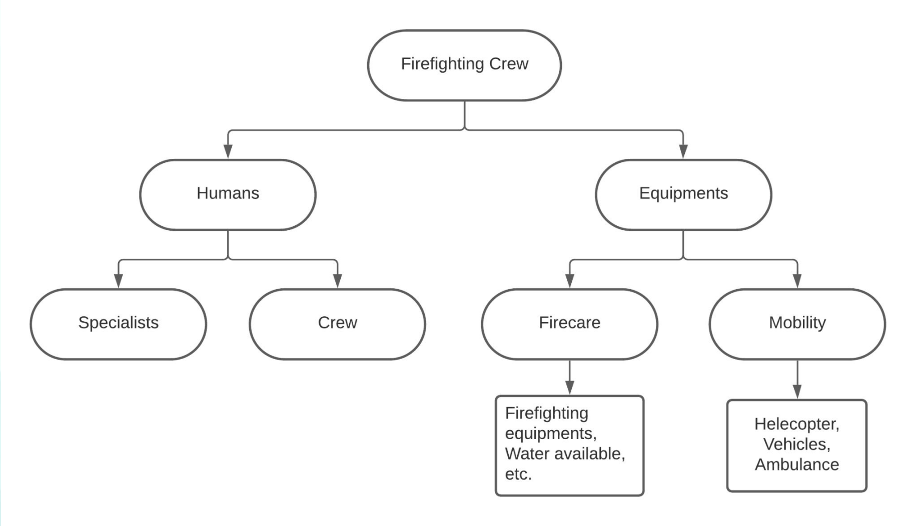
Class name	Risk value	Sub-models
Very High	4	Fuel risk Sub-model
High	3	Fire Detection Sub-model
Low	1	Fire Response Sub-model

Forest fires simulation model

Based on the prediction model, each subdivisions can be assigned with a team & inventory based on the proneness of the forest fire. An automated approach is needed to select the combat team based on efficiency and experience.In this case, Rule-based system entity structure (RUSES) needs to be followed (10.1007/978-3-540-39853-0_40).

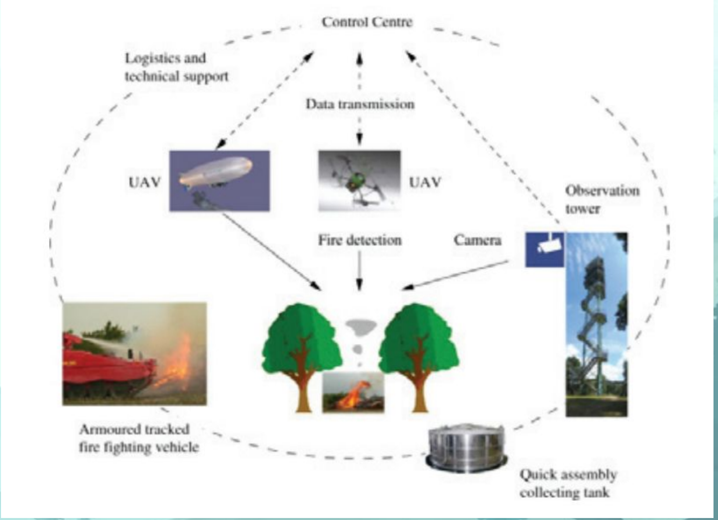
Parameters to consider while forming Incident response team and-

- Area of subdivision
- Risk index
- Mobility
- Specialization & experience



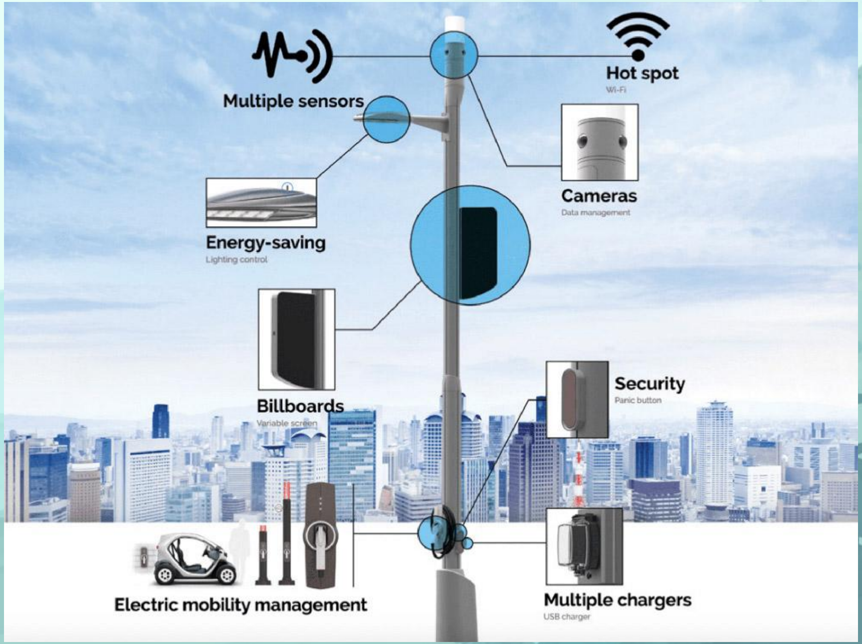
Early stage identification, Control, and Prevention

Robust identification systems can be developed to further strengthen the existing systems of identification. A more **decentralised and local** approach would be to use **drones** or remote controlled unmanned aerial vehicle (UAV) equipped with **gas sensors, microwave radiometer detectors** and **thermal cameras** to to perform **early detection** adequately, thereby reducing false alarms. After successful fire extinction, the drone can further be used as a fireguard to **reduce the risk of re-ignition of the fire**. This solution helps in meeting the problems of lack of manpower and the drones are one time costing asset and also a necessary element to strengthen the existing ecosystem of forest safety department.



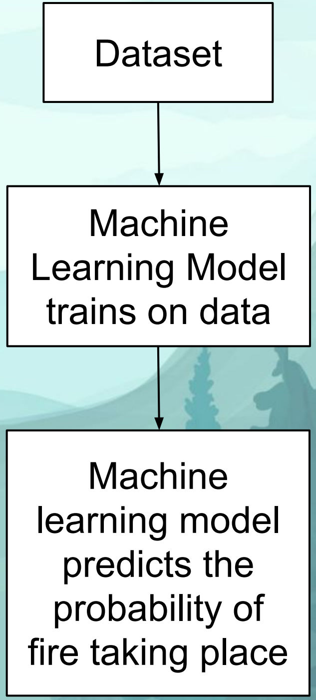
Early stage identification, Control, and Prevention

Smart Poles, equipped with **gas sensors, microwave radiometer detectors and thermal cameras**, powered by solar panels; can be installed in regions of importance or high risk zones to detect fire at a very early stage and thereby mitigating the fire risk effectively. Though the cost would be proportionately large since the Indian forest cover is very huge, it can be installed with due consideration over the regions which have a huge financial significance so as to justify the initial capital required. The major advantage of Smart pole is that it can also help us **detect** the generally undetected **ground fires** thereby justifying their advantage over the existing MODIS System.

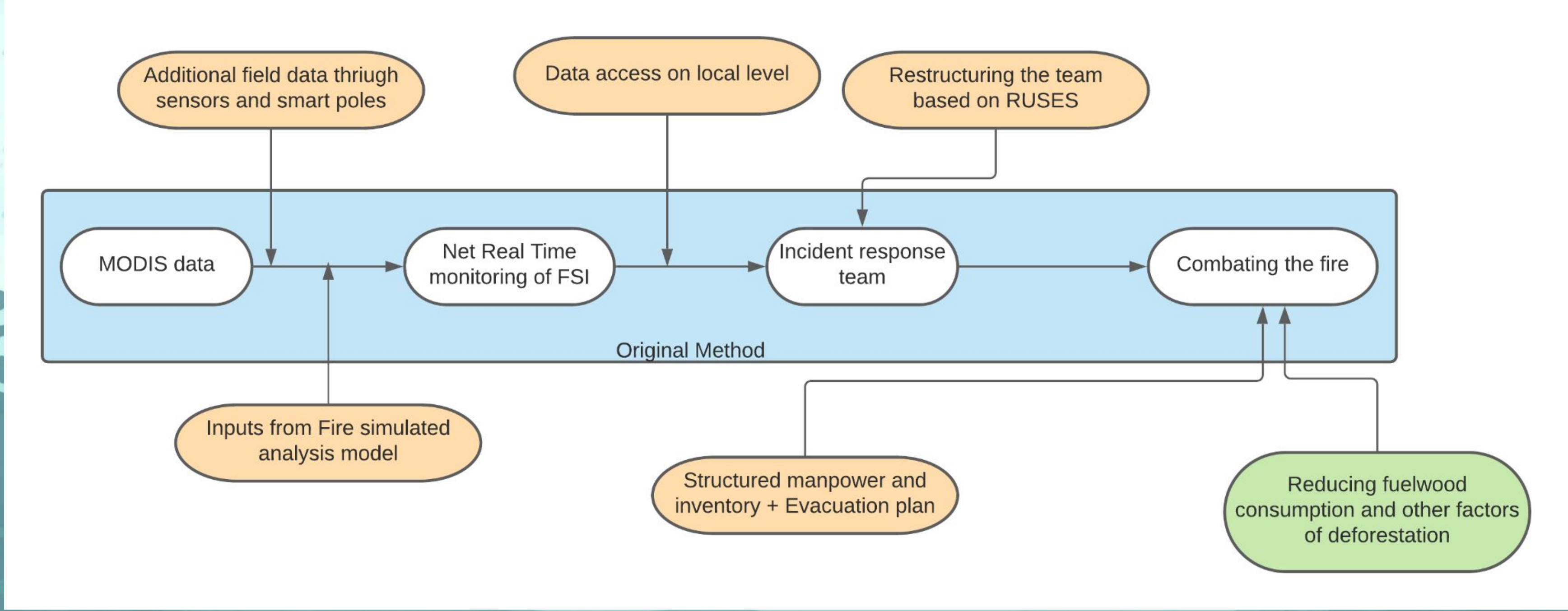


Early stage identification, Control, and Prevention

The primary factors for **detection of fire** in a particular region are : **Oxygen level, Temperature and Humidity**. By measuring these levels and further comparing it with standard data sets of a general forest, a **machine learning model** can be trained to compute the **probability of fire breakout in a particular region**. More data sets can be gathered using the sensors detecting the parameters in the region, which can further help in increasing the accuracy of the model. The sensors can be placed in the forest stations of various zones along with the smart poles of the region and thereby deploying it on a larger scale so that a list can be generated with places having maximum likelihood of fire to take place. This will help us in **smart patrolling of forests** thereby helping us effectively manage our human resource. Thus this method helps us in prevention of forest fires with an **increasing accuracy with time**.



Final Process flow



Estimate Fuelwood consumption

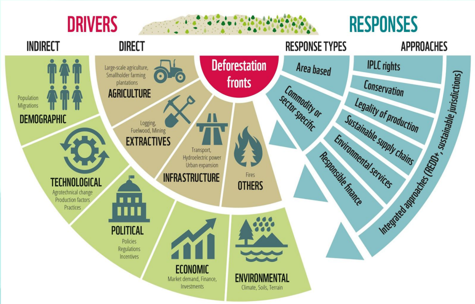
Why to study?

Disconnected with the urban lines, the rural population of forest is completely reliant on the forest resources such as fuel.

While Industrialization and private sector intervention is considered as the major force of deforestation, we often ignore minor causes like fuelwood consumption.

Over-consumption of fuelwood is the major problem our country faces right now that has led to unevenness in forest cover & change in climatic phenomena.

The disastrous after-effects affect both i.e. community(women's health, premature deaths, cancer, etc.) as well as the environment (Greenhouse gases, erosion, degradation, etc.).



54% Indian households still using firewood, cow dung as cooking fuel: Study

Fuelwood consumption led to 10% deforestation in recent years!

Estimate Fuelwood consumption

How to estimate?

To estimate the fuelwood consumption of an area, following parameters should be considered

- Social Factors (Study of Tribal society, Traditions & Customs, adaptability)
- Economic factors
  - Economic development of the area.
  - Infrastructure and connectivity.
  - Availability & feasibility of alternatives.
- Geographical factors (Topography, climate)

But isnt the date already available?

Although the bulk data of fuelwood consumption can be obtained by many agencies (CDF, NSSO, regional forest authorities etc.) and research papers (Based on regional survey), the exact pattern of consumption can be formulated by integrating above parameters in the data available.

Unlocking Public and Private Finance for the Poor

The per capita fuelwood consumption ranged from **423 kg to 1320 kg**

Tackling the Issue

What is the way forward?

Following are some measures that have to be followed to tackle the ill-effects and decrease their dependency on fuelwood-

Administrative steps-

- Introduction of clean energy alternatives.
- Heavy subsidy on LPG, biofuel, etc.
- Setting up village councils under forest division to implement the same.
- Use of advanced remote sensing for fuelwood estimation.

Policy formation-

- Incorporation of scientific data in policy formation.
- Need of custom policies

Technological steps-

- Research in clean fuel through locally available waste.
- Research in advance GIS and AI-ML integration in predicting and analysing consumption patterns.
- Development of Silviculture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Ujjwala beneficiaries back to firewood as LPG prices soar

Not only are PMUY beneficiaries unable to get the LPG cylinders refilled,


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In Sikkim villages, this special 'chulha' from Nepal helps reduce firewood use, pollution

Since 2016, World Wildlife Fund for Nature, India, has been helping rural Sikkim households install these cookstoves also trains people to make these using locally available materials.

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Tackling the Issue

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Technological steps-

- Research in clean fuel through locally available waste.
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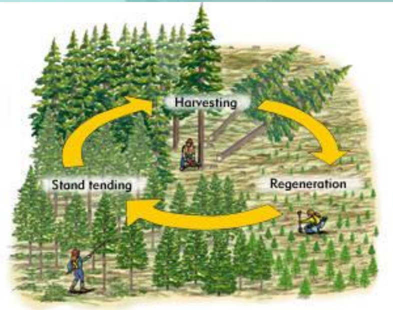

Evacuation plan for the livestock and residents of the forest

The purpose of a plan is to provide a clear direction to the emergency rescue personnel, supporting emergency management stakeholders and local residents with a subset consisting of livestock owners.

The plan has to have a predefined set of goals and their priorities set.

During an emergency, the highest body in-charge of the evacuation may closely monitor the situation and issue levels of orders so as to effectively plan out the evacuation, minimising the losses.

Evacuation plan for the livestock and residents of the forest

Following are the guidelines for a general evacuation plan in case of forest fires:

Level 1 – 'Standby'

The evacuation staff may start planning to address livestock issues. The planning will consider strategies to address responder and producer safety and animal welfare, while considering financial, social, environmental impacts of the strategies. The strategies may be shelter in place or potential livestock evacuation.

Level 2 – 'Evacuation Alert'

Due to the enormity of the task of evacuating livestock, once it's been decided that the disaster requires the evacuation of the livestock, an alert to start the evacuation may be issued to the evacuation staff which start implementing the plan of evacuation as per the strategies planned during the standby stage.

Evacuation plan for the livestock and residents of the forest

Following are the guidelines for a general evacuation plan in case of forest fires:

Level 3 – 'Evacuation Order'

To provide for the safety of first responders, residents and livestock owners, once an Evacuation Order has been executed, there will be no re-entry of residents and/or livestock owners into an Evacuated Area. Designated coordinators from the emergency staff will continue a livestock evacuation within a specified section of an evacuated area with the permission of on-site disaster in-charge.

Level 4 – 'Evacuation Alert' or 'Evacuation Order' rescind

Once the 'Evacuation Alert' or 'Evacuation Order' has been rescinded the livestock owner must within four days assume the full responsibility of the livestock and immediately make arrangements to move the livestock at the owner's expense from the temporary livestock holding area.

Conclusion

India has a very robust forest fire detection system. Due emphasis should be rather paid on fire combating, effective staff and early prevention.

Policy

- National policy should be flexible and involve regional planning
- Private sector initiative should be encouraged
- The process of formulating the national policy should be open, consultative, clearly defined, and time-bound.

Technology

- Digitization of management and administrative mechanism.
- Use of AI-ML algorithms in staff selection
- Incorporating wireless monitoring technology for field observations.

Community Engagement

- Sensitization of communities should be done to ensure that fire is used responsibly in a way that promotes forest health, while seeking to avoid damaging and out-of-control fires.
- Provision of training should extend beyond state-managed forests to community institutions in regions such as the Northeast, where communities are responsible for managing most of the forest estate.

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