Stubble Burning: Pollution Crisis, Health Risks, and Pathways Forward

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Recent stubble burning in North India is once again loading the winter air with smoke, worsening pollution levels and helping trigger the dense fog and smog that shroud the Indo-Gangetic plains each year. This mix of tiny particles and toxic gases not only obscures visibility but also poses a serious and immediate threat to public health.

Why farmers burn stubble

In states like Punjab, Haryana, Uttar Pradesh and parts of Rajasthan, a rice–wheat system leaves huge quantities of paddy straw on fields just weeks before wheat sowing. With narrow sowing windows, labour shortages and high mechanisation, many farmers still find burning the cheapest and fastest way to clear residues.

- Combine harvesters leave loose, standing stubble that is hard to incorporate quickly without specialised machinery such as Happy Seeders or mulchers.
- Policy signals and procurement patterns have locked farmers into paddy, creating residue surpluses that on-farm uses and current markets cannot absorb fully.

How stubble smoke worsens winter pollution

- When crop residues burn, they release huge amounts of particulate matter (PM2.5 and PM10), carbon monoxide, methane, nitrogen oxides, volatile organic compounds and carcinogenic hydrocarbons. During peak burning episodes, these emissions can contribute 40–70% of the particulate pollution on some days in North India, especially around Delhi and the wider Indo-Gangetic region.
  In October–November, satellite and ground studies consistently show sharp spikes in fire counts over Punjab and Haryana that coincide with rapid deterioration of air quality downwind.
- Under stable winter conditions and temperature inversions, smoke cannot disperse upward; it remains trapped near the surface, which magnifies pollution and creates persistent haze.

Link with fog and smog in winters

Fog formation in North Indian winters is a natural process, but stubble smoke significantly intensifies and prolongs it. The fine particles from burning act as condensation nuclei, allowing water vapour to condense and form denser, longer-lasting fog droplets that turn into smog when mixed with pollutants. Research on winter fog over the Indo-Gangetic plain shows that aerosol particles from open fires soak up water vapour, swell, and thicken the fog layer, sharply reducing visibility over highways, rail tracks and airports. During inversion and calm wind conditions, high PM levels from burning in the first half of November are a primary reason for widespread haze and visibility collapse across the region.

Health and environmental costs

The toxic cocktail from stubble burning is strongly linked to respiratory and cardiovascular problems across age groups. Studies in rural Punjab villages have documented reduced lung function and a two- to three-fold increase in symptoms like wheezing, breathlessness and eye irritation during the burning season.

- Fine PM2.5 particles penetrate deep into the lungs, increasing risks of asthma, COPD, bronchitis and even lung cancer, with women and the elderly particularly vulnerable.
- Repeated burning also damages soils by destroying organic matter, killing beneficial microbes, and depleting nutrients, which undermines long-term agricultural productivity.

The way forward

- The good news is that some recent seasons have seen a marked decline—one analysis reported nearly 68% fewer burning incidents in parts of North India compared with past years, thanks to tighter enforcement and support schemes. Yet, scientists and policy analysts warn that blaming farmers alone will not solve the winter smog crisis; systemic changes are essential.
- Key measures include large-scale promotion of residue-management machines, viable markets for straw (bioenergy, packaging, biochar), and diversification away from water-intensive paddy. business.
- Stronger regional air-shed management, year-round emission controls on transport and industry, and

real-time monitoring of changing fire-timing patterns are needed so that the winter sky over North India is no longer synonymous with a suffocating grey blanket.

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