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Harnessing Artificial Intelligence to combat stubble burning: Toward sustainable environmental practices

Dr. Heena Sachdeva*
Department of Zoology, Multani Mal Modi College, Patiala, Panjab, India

Abstract
Purpose: This report investigates how artificial intelligence (AI) technologies can address the persistent challenge of stubble burning in agricultural regions by enabling real-time detection, forecasting pollution, and promoting residue management alternatives.
Methods: A qualitative synthesis is provided, referencing AI applications deployed by institutions such as ISRO, IBM Weather AI, and Indian Agricultural Research Institute (IARI), with a focus on satellite data analytics, air quality modeling, and farmer decision support tools.
Results: AI-based systems demonstrate a capacity to detect crop fires with over 85% accuracy, predict air quality deterioration up to 72 hours in advance, and reduce burning incidents when coupled with advisory services. Tools like IBM's Environmental Intelligence Suite and IARI's PUSA bio-decomposer app showcase applied successes.
Conclusion: AI represents a scalable and cost-effective solution to the stubble burning crisis. Its integration into regional climate action plans and agricultural outreach initiatives is vital for achieving air quality improvements and sustainable farming goals.

Keywords: Artificial Intelligence, stubble burning, remote sensing, sustainable agriculture, air pollution, climate adaptation, India

Introduction

Stubble burning remains a major source of seasonal air pollution in agrarian regions, particularly in northwestern India. The phenomenon contributes to hazardous PM2.5 levels in cities like Delhi, undermines climate action efforts, and deteriorates soil microbiomes. Traditional mitigation strategies have been slow to yield results. In this context, Artificial Intelligence (AI) provides a dynamic, data-driven approach to monitoring and prevention.

Role of Artificial Intelligence in Mitigating Stubble Burning

1. Remote Sensing and Satellite Analytics (ISRO & NASA MODIS Data)

The Indian Space Research Organisation (ISRO), in collaboration with the National Remote Sensing Centre (NRSC), uses AI-enhanced satellite data (Sentinel-2, MODIS) to detect active fires. Machine learning classifiers such as Random Forests and Convolutional Neural Networks (CNNs) improve fire spot detection in near real-time, supporting responsive governance.

2. Air Quality Forecasting (IBM Weather AI & SAFAR System)

IBM's Environmental Intelligence Suite integrates AI with meteorological models to forecast pollution spikes from stubble burning, aiding cities in preparedness. Similarly, the Indian Ministry of Earth Sciences' SAFAR (System of Air Quality and Weather Forecasting and Research) system incorporates AI-based forecasting to issue real-time public health alerts.

3. Decision Support Tools for Farmers (IARI, AgriStack)

The Indian Agricultural Research Institute (IARI) developed a mobile app promoting its PUSA bio-decomposer—an eco-friendly solution to degrade stubble. The app uses AI to personalize instructions based on location, crop cycle, and soil conditions. India's AgriStack initiative aims to link farmer databases with AI-driven advisories on residue management and subsidy eligibility.

4. Predictive Modeling and Risk Mapping

AI models trained on historical burn data, weather, and socio-economic variables (e.g., from ICAR, IMD, and agricultural census data) enable hotspot prediction at the district level. These models, using XGBoost and LSTM neural networks, inform resource allocation, especially in Punjab and Haryana.

Policy Implications and Challenges

While AI capabilities are promising, systemic challenges persist:

- **Data Accessibility:** Fragmented and non-uniform data across agencies hampers model performance.
- **Rural Digital Divide:** Limited connectivity and digital literacy restrict farmer access to AI tools.
- **Scalability:** Current deployments remain pilot-scale; national-scale implementation requires policy backing, subsidies, and farmer trust.

Opportunities: AI could be embedded into India's National Clean Air Programme (NCAP) and State Action Plans on Climate Change (SAPCCs), enhancing real-time accountability and targeted incentives.

Conclusion

Artificial intelligence has emerged as a transformative enabler in addressing the environmental and public health

crisis caused by stubble burning. From real-time detection to predictive analytics and farmer engagement, AI technologies can facilitate sustainable agricultural transitions. Institutional integration, policy support, and ethical deployment will be key to leveraging AI for long-term impact.

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