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Spatial Forest Fire Management and application of contemporary technology in India

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Abstract – Forest fire is global, repetitive, seasonal phenomena occurring naturally or anthropogenic, occurring in India from November to June months. ISF report 2019 estimate more than 36% of Indian forests are prone to frequent fires, out of which 10% to extremely high. Forest management involves pre fire, during fire and post fire dimensions, structuring prevention, monitoring active, near real time and large fires, also post fire assessment. Access to Quick and reliable data plays crucial role in management process. Earlier to 1980s manual method was in practice to compile data. Prof. Dr. Satish Dhawan, then Chairman of ISRO pioneered the application of remote sensing in forest management. In June 1981, Indian Forest Survey was restructure as a nodal agency under then Ministry of environment, started new era of technology application. Since 1987 Landsat MSS, TM sensors, in 1990s IRS- IB LISS II; IC LISS III, since 2004 MODIS, addition of SNPP VIIRS sensor has emerged as a leading user of remote sensing and geographical information system in forest fire management. Fire hot spots detection at Shadnagar Earth Station NRSC, received by FSI, automatic generated alerts .KML files to SFDs and general public, VAN AGNI Portal, feedback system are contemporary practices.

Key words: ***Forest Fires, Remote sensing and GIS, Fire management.***

I. INTRODUCTION

According to Food and Agricultural (FAO) of United Nations, 'Land with tree canopy cover more than 10 percent and area more than 0.5 hectare' is forest. [1] In India legal status of the forest is taken into consideration if it is grants in revenue records. Forest area is an area recorded as forest in the government revenue records is commonly known as 'the recorded forest area'.[2] Forest provides renewable raw material as resources and energy, sustain biological diversity, mitigate climate change, conserve land and water resources, improve air quality and help alleviate poverty. Forests are affected by fire, grazing, pest and invasive species and are also the primary targets of agriculture and urban expansion.[3] 'India is ranked 10th in the world with 24.4% land area under forest and tree cover, even though it accounts for 2.4% of the world surface area and sustains the need of 17% of human and 18% of livestock population.'[4] Indian forests have witnessed strategies and policies to maintain its status since ancient times, colonial period as well post-independence period with changing priorities and management methods. Forest management in India must address biodiversity and environmental conservation assist in meeting the livelihood needs of around 350 million rural poor expand forest cover and increase productivity in accordance with national and international commitments. [5] According to Planning Commission 2001 the forest policy of India is based on the principle that sustainability is not an option but an imperative. Presently, National Forest Policy 1988 is in operation as it provides framework for national forest management prioritizing conservation of forest, meeting local needs and participation in protection, management of forest.

Since long time, forest fire has been a part of India's landscape. It plays a vital role in maintain healthy forests, recycling nutrients, helping tree species regenerate, removing invasive weeds and pathogens and maintain habitats for some wildlife.[6] But huge losses are another dimension to understand forest fires. Global forest resource assessment [GFRA] 2020 and other scientific studies have reported that the wild lands including forest areas are increasingly facing difficult fire weather conditions, extended fire seasons and large fires, influenced by climate change, which is likely to have immense cost in terms of loss of biodiversity, ecosystem services, human well- being, livelihood and national economies. [7] 26% to 29% of Global 2001- 2019 forest loss was due to fire.[8] 54.40% of forests in India are exposed to occasional fire 7.49 to moderately frequent fires and 2.40% to high incidence level while 35.71% of India's forests have not yet been exposed to fires of any real significance.[9]

Historically government agencies collected Burnt Area (BA) information from ground estimates, based on report from fire management team.[10] Countries applied different methods to collect forest fire degraded area data as well there was discontinuity in data collection. This created obstacles in analyzing data of forest fires which in turn affects strategies for sustainable management of forests. To overcome, Satellite imageries have been used since the satellite observation. Procuring data through Remote sensing, analyzing through Geographical Information System (GIS),

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bringing process towards accuracy for planning, management and meeting global targets has become the need at global level. Present work attempts to develop understanding of forest fires, its mechanism, geographical distribution, technological progress in observation and early detection of forest fires. India's strategies, planning and implementation of forest fire management.

II. METHODOLOGY AND DATA SOURCES

Beginning with an overview, the development of forest fire detection, monitoring and management, from colonial era to post independence contemporary period, gradual shifting from manual to technological method is explored. Since 1987, application of Remote Sensing and GIS, has helped in immense way to meet national and global objectives of forest conservation. Forest Survey of India, publish biannual reports regarding forest status of India. Technical reports, research, are also published to state authentic information. Details are analyzed regarding platforms, sensors and communicating up to state departments and local public to impart quick and authentic information. World Bank reports, World Agriculture Organization published reports helped in assessing the contemporary state of forests in India.

1.1 forest fires

Earths existence is since four billion years. Around 600 million years ago and during the Paleozoic, conditions for natural combustion started developing with increasing speed. Fire needs fuel, oxygen and heat to ignite and spread. [11] It is necessary to consider the thermal decomposition of forest fuel, since this stage is characterized by the release of gaseous combustible products. These products largely determine further ignition and flame combustion stages. This stage is decisive in the forest fire occurrence.[12] Wildfires are uncontrolled and unpredictable blazes. They are strengthened by weather conditions, wind and an abundance of dry fuel.[13]

Weather and Climate including temperature, precipitation, wind and atmospheric moisture are critical aspects of fire activity.[14] Weather has effect on fuel and ignitions. Fuel types partly determined by the topography elevation and aspect, and the fuel moisture content depends on the meteorological conditions.[15] Latitudinal distribution of temperature and precipitation controls type of vegetation which shapes natural regions. This vegetation is fuel, the characteristics of which plays dominant role in fire. Fuel moisture which may be the most important aspect of fuel flammability, is a function of weather. [16] Fuel gets dried, its decomposition conducts ignition which ultimately leads to fire. Forest fuel drying means the evaporation of water from it, which leads to thermal decomposition of the substance. During decomposition gaseous volatile substance that support combustion are released into the atmosphere. This is conductor of ignition process. Forest fuel ignition is considered the last stage before starting the fire.[17] Wind, the meteorological factor may be dominant for growth and spread offire.

1.2 spatial distribution of forest fires

Globally, forest fires are registered in three major type of forests- Boreal forests, Temperate- Subtropical forests and Tropical forests. Forest fire incidences vary accordingly, as climatic, vegetation characteristic differ spatially over the surface of the Earth. Climatic conditions, soil, vegetation cover and human factor vary latitudinally in these forests. Boreal forests are located mostly in the northern hemisphere between 50^0 and 65^0 high latitudes, also known as Taiga. These forests cover 17% of the Earth's land surface area as per NASA Earth Observatory, and covers 29% of world's total forest area as per Food and Agricultural Organization, which covers geographically Russia, Canada, Alaska (US) and Nordic countries Finland, Norway, Sweeden. Average precipitation less than 900mm/yr., average low temperature - 3^0 and warmest remains greater than 10^0 to less than 22^0C in this forest. Snow covered for at least five months. Slow vegetation growth is protected by permafrost. International Pannel on Climate Change (IPCC 2000) estimates that Boreal Forest covers 1.37 (10^9 ha) area, and has 559 GtC stock, of which 88 GtC is hold by vegetation and 471 GtC by soil. Terrestrial ecological systems, in which carbon is retained in live biomass, decomposing organic matter and soil, play important role in the global carbon cycle.[18] Soils are generally covered with a more or less deep organic layer which insulates the mineral soil and greatly ameliorates effects of soil heating, which even under severe burning rarely penetrate more than a few cm into mineral soil.[19] Lightning- not the human activity is the dominant cause of wild fires in Boreal forests.[20] Temperate region is in between Polar and Subtropical region, approximately 25^0 to 50^0 North and South latitudes. Principal forest types are broad leaved deciduous, broad-leaved evergreen, Coniferous and Mixed, geographically spread over North America, Central and Western Europe, North East Asia, Southern Chile, New Zealand and Mediterranean. This region has managed forests which can contain fewer species and store less carbon. Fire in this region will cause significant risk for people and nature.[21] Typical temperate forests contain about 100MgC ha^{-1} in the soil profile.[22] Climate change, Land Use change and wildland – urban interfaces are associated with forest fires. The wildland-urban interface WUI is focal area for human environment conflict, such as destruction of homes by wild fires, habitat fragmentation, introduction of exotic species and biodiversity decline.[23] Tropical Forests are located approximately $30^0$from Equator in northern and southern hemisphere. Deforestation, ground clearance for expansion of agriculture to sustain population creates pressure on Tropical Forests. All fires that occur in tropics are started by people rather than sparked by natural ignition like lightning.[24]. Fig. No.1. illustrates tree cover loss in hectares since 2001 to 2021 in Boreal,

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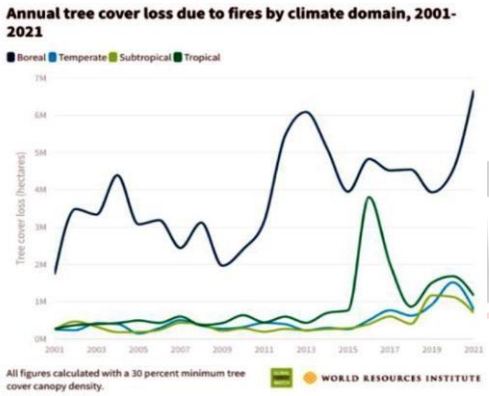
Temperate, subtropical and tropical forests. Boreal forests register highest loss of tree cover. Temperate, subtropical and tropical had below 1 million tree cover loss, but since 2013-14 tropical forest slightly increased and 2015 onwards there is huge and steep increase beyond 3 million hectares loss is indicated. Comparatively in temperate and subtropical forests, up to 2015 below 1-million-hectare loss is registered, bur onwards both the forests are showing increase. All three forests, like, tropical, temperate and subtropical are showing similar pattern of increasing fires after 2015.Aternate increasing and decreasing and trend is common feature in all types of forests. One more remarkable observation is that, when there is decreasing trend in Boreal Forest, increasing trend in rest of the three forest is seen.

Fig no.1. Annual tree cover loss due to fires by climate domain, 2001-2021



Source- World Resource Institute

1.4. spatial distribution of Indian forest fires

India is located in the tropical and subtropical region, extending 8^0 4' to 37^0 6' North latitudes and 67^0 7' to 97^0 25' East longitude. Therefore, India has mixed climate but, monsoon climate dominates. The Indian subcontinent

receives around 80% of its annual rainfall during the summer monsoon, from June to September. But, general pattern of monsoon rainfall and temperature pattern are deviating from normal. India has observed an increasing trend in precipitation extreme and heat waves attributed to global warming.[25] The annual mean, maximumand minimum temperatures averaged over India as a whole, show significant warming trend of 0.15^0C, 0.15^0C, and

0.13^0C per decade for the annual mean, minimum and maximum temperatures respectively, between 1986 and 2015. The warming is not uniform across the season, with considerably more warming in pre monsoon season March to May; (MAM) than in other seasons.[26] Warming period resembles the forest fire incidents duration. The forest fire season in the country is normally from November to June. [27] In India severe fires occur in many forest types particularly dry deciduous forests, while evergreen, semievergreen and montane temperate forests are comparatively less prone. [28]

1.5. forest fire management in India – application of Remote Sensing and GIS

1.5.1. Background- Prior to 1980's bureaucratic method was in practice to estimate forest cover. Thoughtful task regarding application of satellite Remote Sensing for forest mapping in India was pioneered at IIT Bombay Conference in December 1981. Prof. Satish Dhawan, Chairman ISRO, initiated the task, which was accomplished by the team, Dr. Parth Sarathi Roy, Prof. B. Deekshatulu, Director NRSC Dr. Y.S. Rajan, Scientific Secretory ISRO, Dr. L R A Narayana, Dr. N V Madhavan Unni, Dr. Nagraja, and Dr. SPS Kushwaha. [29] Indian Forest cover from 1972-75 and 1980-82 was assessed by Remote sensing for the first time.

During same time, one more remarkable decision was taken by the Government of India- formation of Forest Survey of India FSI. Historically, in 1965, Government of India started FAO and UNDP sponsored project 'Preinvestment' Survey of Forest Resources'(PISFR), to make out accessibility of raw material for wood industries. On recommendation by National commission of Agriculture (NCA) in 1976 to form an organization 'National Forest Survey', in June 1981 PISFR was restructured as FSI. Presently, FSI is under Ministry of Environment, Forest and Climate Change MOEFCC, the headquarter at Dehradun, with the objectives laid by the GOI, functioning as a Nodal Agency to assemble, compile, store and circulate the necessary information regarding forest. It prepares The State of Forest Reports SFR biennially, using Aerial photographs prepare Thematic Maps on 1:50000 scale, impart trainings in application of Remote Sensing and GIS technology, assisting state /UT for surveying and mapping.

Remote Sensing and GIS technology make available the data for forest fire management at three steps. First is pre forest fire stage, second is during fire incidence and third is post fire stage. Pre-Fire stage incorporate risk of fire hazard based on condition of fuel, climatic parameters, terrain characteristics etc. During fire monitor hot spots of fire location and is spread, whereas, post fire stage assesses the burnt area loss in terms of ecology, economics, livelihood. It also plans about rehabilitation. [30] Since 1987 FSI is applying Satellite data to bring more accuracy in assessing, monitoring and communicating Forests fires in India. (Table 1) Shows gradual change in technology since 1987 to 1993, LANDSAT satellite with sensor MSS and TM was in use to monitor forest fire in India, from 1995 to 2003 IRS IB, IC satellites with LISS II and LISS III sensors were in action. Since 2004, MODIS with high temporal resolution is playing important role in detection and monitoring forest fires. Since 2018, SNPP VIIRS sensor has been added, which provides more detailed and accurate information of forest fires. To communicate the information of detected fire to state departments and local people, transformations from email to WMS has been achieved.

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Table.1 Contemporary application of Remote Sensing data and Communication Technology in forest fire management in India

Year	Satellite and Sensor	Communication to state/UT/District
1987-1993	LANDSAT MSS (1987) TM (1989-1993)	
1995-2003	IRS-IB LISS II (1995-97) IRS-IC LISS III (1999-2003)	
2004	MODIS	Forest fire alert through email/fax
2008		Number of fires alert through SMS
2012		KML Files in email alerts
2016		Python script-automatic pre alert
2017		Complete automation of FFAS
2018	SNPP VIIRS sensor added	Improved feedback system of FFA
2019		Van Agni Geo Portal, FWI- alert
2020		WMS and API to state Forest Dept.
2021		

Source- FSI web site. Compiled by author.

LANDSAT – Joint mission of NASA and U S Geological Survey. (Rename of ERTS 1) MSS- Multispectral Scanner. TM- Thematic Mapper. IRS - Indian Remote Sensing Satellite. LISS- Linear Imaging Self Scanning Sensor.

MODIS - Satellite based sensor. (Moderate Resolution Imaging Spectroradiometer operating on Terra and Aqua satellites) NASA SNPP VIIRS- Visible Infrared Imaging Radiometer Suit). Onboard the Suomi National Polar Orbiting Partnership satellite platform.

Nasa/NOOA

KML - Keyhole Markup Language, stores geographic data. FFAS - Forest Fire Alert System

WMS - Web Map Series

1.5.2. Pre-fire management- Susceptibility of any area to start the process of ignition, generation of fire and its spread indicates fire risk or danger of that area.[31]. Recent past incidences of fire in such area provides more understanding of temporal situation of biotic and abiotic factors contributing in fire generation. [32] Earlier, weather-based parameters were used to detect fire risk which needed larger area network of weather stations. Remote sensing and GIS provide continues data for area, which helps effectively in generating fire risk mapping as well fire hazard mapping. Fire hazard mapping and Fire risk mapping are incorporated in pre-Fire management.

1.5.2. a. Fire hazard mapping- Vegetation mapping is foremost stage for estimating fire hazard. [33] Vegetation cover is studied from morphological (fuel, biomass, species), physiological dimensions (moisture status). At global level, Fuel maps are produced from Multispectral Coarse Resolution sensors MODIS- ASTER and Landsat TM/ETM. Hyperspectral sensors Hyperion, AVIRIS, and Sentinel 2A are also used. [34]. High resolution commercial satellites, and active sensors effectively map vegetative cover characteristics. Historical data of forest fires is also generated form RS. Recently, Unmanned Areil Vehicles UAVs with multispectral and hyperspectral sensors are gaining place in fuel mapping. In coming times, as the sensor technology will enhance by providing lighter, cheaper and smaller sensors, UAVs application may increase.

Reference no. [35] reveals fire prone forest areas based on detecting last thirteen years forest fire points FFP, from 2004 to 2017. While, India State of Forest Report 2021 assess forest fire point-based fire hazard region based on FFP from 2004 to 2021. Fire frequency over long period helps in identification of forest fire prone areas. To compute frequency, long period fire point data is superimposed over standard grid coverage of 5km

× 5km grid (NRSC), to eliminate false fires other than in forest latest forest cover map is overlapped, as well administrative boundaries of India to generate state wise data. Eastern states of India Mizoram, Tripura, Meghalaya and Manipur have extreme forest fire possibilities. Plateau region comprising western Maharashtra, southern Chhattisgarh, central Odisha, few parts of Telangana, Andhra Pradesh and Karnataka have extremely to very high forest fire prone area. Mapping forest fires hazards lay foundation for the investigating cause of fire and its impact.

1.5.2.b. Fire risk mapping – Despite of similar inputs that are used in fire hazard mapping, Fire risk mapping is different as it makes available risk data for short period like forthcoming days or weeks only. Constantly changing climatic variables and vegetation condition. Live Fuel Moisture Content LFMC variable plays crucial role in risk mapping with spatial and temporal dimensions, as it affects ignition and fire propagation. Coarse spatial Remote sensing data such as MODIS and AVHRR are used in LFMC estimation.[36] Integrating potentially contributing variables for forest fire and expressing in mathematical form is 'Index'. Canadian Forest Fire Danger Rating System CFFDRS based on Forest Weather Index FWI is applied by many countries.

Forest Survey of India since 2006 provides Forest Fire Danger Rating System FFDRS and Pre-Fire Alert System PFAS. This helps in identifying spatially vulnerable area for forest fire in immediate future to reduce risk and facilitate resource allocation and mobilization. System is analogous to the CFFDRS. Six components are taken in Weather Fire Index WFI. [37] Three values are Fuel Moisture Code, which is moisture content of the forest floor and dead organic matter. Value increases with decreasing moisture. Other three values are- fire behavior indices, fuel availability for

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combustion and frontal fire intensity. Fire danger increases values of these three components increases. FWI is satellite calibrated data, downloaded from GOES5 daily data from NASA's GFWED. Physiographic divisions of India and past forest fire archival data, forest type is superimposed by the downloaded database. Five categories of danger rating – Extreme high, very high, high, moderate and low are indicated on the state boundaries map.

Pre fire alerts are issued on every Thursday which is validated up to subsequent week. Alert helps in preparing to combat forest fires. Extreme high and very high-ranking region is informed with 'Pre fire alert' and is delivered in KML file format (compatible to Google Earth) to State Forest Departments SFD's.

1.5.3. Fire detection and monitoring – Fire detection is primal step to combat forest fires. Active forest fires detection was by primary censor AVHRR. In 1999, Tera and Aqua platforms with MODIS sensor launched, which became primary sensor at regional and global level. As its temporal resolution is high. Data is captured daily twice. Aqua MODIS 1.30 AM to PM, and Terra MODIS 10.30 AM to PM. Recently UAVs are gaining importance to detect and monitor forest fires at local level.

In India, on the ground monitoring of the forest fires will be continued essential even with the advances in Remote Sensing and alert system. To assist with fire detection and response, fire department hires seasonal fire watchers from the local community in most areas. Fire watches are paid wages in exchange of their services; however, about half noted delays or shortages. [38]

Near Real-Time Forest Fire Monitoring in India is based on MODIS (Moderate resolution Imaging Spectro- radiometer) sensor resolution (1km × 1km) on board Aqua and Terra Satellite of NASA, and SNPP- VIIRS

[39] (Suomi National Polar -Orbiting Partnership-Visible Infrared Imaging Radiometer Suit, resolution 375m

×375m), at least six times in 24 hours, detect the forest fire incidences. Fire hotspots are received at Shadnagar Earth Station (National Remote Sensing Centre) and processed using standard algorithm. Electronically these hot spots are sent to FSI headquarter Dehradun. FSI processed it further and filter to identify false fires other than forests. Subscribers are notified with alert of fire. SFDs nodal officers are also informed through e-mail. Information is uploaded on FSI website and Van Agni Geo Portal.

1.5.3.a. Large forest fire monitoring – Forest surveyof India FSI has launched the beta version of the Large Forest Fire Monitoring Program on 16/01/2019 using near real time SNPP-VIIRS data. This program is part of FAST

3.0 Version (FSI Fast Alert System).[40] To identify large fire, at least 3 VIIRS pixels need to be closely spaced. Once detected, LFF is monitored till it gets inactive, and even for additional three days after its inactive phase. Generally, LFF are named after its administrative location. FSI enables SFDs to monitor LFF to bring timely support from agencies like SDMA, NDMA, Armed Forces. LFF monitor program also incorporates developing large fire database for future policy and research. Rehabilitation of these areas is also aspect of LFF monitor program.

1.5.4. Forest survey of India- fire alert system (version 1.0 to 3.0)

1.5.4.a. Alert system includes quick and reliable signals to SDFs and general Public to initiate preventive measures at their end. [41] In 2004, FSI started providing MODIS alert to only SFDs. Since 2010, registered users at FSI website started availing facility of fire alert by SMS. Since 2012, alerts disseminated along with Google earth Compatible KML files through email. 23rd January 2017 was remarkable, as fire alerts started to send on SNPP- VIIRS sensor data. Alert system was automated, customized alerts, improved users experience and control panel for Nodal officers. 2019, is marked with more quick and reliable systemof alert. Large Forest Fire Program with

1.5.4.b. **Table no.2 FSI Technical Information System.**

2019 Version 3.0	Automated Large Forest Fire Monitoring -up to six times a day Geo Portal, State Portal WMS, jpg - Fire Alert Improved feed back
2017 Version 2.0	Fully automated Data Processing - 4 times a day Email, SMS Fire alerts Up to Beat Level
2004 to 2016 Version 1.0	Manual Data Processing - Once a day Only Text Alert District Leve

Source- FSI Technical Information System. Vol.1 no2. 2019

automatically detected and monitored. Web Map Service to SFDs, Customized alerts to 20 states at beat level and two states at range level, improved feedback and nodal officer's page. [42] Forest fire dashboard in FSI web site- The forest officers, staff, citizens can explore the information of forest fire detection, alert, monitoring, spread, status (.kml link) of fire incidence of their region on the Forest Portal of FSI on Forest Fire Monitoring Program Dashboard. [43]

1.5.4.c. FSI- forest fire geoportal- Forest Fire Geoportal VAN AGNI 1.0 is created by FSI, using opensource software viz. Map Server 7.0.7 and Geo MOOSE2.9 [44] Automation with python script, automated integration of Near Real Time Forest Fire Data and Large Forest Fire Data. It is user friendly with easy tools and search

capability. Active forest fires, large fires, fire prone areas can be visualized through maps on portal.

1.5.4.d. WMS service- Web- Map Series is completely automated, created using Open-Source Map

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Service

7.0.7 and Python. It facilitates visualization of last three days data of forest fire points on near – real time basis in three different categories with other relevant information to SFDs. [45]

1.5.4.e. Improved feedback system- When Fire alert SMS are sent, a link is also provided to registered users of FSI. Fire regarding information like, confirmation of fire incidence, area affected, associated observations, time, details of it are send by the user. The information is received by FSI, which is used as an input to conduct investigation and research in this domain. [46]

1.5.5. Post fire management- The forest fire prevention and management FFPM practice continues after fires are put off with two major approaches. 1) Post fire data collection and forest fire impact assessment. 2) restoration and rehabilitation. [47] Post Forest fire data sources incorporates field reporting and remote sensing. During peak fire season, daily and weekly updates are sent to respective state government of fire point. If fire is large and cause damage to life and property, FIR is filed in police department. Insufficient staff, difficult terrain, lack of communication infrastructure, in more remote areas, cause inaccuracy in data. Similarly due to fear of action, field reports are underreported. Even with the advent of satellite monitoring of fires, because of how incentives are aligned, field level officers may be more inclined to report back that alerts in their area are false.

[48] Due to incomplete field reporting at the national level, remote sensing is currently the best alternative for the assessment of fire affected area. FSI has done estimation of burnt area for 2014, 2015 and 2016 using higher – resolution AWiFs imageries. FSI does nationwide assessment each year toward the end of fire season. India has emerged as a leading user of satellite data for forest fire monitoring and response. Madhya Pradesh was the first to develop an SMS -based system to alert staff regarding active fire burning in their area. Satellite based detection has helped in filling the gap created by manual ground detection and feedback.[49]

Rehabilitation term implies aiding human and animal life to regain their previous normal life. While restoration is associates with ecological cycles.

1.6. Challenges with Forest Policy 2018- With the objective of 33% geographical area under forest as per National Forest Policy of India 1988, needful address to contemporary challenges is proposed in National Forest Policy 2018. Ministry of Environment, Forest and Climate Change, Government of India organized two days United Nations Forum (UNFF) on Forest Country Led Initiatives (CLI) in Forest Survey of India, at Dehradun on 26th to 28th October 2023. Guideline themes were- Forest fires and Forest Certification.

Indian Meteorology Department research state that mean annual temperature in India has increased by 0.72^0 C over the period of 1901 to 2019. Temperature and precipitation in spatial aspect is undergoing change, In the light of Climate change, FSI has mapped climate change hotspots of forest areas. To meet national and global need, Government of India has made Bonn Challenge. But on the other side, cutting trees for development projects is gaining challenge. As per Forest conservation Act 1980, if forest land is diverted for development process, twice the area has to be put under afforestation. Compensatory land should not be taken over tribals customary rights land-was in demand. In 2016-17 and 2018-19 total 69,44,608 trees across country are permitted by MoEFCC to cut. Decision making process with the aid of Remote sensing technology will help in sustainable development.

Conclusion- Forest Survey of India is the nodal agency to look after forests of India in every aspect. Since 2004, India has adopted remote sensing and geographical information system GIS to address the forest fire hazards to manage Forest fires at three levels- pre fire, during fire and post fire period. MODIS and SNPP VIIRS sensors are in use to detect, monitor and assess post fire damages. To coordinate with state forest departments, providing quick and reliable data and information about forest fire, alert system has updated consistently by the FSI. Forest fire dashboard, VAN AGNI PORTAL, WMS are user friendly and with easy tools. Training and research are provided by FSI to staff to update their skill. Timely reports help in revisiting achievements and future prospects. Locational studies like Tiger reserve forests, Corridors and Lion conservation reports are included in 2021 report. Using L-band of Synthetic Aperture Radar SAR data, capturing above ground biomass has commenced.

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