Geospatial Intelligence for a Climate Resilient and Disaster-Ready India

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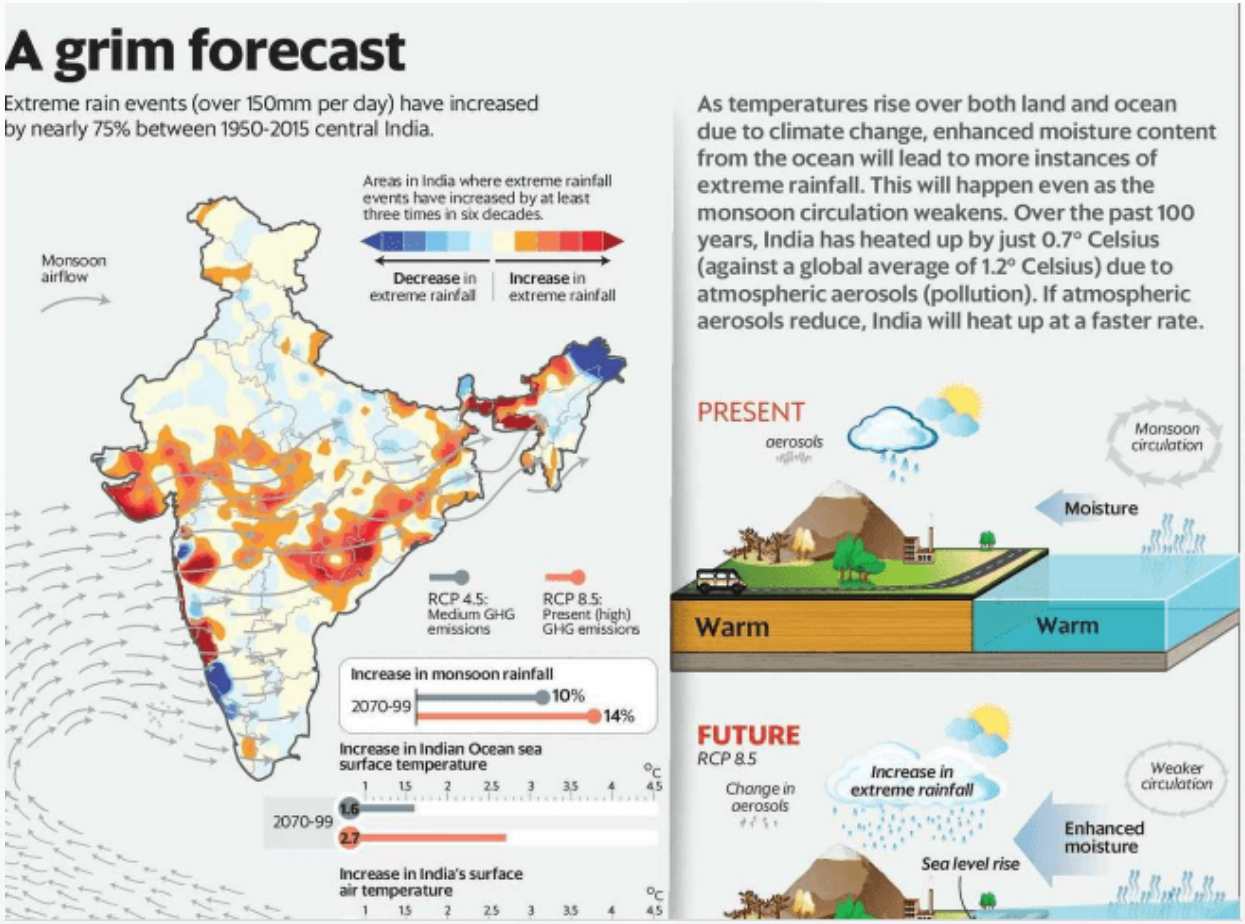
India 2047: Building a Climate-Resilient Future

- India is marching towards Viksit Bharat 2047—a future where development is not just about economic growth but also includes living in harmony with nature. The nation aims to achieve Net Zero by 2070 while becoming weather-ready and climate-resilient. *(https://www.newsonair.gov.in/)*
- **Climate Challenges:**
  - More than 80% of India's population lives in districts highly vulnerable to extreme hydro-met disasters.(CEEW)
  - Frequency and intensity of extreme climate events increased by almost 200% since 2005.(CEEW)
  - **Most Vulnerable States:** Assam, Andhra Pradesh, Maharashtra, Karnataka, and Bihar.(CEEW)
  - **Emerging Threats:** Forest fires intensifying due to rising temperatures, prolonged dry spells, and changing vegetation patterns—requiring enhanced monitoring systems and community-based fire management strategies.(National Action Plan on Climate Change)
- **Strategic Pillars:**
  - **Weather Resilience:** Mission Mausam launched January 2025 for advanced weather prediction and climate monitoring (Meteorological Technology International, January 2025)
  - **Adaptation Focus:** Four thematic areas—Agriculture & Water Security, Health Systems, Labor Productivity, Built Environment (Harvard University & MoEFCC India 2047 Symposium, March 2025)
  - **Forest & Ecosystem Protection:** Green India Mission (GIM) for targeted afforestation, ecosystem restoration, forest fire early warning systems, and community-based forest management to combat climate-induced forest fires (UNDP Climate Change Adaptation - India)
  - **Financing:** Energy transition requires ~USD 250 billion per year till 2047; adaptation needs ₹56.68 trillion (~USD 648.5 billion) till 2030 (PIB - Framework of India's Climate Finance Taxonomy, May 2025)
  - **Green Innovation:** Target: 5 million tonnes green hydrogen annually by 2030, reducing crude oil imports by 1 lakh crore/year (Wikipedia - Renewable Energy in India, September 2025)
  - **Governance:** Inter-ministerial coordination ensuring ministries don't work in silos; MoES-led teams tracking hazards and resilience of every village, town, and city (Down to Earth - Vision 2047, June 2024)

Disasters and Climate Resilience in India

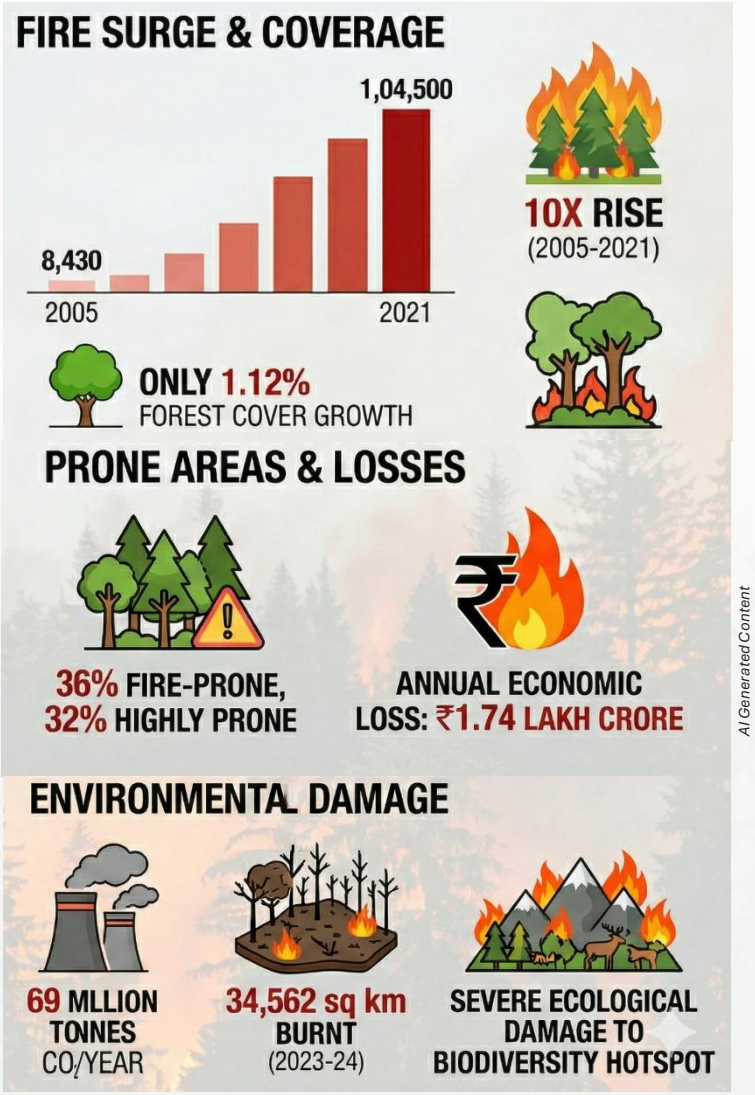
- **Climate extremes are intensifying disasters**, with rising temperatures, erratic rainfall, heatwaves, and prolonged droughts increasing India's vulnerability.
- **Forest fires have surged**, driven 95% by human actions but greatly amplified by climate change, creating a vicious cycle of warming → drying → more fires.
- **Massive CO_2 emissions from fires accelerate climate change**, weaken carbon sinks, and extend fire seasons across India.
- **Biodiversity hotspots**—Western Ghats, Himalayas, and Northeast—are severely impacted, experiencing habitat loss, species shifts, and long-term ecological degradation.
- **300 million forest-dependent people** face livelihood loss, smoke-related health risks, and resource scarcity, with annual economic losses reaching a significant cost.
- **Post-fire soil erosion increases floods and landslides**, especially in hilly regions, linking forest fires to secondary disasters.
- **Loss of vegetation alters local rainfall and microclimates**, weakening natural water regulation and increasing drought severity.
- **Forest fires threaten India's climate commitments**, reducing progress toward carbon sink targets, land restoration goals, and SDGs on climate action, biodiversity, and poverty reduction.
- **Increasing fire frequency strains disaster-response systems**, diverting resources from other major climate disasters like floods, cyclones, and drought relief.



Source: Livemint

India’s Emerging Forest Fire Challenge

- India has seen a tenfold rise in forest fire incidents over the last two decades, even though forest cover increased by only 1.12%, showing rising vulnerability.
- Forest fire events jumped sharply from 8,430 in 2005 to 1,04,500 in 2021, indicating a major escalation in fire frequency.
- In Central India, forest fire activity during 2006–2020 doubled in the traditional fire season and tripled during the non-fire season, revealing a major shift in fire behavior and climate response.
- Uttarakhand alone reported 5,315 fires between Nov 2022 and Jun 2023, making it one of India’s worst-hit states.
- Nearly 36% of India’s forest area is fire-prone, and 32% is classified as highly fire-prone, demanding intensive monitoring and management.
- The fire season is expanding, now commonly occurring from February to June, with peak fires in March–April, linked to hotter, drier pre-monsoon conditions.
- In 2019, forest fires were formally recognized as a national disaster under the National Disaster Management Plan, highlighting the growing national concern.
- India loses an estimated ₹1.74 lakh crore annually due to forest degradation and fires, impacting livelihoods, biodiversity, and ecosystem services.
- Forest fires contribute around 69 million tonnes of CO_2 every year, adding significantly to India’s greenhouse gas emissions.
- During the 2023–24 fire season, about 34,562 sq km of forest burned, accounting to over 1% of India’s geographical area.
- The Western Ghats, one of the world’s top biodiversity hotspots, is severely affected, with repeated fires causing irreversible loss of species and ecosystem functions.

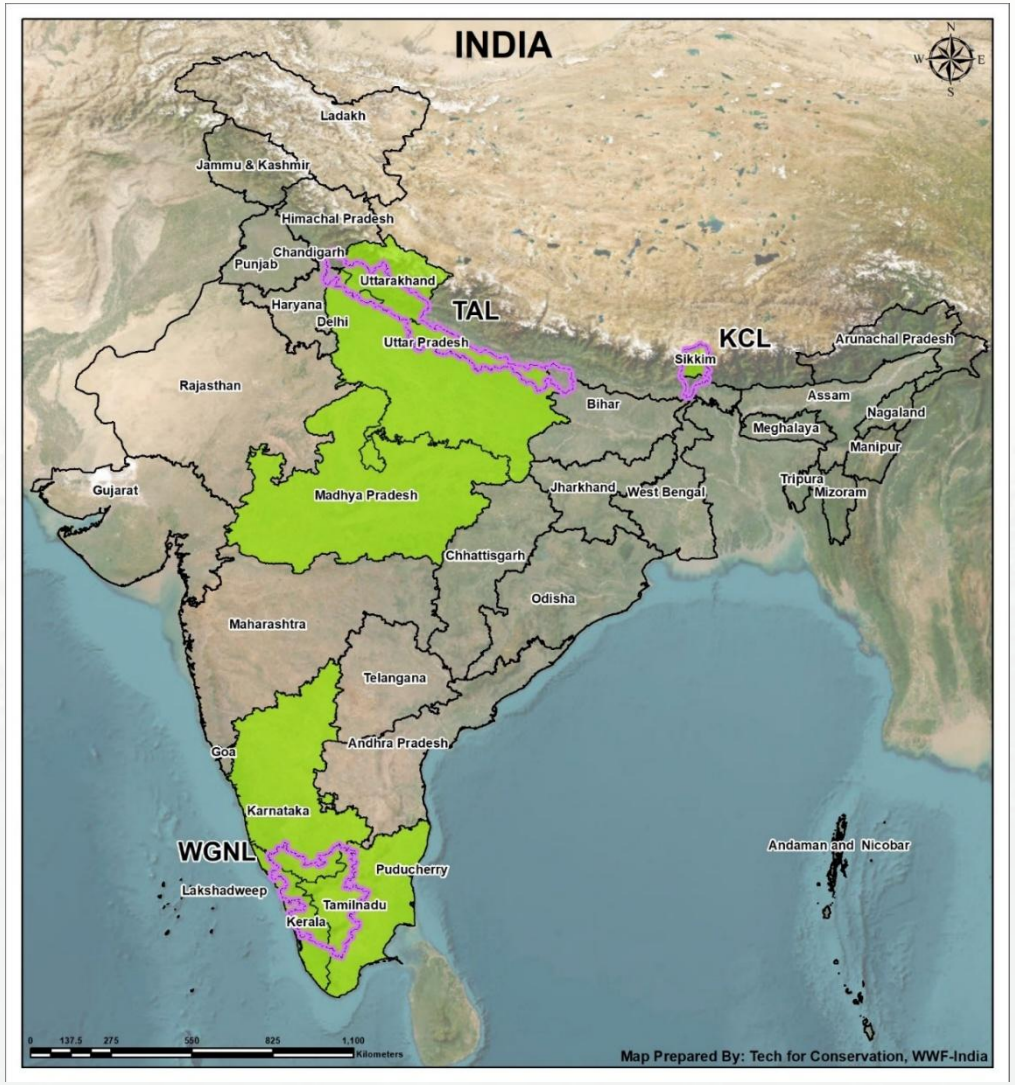


Geospatial Tools for Forest Fire Monitoring

- The Forest Survey of India (FSI) utilizes satellite data from NASA's MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite) sensors for real-time forest fire detection, mapping, and dissemination of fire warnings to forest departments and local authorities.
- Fire-prone zones in states like Madhya Pradesh and Odisha have been successfully mapped using GIS-based analysis with 85% accuracy, allowing for strategic positioning of fire-watch towers, firebreaks, and rapid response teams.
- Machine learning algorithms are now widely used to forecast fire-prone areas based on analysis of historical fire data, vegetation indices derived from satellite imagery, and climate projections, enabling predictive fire risk assessment.
- States like Tamil Nadu and Odisha have piloted drone-based forest fire monitoring technologies using thermal imaging cameras for improved monitoring and firefighting , although national-level implementation is needed.
- The FSI Fire Alert System has issued over 300,000 fire alerts since its establishment in 2015, helping local agencies respond quickly to fire incidents, with particularly successful implementation in fire-prone states like Madhya Pradesh and Odisha where fire zones were mapped with 85% accuracy.
- **Key indices used to analyze forest fire :**
  - **Normalized Burn Ratio (NBR) and Differenced NBR (dNBR):** These are used to map burn scars, vegetation loss, and assess fire severity.
  - **Normalized Difference Vegetation Index (NDVI):** This index assesses vegetation health and is used for post-fire analysis and recovery monitoring.
  - **Brightness Temperature (BT):** Derived from thermal infrared (TIR) data to detect heat anomalies, identify active fire locations, and estimate fire intensity.

Forest Fire Analysis

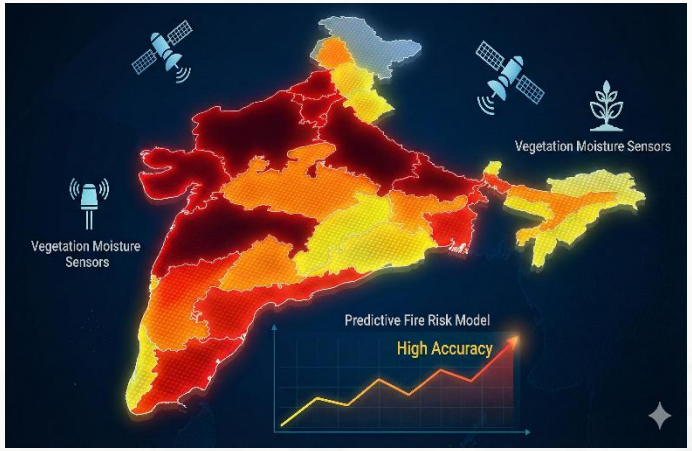
- **Objectives:**
  - ✓ Identification of spatial and temporal fire patterns using clustering and hot-spot analysis to understand recurring fire-prone zones.
  - ✓ Development of predictive AI/ML models to estimate the probability of forest fire occurrence using environmental variables and satellite-derived indices.
  - ✓ Utilizing AI models and developing a system to predict forest fires locally through images and relevant variables.
  - ✓ Engaging with key stakeholders essential for implementing on-the-ground measures to mitigate risks of forest fires.
- **Dataset used:** VIIRS generates a 375m product offering improved mapping of smaller fires and fire perimeters.
- **Parameters used:** Forest fireSlope, Aspect, Elevation, LULC, NDVI, Topographic Wetness Index, Proximity from towns and roads, Humidity, Temperature, Precipitation, Wind Speed
- **Methodology:**
  - ✓ **Space–time cube and Emerging Hotspot Analysis** to examine temporal trends and detect persistent, sporadic, or intensifying fire hotspots.
  - ✓ **Integrate satellite-derived indices** with environmental variables to analyze fire behavior and risk patterns.
  - ✓ **Train and validate machine learning models** to generate fire-risk maps and localized fire-probability predictions.

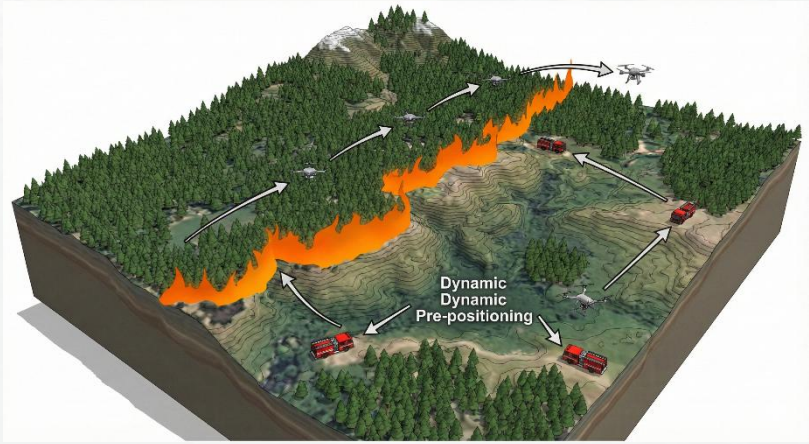


Source: Tech For Conservation, WWF India

Vision 2047: A Tech-Enabled Forest Fire Framework

- **AI-driven early warning** using real-time weather, vegetation dryness, and fuel-load data to generate high-accuracy fire risk forecasts *(Jain et al., 2020; UNDRR, 2022).*
- **Machine learning prediction models** such as Random Forest, LSTM, CNNs used to identify potential fire hotspots several days in advance *(Kumar & Roy, 2021).*
- **AI-powered fire spread simulation** models that explains movement of fires across terrain using satellite and meteorological inputs *(Finney, 1998; UNDRR, 2022).*
- **Proactive response planning** helps forest departments pre-position crews and equipment, limiting fire spread and reducing emissions *(Stephens et al., 2018).*
- **Strengthening climate resilience** by minimizing megafires, protecting carbon stocks, and supporting adaptive forest management under Vision 2047 *(Stephens et al., 2018).*
- **Digital command dashboards** unify predictions, simulations, and real-time data for faster decision-making and coordinated response *(UNDRR, 2022).*
- **Community-enabled intelligence** through mobile apps, citizen reporting, and AI-assisted risk communication strengthens last-mile resilience *(ITU WMO, 2020).*





AI Generated Content

Thank You

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