Stubble Burning Status Report: 2025

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International Forum for Environment, Sustainability and Technology

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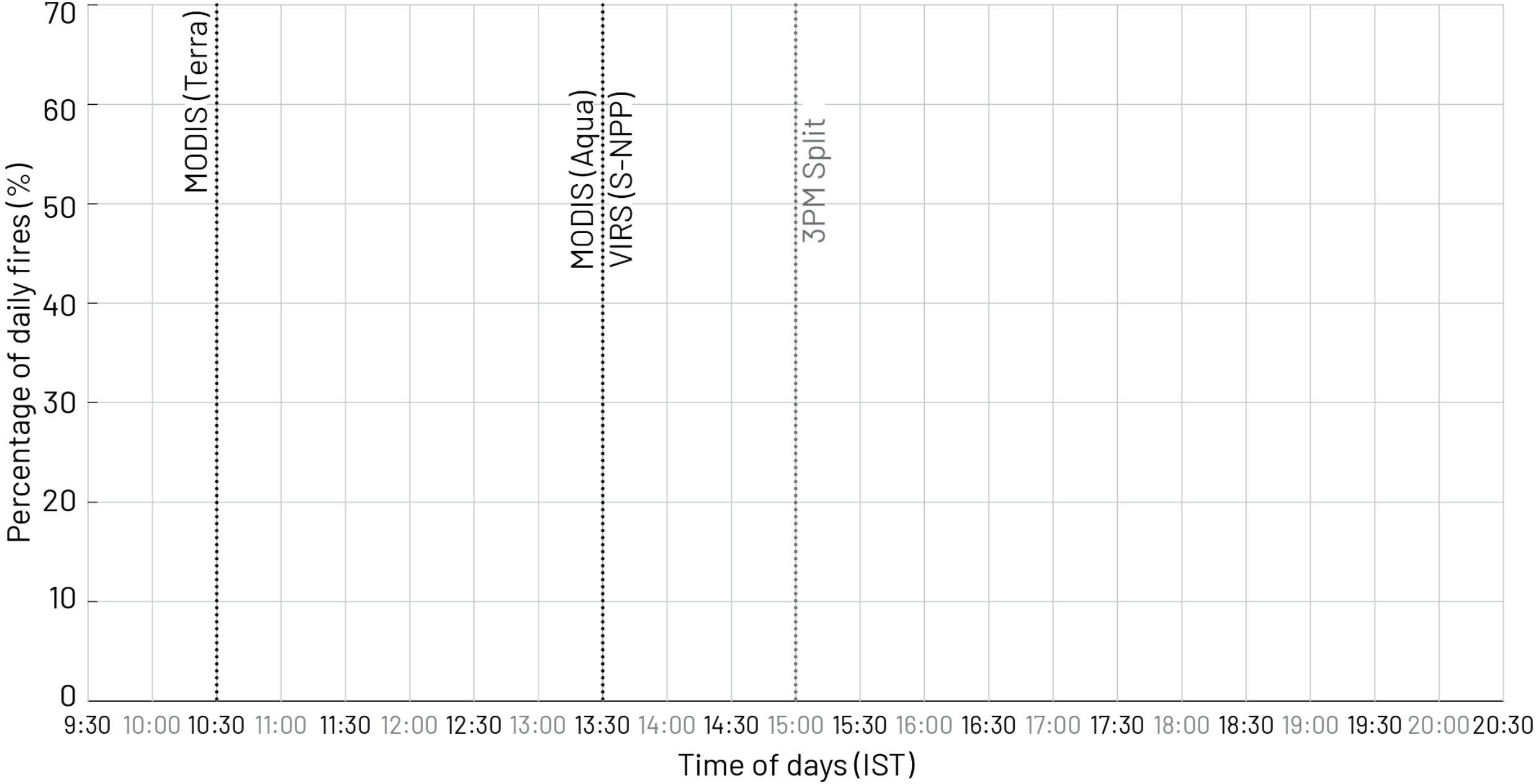
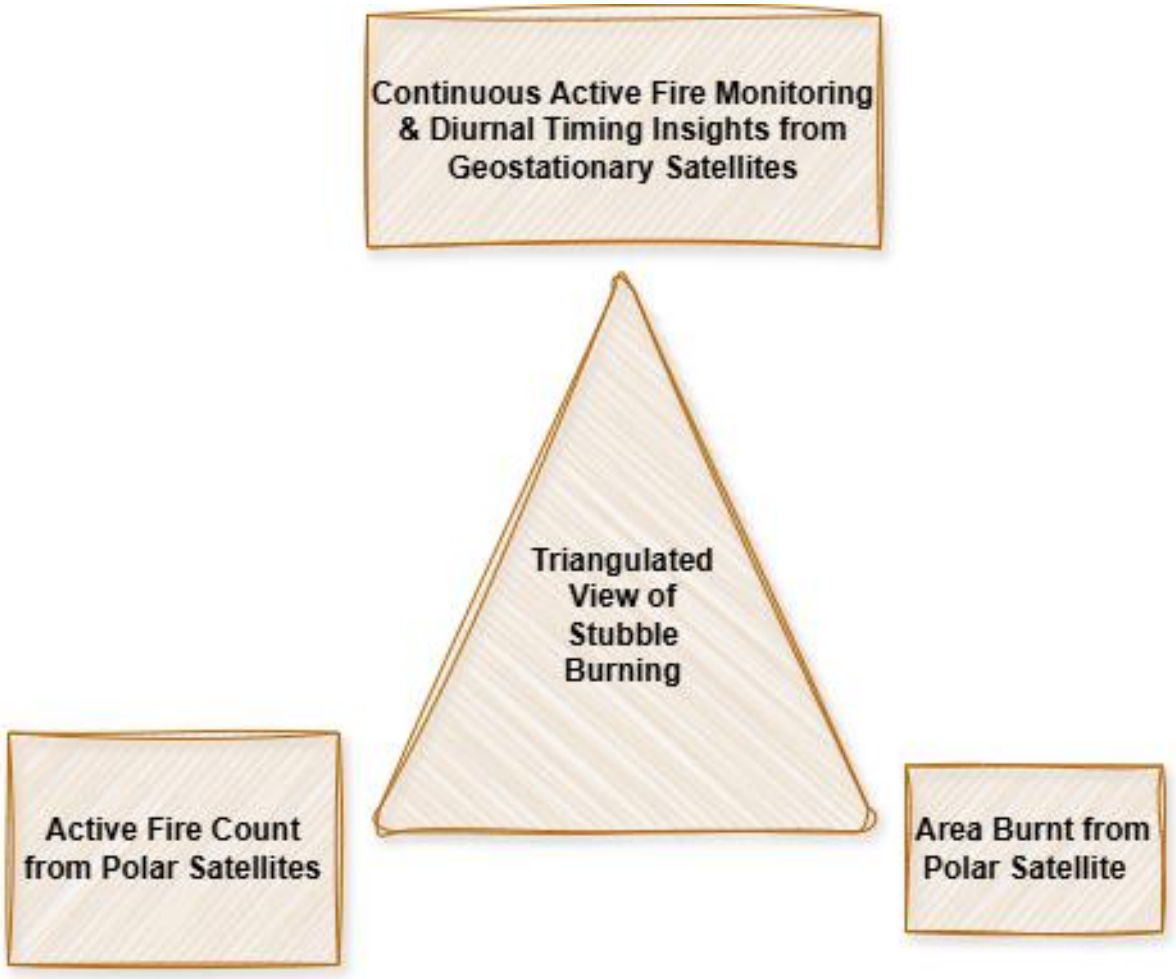
Current protocol: Active fire count from polar satellite for a limited time window

Satellite	Sensor	Satellite	Overpass Time – India	Spatial Resolution	Temporal Resolution	Variable	Data Availability for Analysis
Polar Satellite	MODIS	Terra	10:30 AM (Day)	1 km x 1 km	1 day	**Active Fire Count**	Lag of 24 hours after the observation
		Aqua	1:30 PM (Day)				
	VIIRS	Suomi-NPP	1:30 PM (Day)	375 m x 375m			
			1:30 AM (Night)				


70
60
50
40
30
20
10
0
Percentage of daily fires (%)
MODIS (Terra)
MODIS (Aqua)
VIRS (S-NPP)
3PM Split
9:30
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
19:30
20:00
20:30
Time of days (IST)

Beyond Current Protocol: Triangulated View of Stubble Burning



Full Stack of Satellites for Monitoring Stubble Burning Used In iFOREST Analysis

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	Multispectral Instrument (MSI)	**Sentinel - 2**	**10:30 AM (Day)**	**Our analysis at 100m x 100m (possible to do at 20m x 20m)**	**5 days**	**Burnt Area**	**Lag of 8 – 15 days**
Geostationary Satellite	**SEVIRI-MSG**	**Meteosat 8 Meteosat 9**	**00:00–23:45 (Day/Night)**	**~ 4 km x 4km to 6km x 6km**	**15 minutes**	**Active Fire Count and Diurnal Timing**	**Lag of 3 hours**

What Do We Track: Fire Count, Burnt Area & Burning time

Aspect	Fire Count (MODIS/VIIRS)	Burnt Area (MSI)	Diurnal Timing (SEVIRI)
What it measures	Number of active fire detections	Land area that got burned	What time the burning happened
Strengths	Quick, daily updates; good for tracking activity	Data after a lag; but more reliably measures actual burning	Shows fire count readings every 15 minutes
Limitations	Can miss small or short-lived fires; doesn't show size	May miss very small patches; depends on clear skies	Coarse resolution so can only capture big fires.
Ideal use	Monitoring trends, alerting, counting events	Measuring damage, estimating emissions contribution	To capture the timing of burning

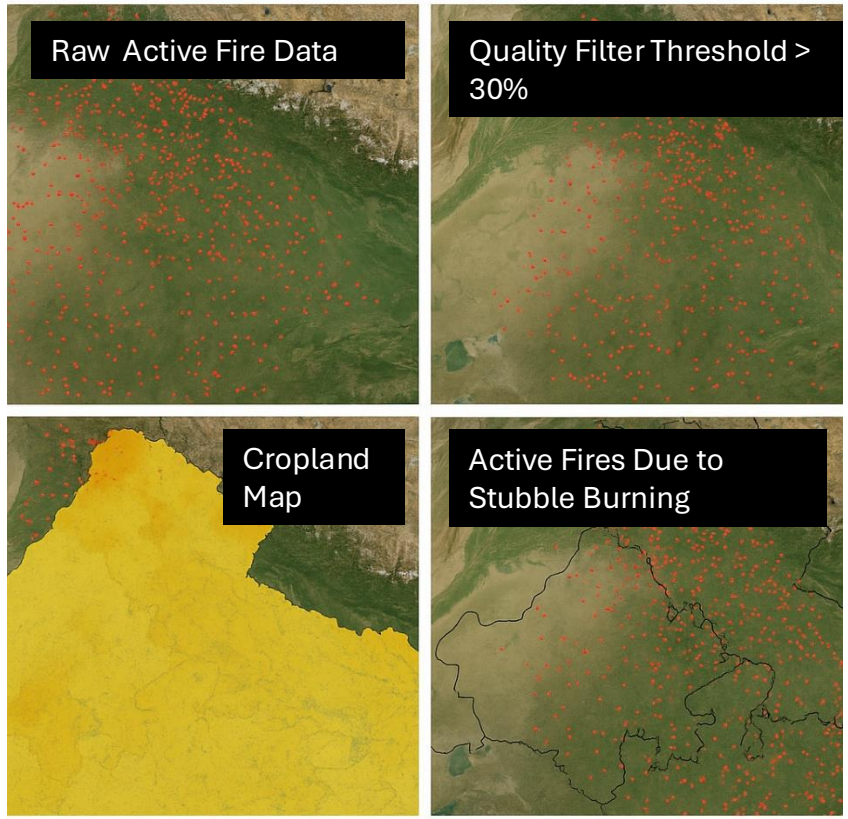
Fire count vs. Burnt Area: Why they tell different stories ?

Scenario	Fire Count	Burnt Area	What it means
Many small fires	High	Low	Lots of activity, little damage
One large fire	Low	High	Few incidents, big impact

Burnt area is often more meaningful:

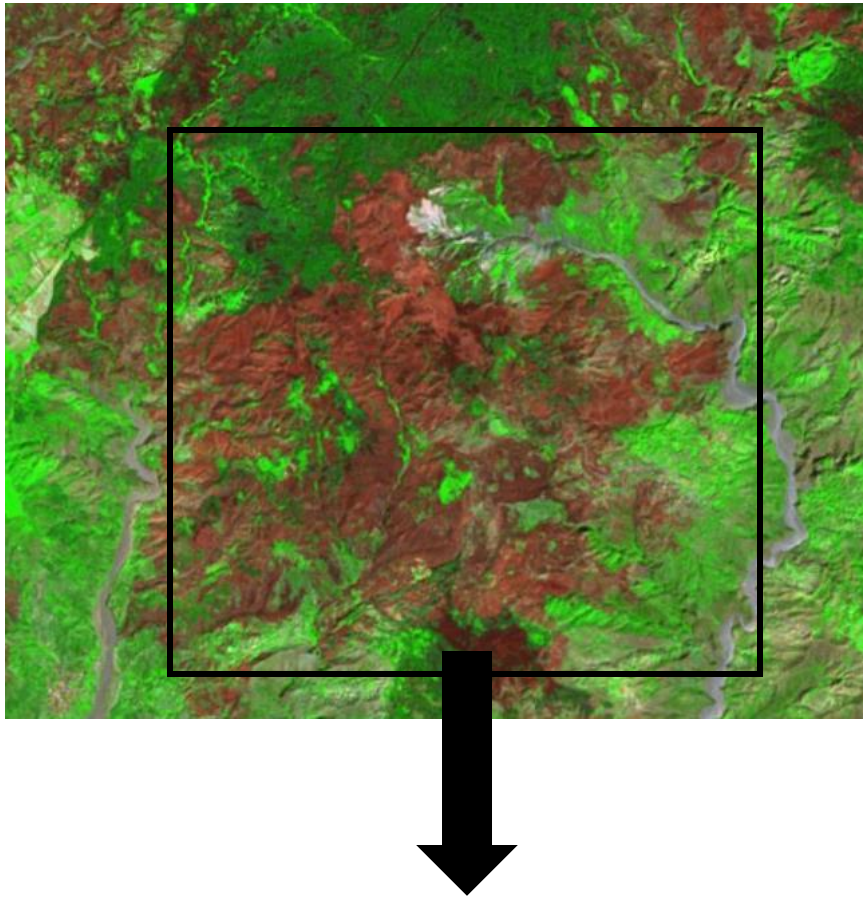
- Smoke depends on **how much land burned (a proxy for stubble);** not how many fires were seen.
- Fire count can miss small fires or fires under cloud.
- Burnt area gives a **better picture of impact**.

Methodology: Fire Count



1.Active Fire Data	We used satellite-based thermal sensors (VIIRS and MODIS) to identify “hot pixels” on the ground. Each hot pixel is counted as one fire event.
2.Quality Filter	Only high-confidence detections were retained. Any fire point with a confidence score below 30% was rejected.
3.Cropland Map	Cropland areas were delineated from the Copernicus Global Land Cover (CGLS-LC100) dataset.
4. De-duplication	A single fire can be detected multiple times within a day. We removed overlapping detections, so each fire is counted only once, giving a clean and accurate picture of daily activity.
5. Attribution to Stubble Burning	Finally, any confirmed fire detected inside cropland boundaries was attributed to stubble burning. This allows us to isolate agricultural fires from other types of burning.

Methodology: Burnt Area



Burnt Area Patch as observed in Sentinel 2

1. **Compute Pre-Fire and Post-Fire NBR**: The Normalized Burn Ratio (NBR) was calculated separately for pre-fire and post-fire images using:

$$\mathrm{NBR} = \frac{\mathrm{NIR} - \mathrm{SWIR}}{\mathrm{NIR} + \mathrm{SWIR}}$$

2. **Calculate Delta NBR (dNBR)**: Burn severity and burnt area were identified using the change in NBR between pre-fire and post-fire dates:

$$\mathrm{dNBR} = \mathrm{NBR}_{\text{pre-fire}} - \mathrm{NBR}_{\text{post-fire}}$$

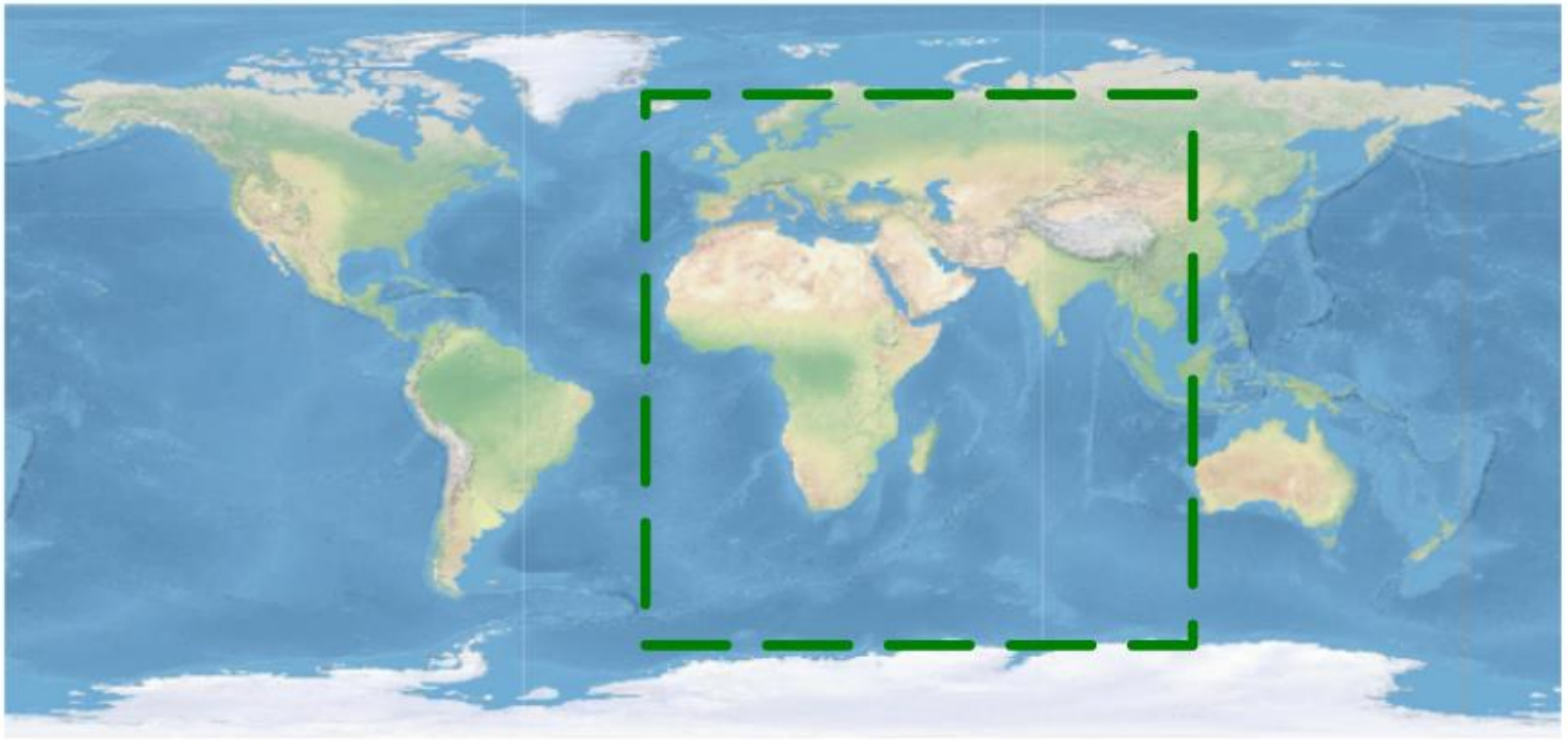
3. **Temporal Analysis**: To capture continuous burning activity, NBR values were computed for multiple time intervals. For each interval *i*:

$$\mathrm{dNBR}_i = \mathrm{NBR}_{i-1} - \mathrm{NBR}_i$$

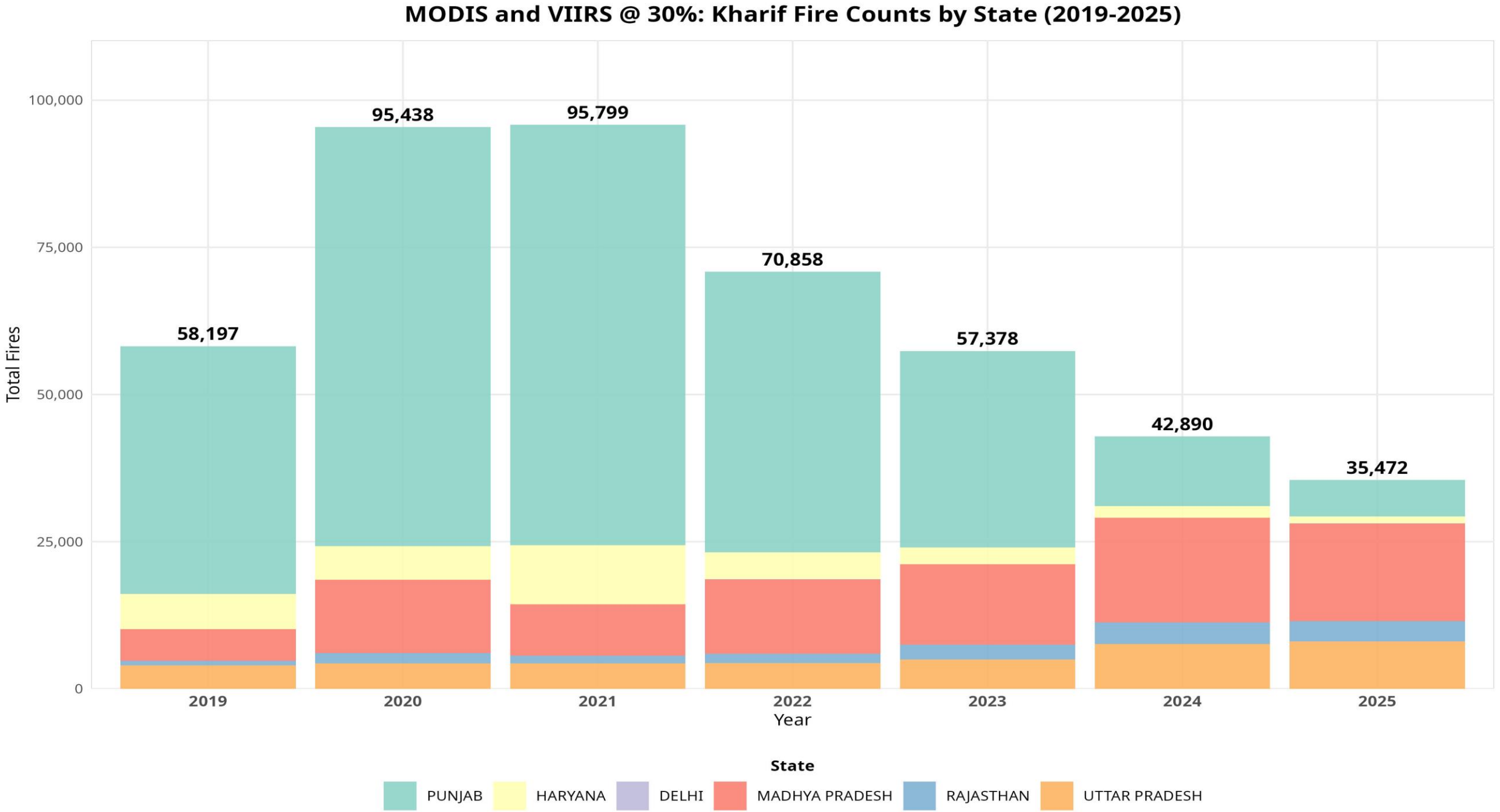
Diurnal Timing: Geostationary Satellite

Feature	Specification
Satellite	Meteosat-9 (MSG-2), Meteosat-8 (before 2022)
Product	Active Fire Monitoring (FIRC-IODC) (Indian Ocean Data Coverage)
Orbital Position	45.5° East
Sensor	SEVIRI (Channel IR3.9 used for thermal detection)
Pixel Size	3 km (Nadir) / **~4 km to 6 km (India)**
Update Rate	15 Minutes
Data Format	CAP (XML inside .nat)

SEVIRI – MSG Field of View (FOV): How much of the Earth a satellite can “see” at one time?

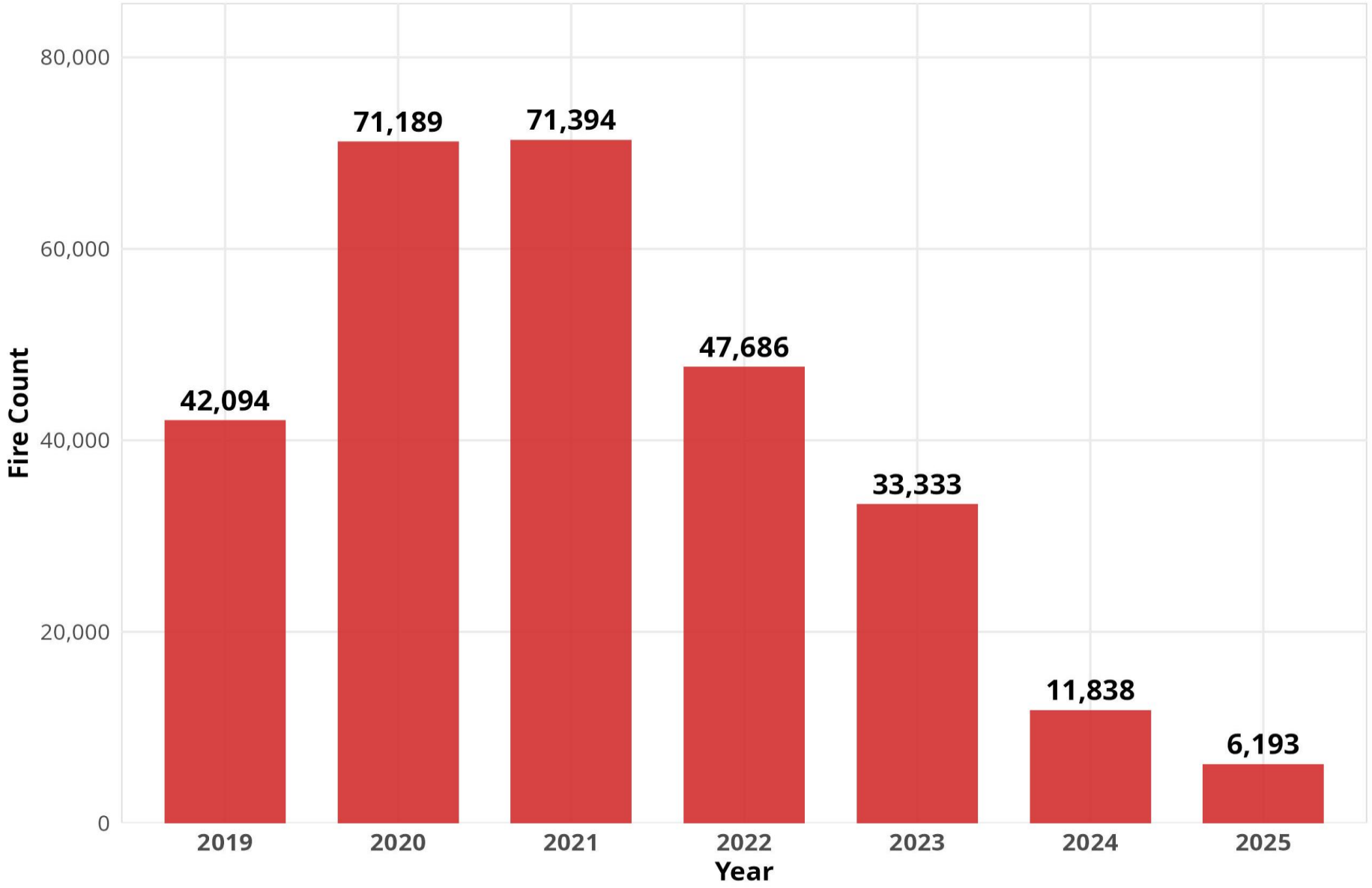


Active Fire Count


MODIS and VIIRS @ 30%: Kharif Fire Counts by State (2019-2025)
Total Fires
100,000
75,000
50,000
25,000
0
58,197
95,438
95,799
70,858
57,378
42,890
35,472
2019
2020
2021
2022
2023
2024
2025
Year
State
PUNJAB
HARYANA
DELHI
MADHYA PRADESH
RAJASTHAN
UTTAR PRADESH

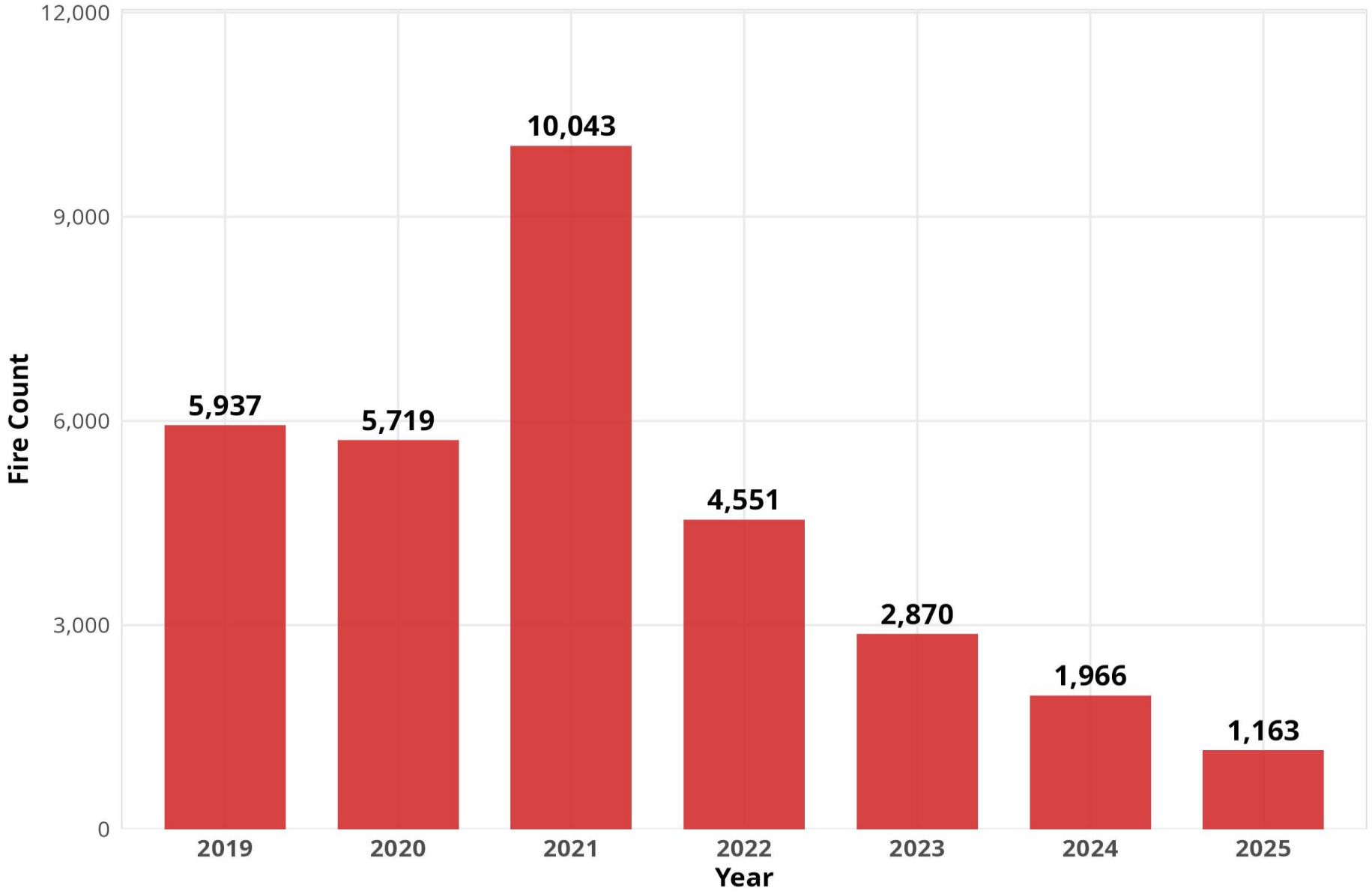
MODIS and VIIRS @ 30%: PUNJAB

Kharif fires (2019-2025) = 283,727



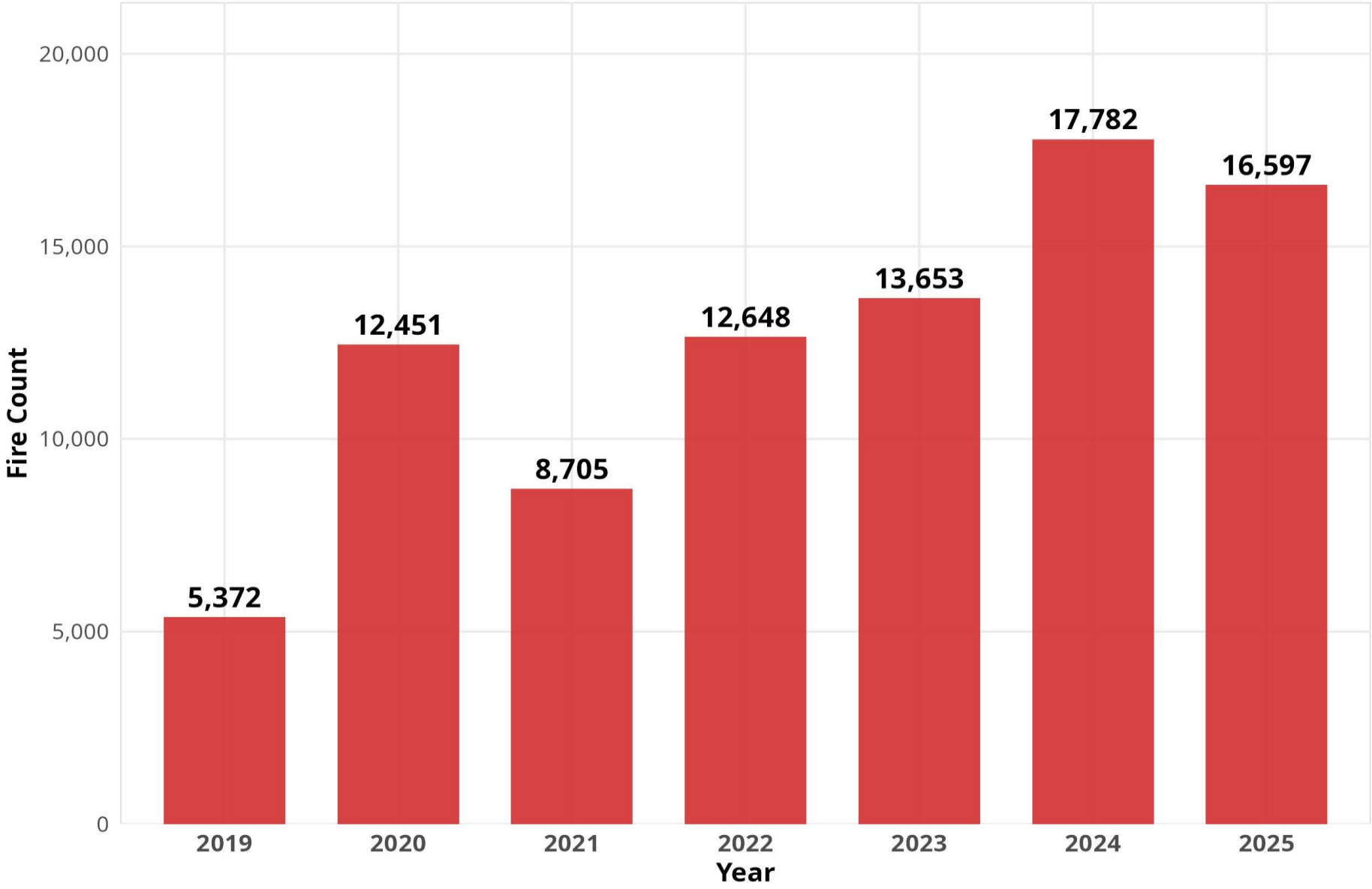
MODIS and VIIRS @ 30%: HARYANA

Kharif fires (2019-2025) = 32,249



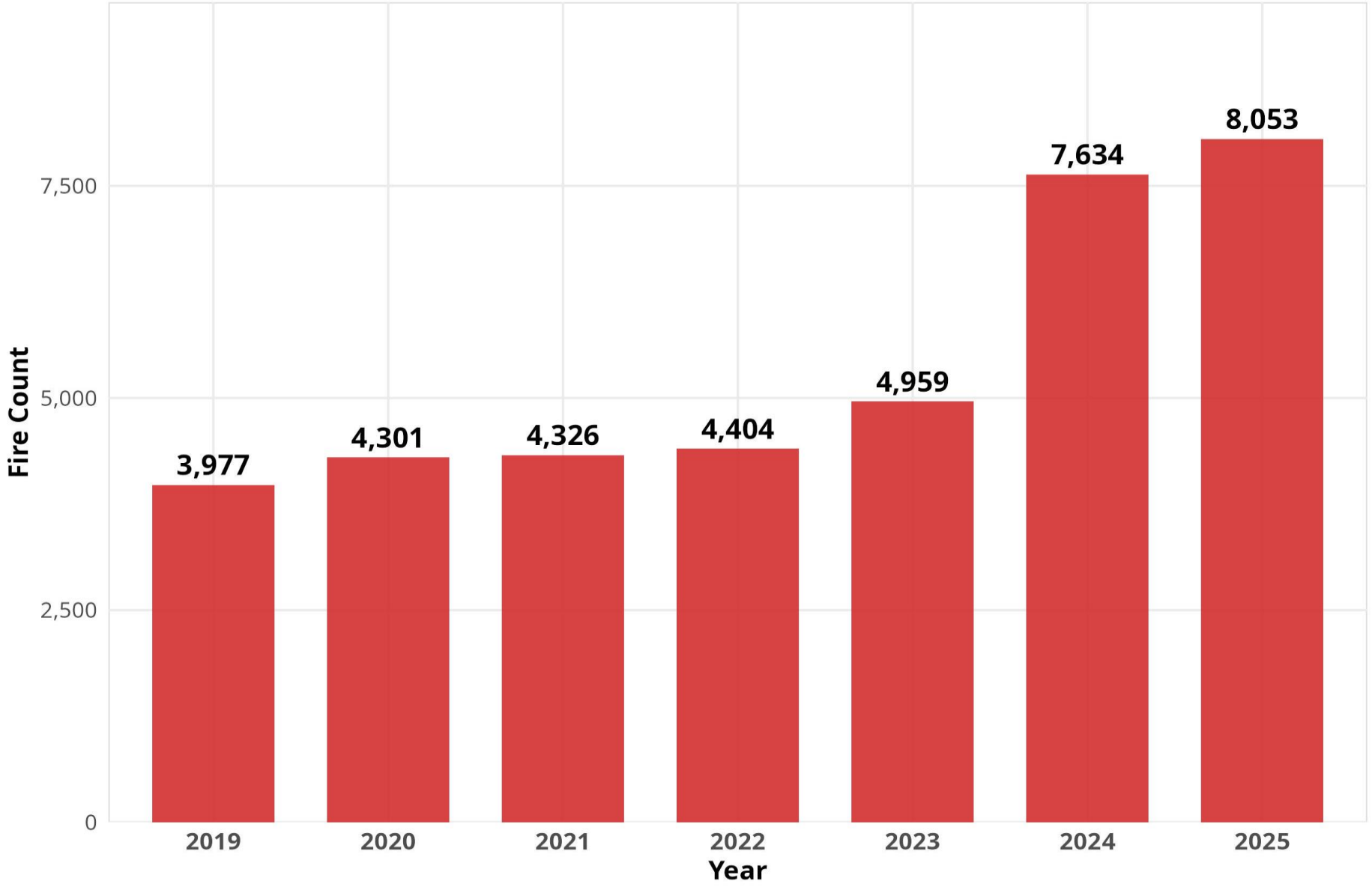
MODIS and VIIRS @ 30%: MADHYA PRADESH

Kharif fires (2019-2025) = 87,208



MODIS and VIIRS @ 30%: UTTAR PRADESH

Kharif fires (2019-2025) = 37,654



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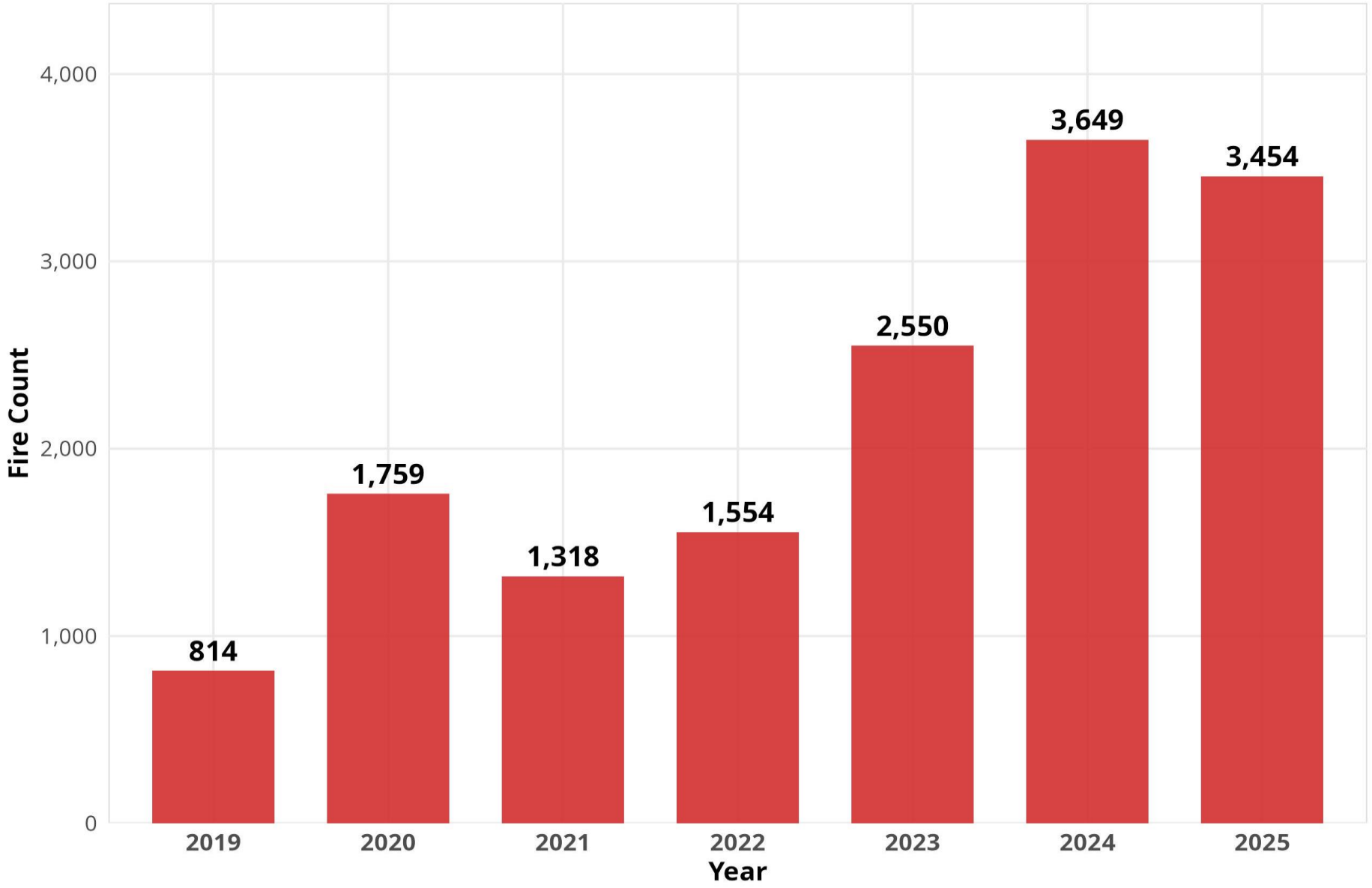
MODIS and VIIRS @ 30%: RAJASTHAN

Kharif fires (2019-2025) = 15,098

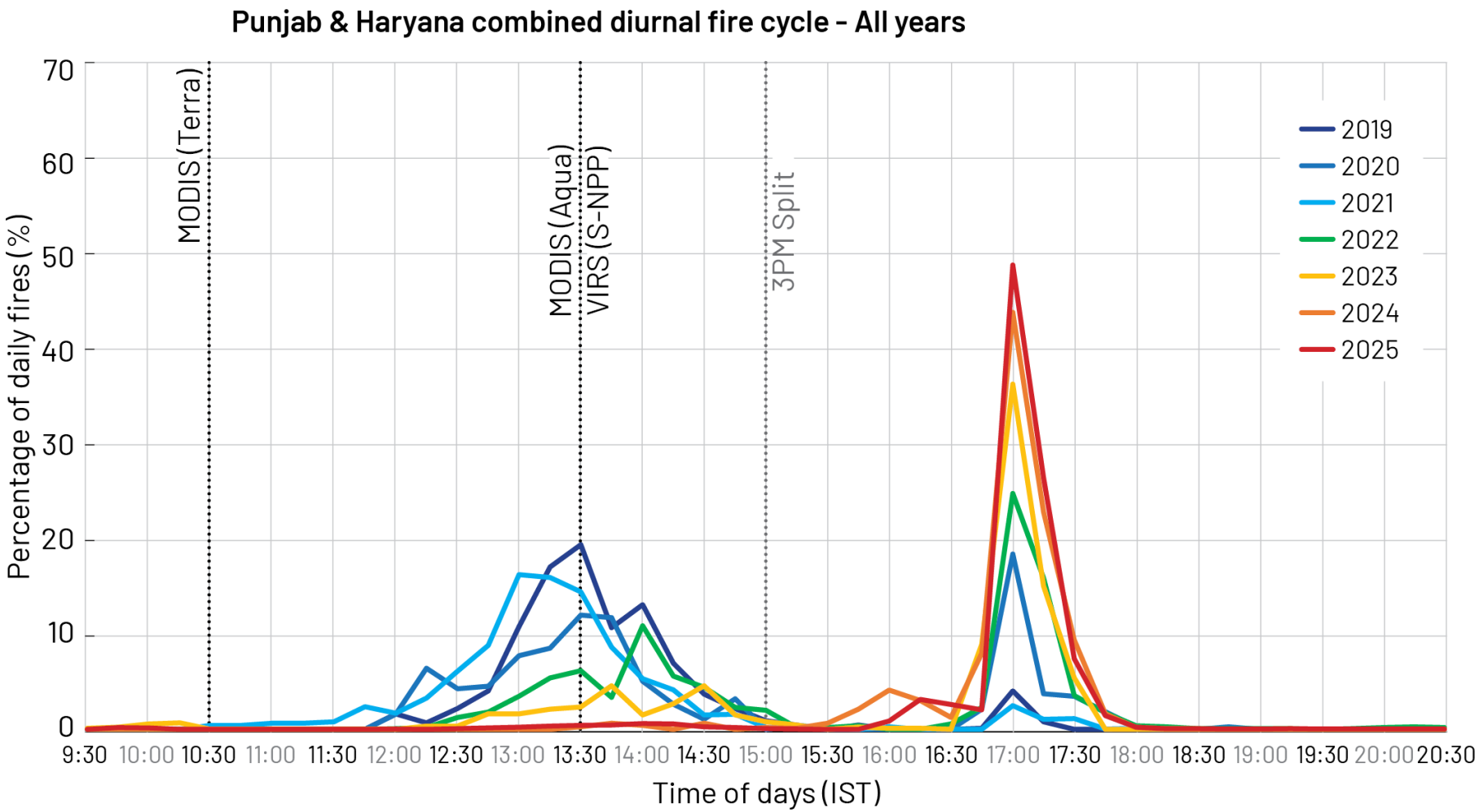


What the geostationary satellite tell us about active fire count?

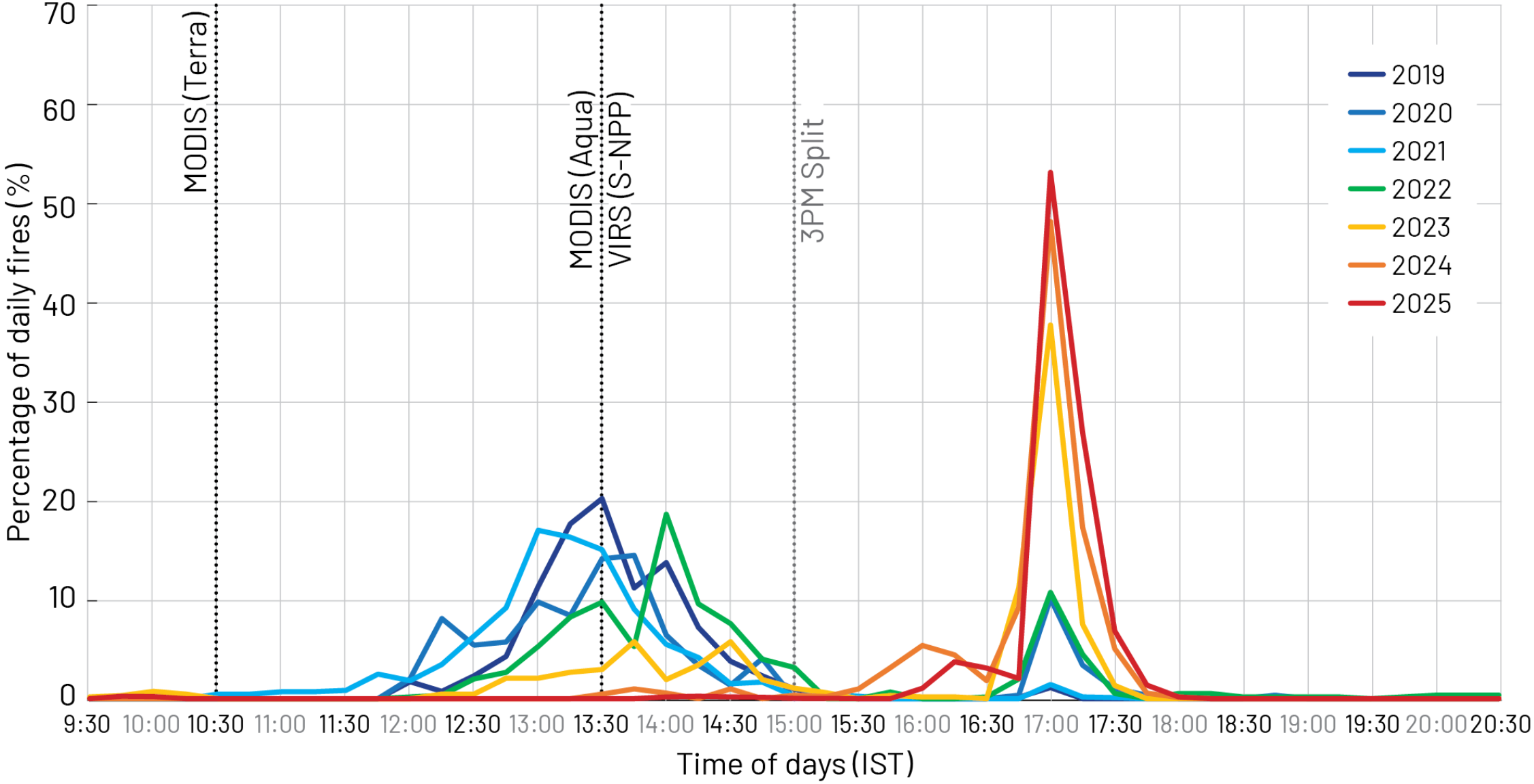
The percentage shows **how many of all detected fires occurred at a specific time of day**.

How to interpret the chart?

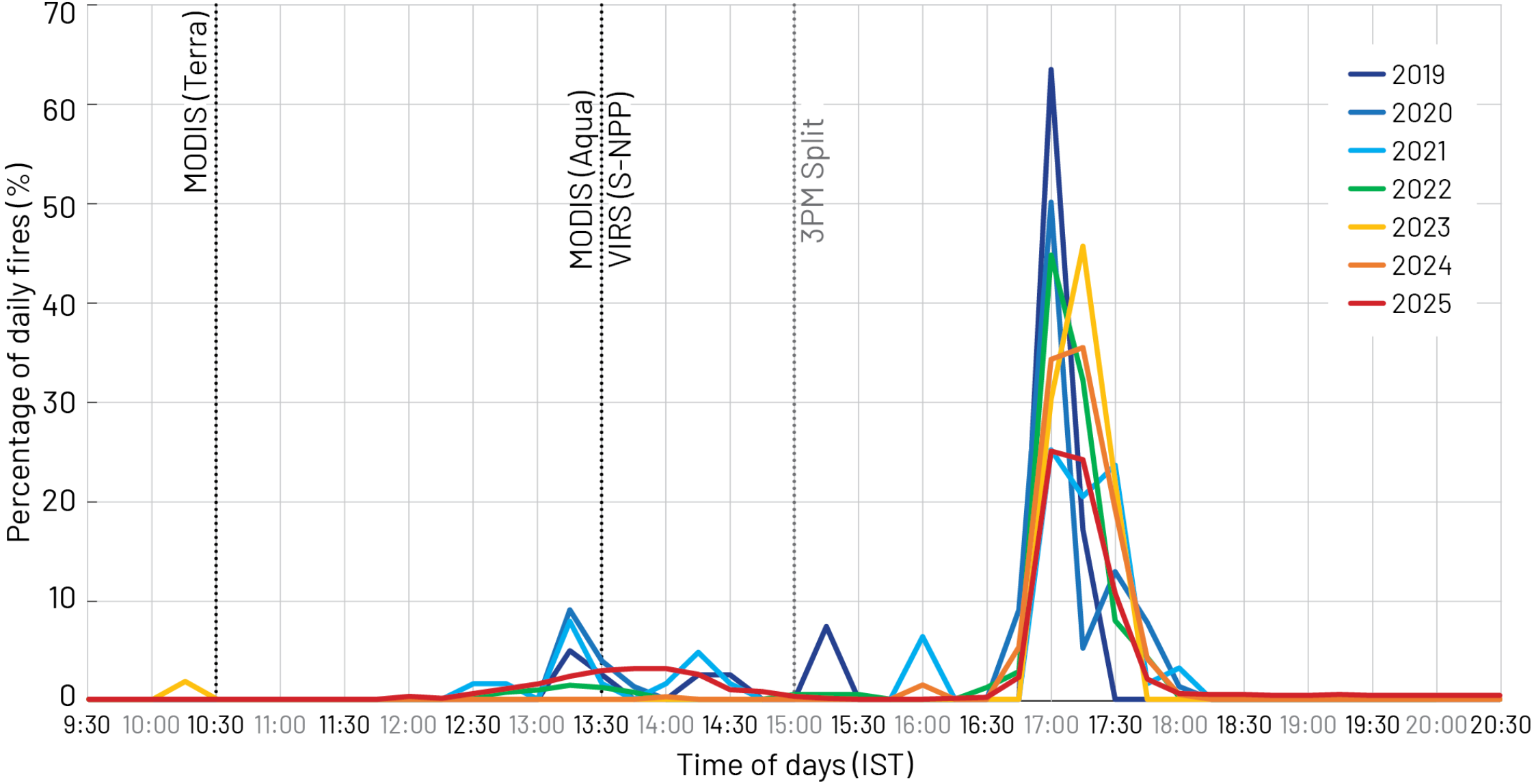
Example: In 2025, the chart shows fire events peak 50% at 17:00, it means 50 % of all fires detected in 2025 were recorded around 5 PM.



Punjab diurnal fire cycle - All years

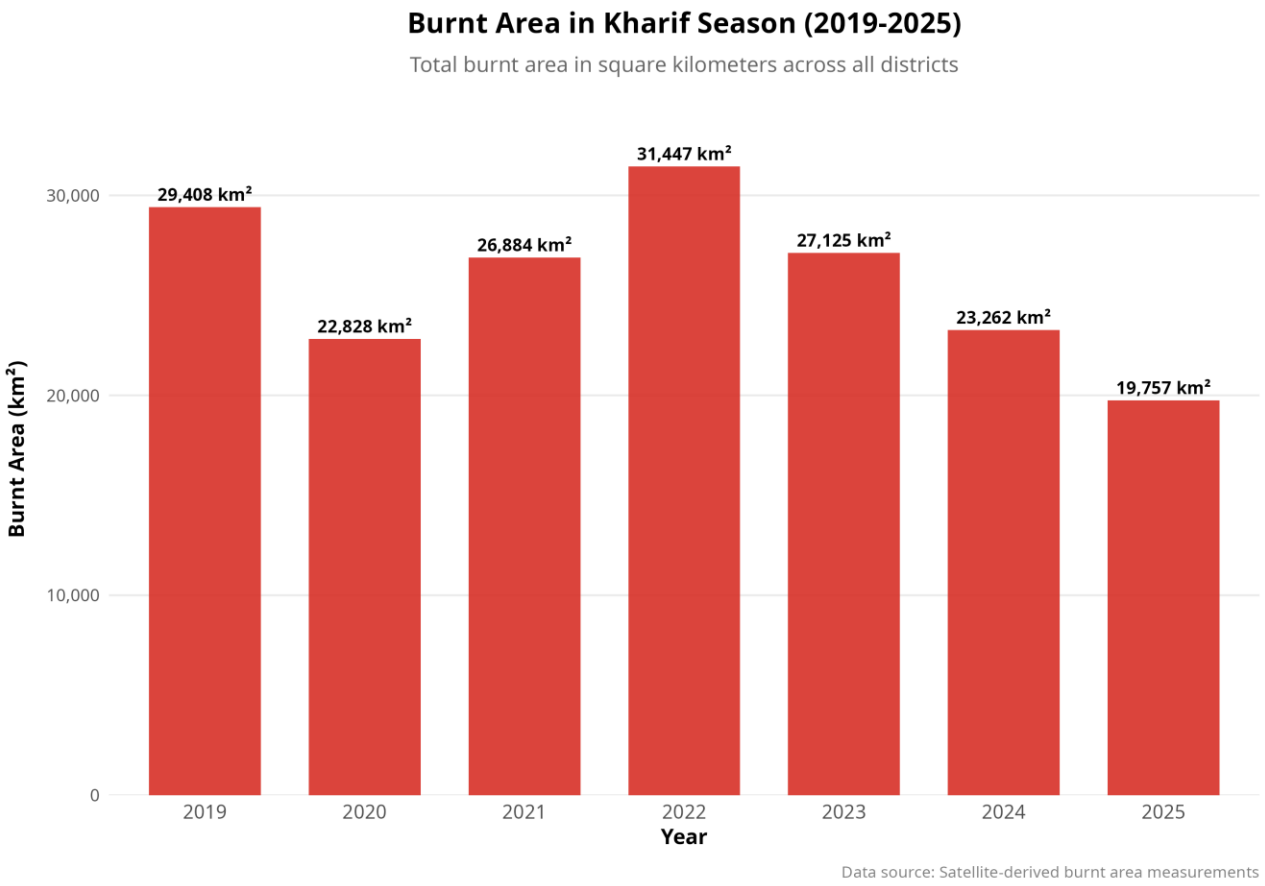


Haryana diurnal fire cycle - All years



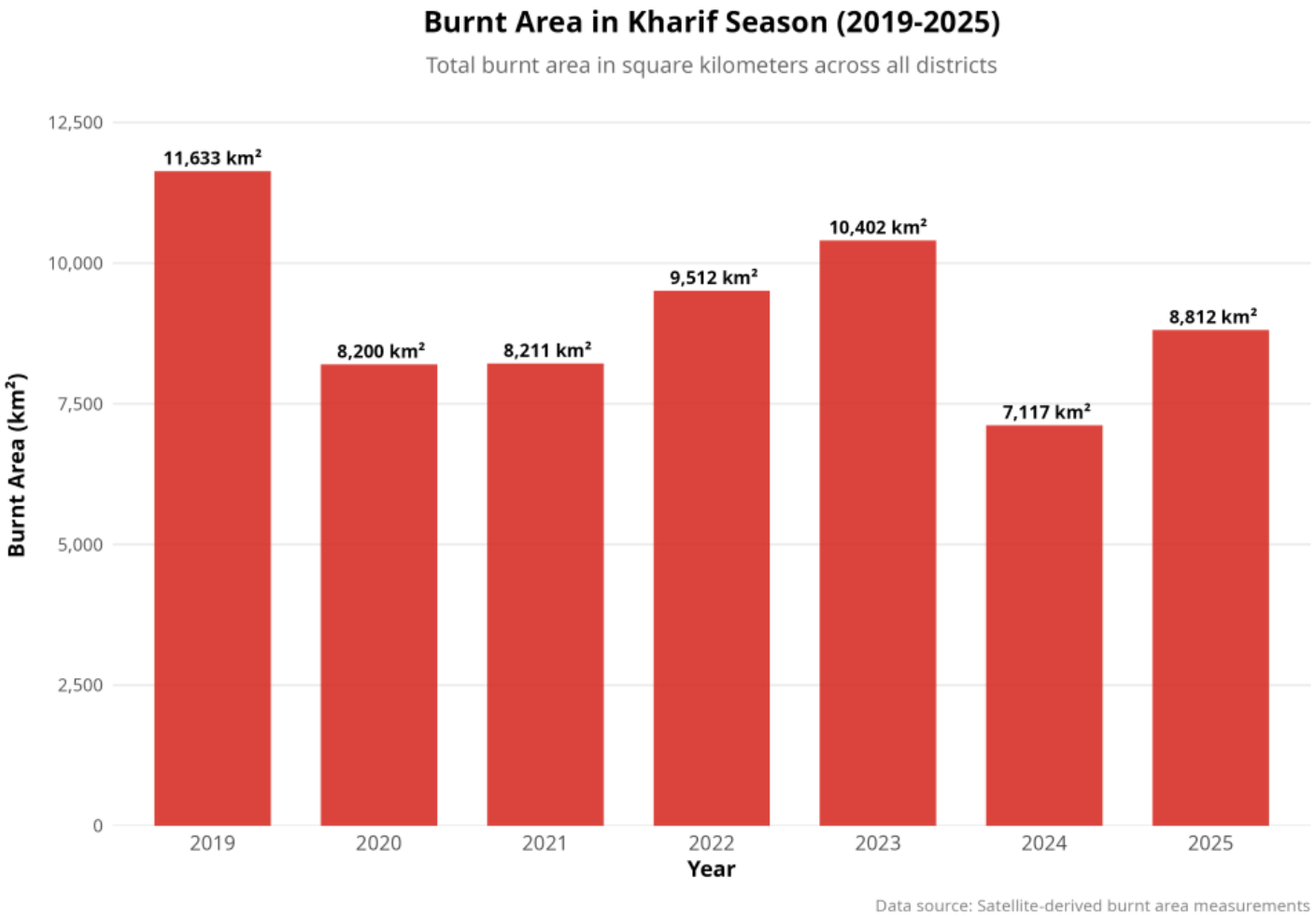
What the burnt area show us?

In Punjab, kharif burnt area has reduced by 35% since 2022.



For 2025, the burnt area analysis uses data available up to **27 November 2025.** The numbers are likely to rise.

In Haryana, kharif burnt area has reduced by 25% since 2019.



Haryana's burnt area has swung between 7,000-10,000 km^2 since 2020.

For 2025, the burnt area analysis uses data available up to **27 November 2025.** The numbers are likely to rise.

Conclusion

Summary

1. MODIS and VIIRS capture active farm fires only during a narrow time window—10:30 AM to 1:30 PM.
2. MODIS/VIIRS data indicate that active fire counts in 2025 have reduced by 92% in Punjab and by 90% in Haryana from their respective peaks in 2021.
3. However, SEVIRI 15-minute observations (Meteosat-8 and Meteosat-9, ~05:30–19:30 IST) clearly show that the majority of large farm fires now occur after 3:00 PM, beyond the overpass times of polar satellites.
4. SEVIRI data show that more than 90% of large farm fires in Punjab in 2024 and 2025 occurred after 3:00 PM. In 2021, only 3% of large fires occurred after this time.
5. In Haryana, most large farm fires have taken place after 3:00 PM since 2019; thus, MODIS/VIIRS has been underestimating fires in Haryana for several years.

Summary

6. Sentinel-2 MSI burnt-area mapping shows that burnt area in Punjab during the Kharif season declined from a peak of 31,447 km^2 in 2022 to about 20,000 km^2 in 2025—a 37% reduction.
7. Burnt area in Haryana during the Kharif season reduced from its peak of 11,633 km^2 in 2019 to 8,812 km^2 in 2025—a 25% reduction. However, burnt area has fluctuated between 7,000 km^2 and 10,000 km^2 from 2020–2025, showing no consistent trend unlike Punjab.
8. While burnt-area analysis shows clear reductions in farm fires in Punjab and Haryana (25–35%), these reductions are significantly lower than those suggested by active fire counts (>95%).

Policy Implications

1. The push to reduce stubble burning in Punjab and Haryana through in-situ and ex-situ practices is delivering positive results. However, large-scale burning—around 20,000 km^2 in Punjab and 8,000 km^2 in Haryana—continues to significantly affect air quality in both states and in Delhi-NCR.

2. In-situ and ex-situ stubble-management practices must be further intensified in both states to reduce stubble burning more substantively.

3. Stubble burning is increasing in other states. While the iFOREST study has not estimated burnt area in Madhya Pradesh and Uttar Pradesh, active fire-count data show a significant rise. It is time to expand policy focus beyond Punjab and Haryana.

4. Active fire counts are a poor indicator of the scale and impact of stubble burning. Using them to estimate pollution contributions leads to significant inaccuracies.

Policy Implications

5. The Decision Support System (DSS) for air-quality management in Delhi, run by the Indian Institute of Tropical Meteorology (IITM), should revise its methodology to more accurately quantify the contribution of stubble burning to air-pollution loads in Delhi-NCR.

6. CREAMS should begin monitoring and publishing burnt-area data to provide a comprehensive and accurate picture of stubble burning across India.