Crop Residue Burning & Air Pollution: Sustainable and Scalable Solutions to Help Farmers

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Air Pollution is a Serious Concern for Humanity

‘Air pollution killed 81k in Delhi & Mumbai, cost ₹70,000cr in 2015’

Mumbai: Air pollution contributed to a total of 80,665 premature deaths of adults over 30 years in Mumbai and Delhi in 2015, a two-fold jump from 195, according to a new study at the Indian Institute of Technology, Bombay.

In economic terms, air pollution cost the two cities ₹10.66 billion (approximately 0.71% of the country’s gross domestic product). The study has said the impact on health and productivity as a result of exposure to pollution and the consequences.

Delhi's Government Declares A Public Health Emergency As Air Pollution Chokes The City

Delhi air pollution: A (crop) burning issue, and the way out

Delhi's capital city New Delhi was enveloped by toxic smog on Tuesday, forcing the Indian government to declare a public health emergency, ahead of key events, including Independence Day, and the monsoon season.

Nasa images show crop burning surged before toxic smog hit Delhi-NCR

The images, taken by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA’s Terra satellite, show a marked increase in the concentration of particulate matter in the Delhi-NCR region, particularly in areas where crop burning is prevalent.

Delhi air pollution: The current smog and poor air quality in the National Capital Region has been blamed in part on stubble burning by farmers, especially in neighbouring Punjab and Haryana. What is the genesis of the problem? What are its potential solutions?
Rice Residue Burning is a Major Concern in NW India

- Rice residue burning in NW India: 23 mt
  - Loss of >9 mt C (34 mt CO2-eq) per year
  - Loss of ~0.15 mt N (US$ 31 million)
  - Water, health

Each dot indicates active fire detected by satellite

Source: ICAR-IARI (2017)
Burning issues of paddy residue management in north-west states of India

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Farmer Options

In-Situ Rice Residue Management Options
C, A
B, F, A
B, Hand spread, A
B, F, G, H, I
B, F, J, G, H, I
B, Burn, G, H, I
B, Burn, D, I

Ex-Situ Rice Residue Management Options
B, K, L, M, G, H, I
B, K, L, D, H, I
B, K, L, M, A

Transport includes for sale of:
- Paper production
- Biofuel (oil)
- Biothermal power

B, K, E, M, G, H, I
B, K, E, M, D, H, I

Transport includes for sale of:
- Bedding material
- Mushroom cultivation
- Fodder
Ex-Situ: Composting

- How much can be collected and composted?
- Labour availability
- Economics
Ex-Situ: Baling Rice Residues

- How much can be baled in 15-20 days?
- Do we have viable price to offer for baling?
- Economic viability (investment v/s returns)
  - Rs 10 lakh per baler
  - Capacity- 100 ha/year
- Can we afford export of the carbon and nutrients from our fields and still sustain the soil health and goal of reducing chemical load in agriculture?

Other than eliminating burning, what other benefits we can offer?
In-Situ: Incorporation

• Cost effectiveness *(Rs 8000-10000/ha)*
• Immediate economic gains? *(no yield gains)*
• Time for incorporation and its weight loss for seeding operation *(limited)*
In-Situ Retention: Happy Seeder Technology

Development and evaluation of the Turbo Happy Seeder for sowing wheat into heavy rice residues in NW India

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What Option is Better?
Evidence Base From Research on Sustainable Solutions

- Improved productivity and soil health
  (Productivity 1-1.5 t/ha/yr
   SOC 2-4 t/ha/yr)

- Reduced weather risks
  (High adaptability and Low CV
   in crop yield)

- Reduce Chemical load
  (20-25 kg N/ha, Less herbicide)

- More crop per drop: Save irrigation water
  Rice-wheat-mungbean: 60-70 ha-cm/yr
  Maize-wheat-mungbean: 150-175 ha-cm/yr

- More profit: Lower costs and higher yields
  (Profit 20000-25000/ha/yr)

- Lower GHGs emission
  (~1.5 t CO2-eq/ha/yr)

Collaborative research: ICAR-CSSRI & CIMMYT-CCAFS
Rice Residue Burning during 2016

Estimates on Adoption of Zero Till Wheat in Haryana and Punjab Using Remote Sensing (Winter 2016-17)

A Complete In-Situ Management Solution With Sustainability and Scalability

Happy Seeder rice residue management system.
A combine is fitted with a Super Straw Management System (SMS) so that rice residue is spread evenly across the field during harvest. A Happy Seeder follows, planting wheat seed directly into the rice crop residue, and applying fertilizer.

1. Crop residue picked up and shredded
2. Seeds planted and fertilized
3. Shredded residue (mulch) dispersed
   a) Retains moisture
   b) Returns nutrients to soil

Combine harvests crop
Super SMS
Seed & fertilizer
The Solution
Spread of Happy Seeder Operators
Technology is on The Move and Adopted @ Incremental Rate

4-fold rise in green solution to burning of paddy stubble

Good Start But a Long Way to Go

<table>
<thead>
<tr>
<th>Area Under Happy Seeders</th>
<th>Punjab</th>
<th>Haryana</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>20,000</td>
<td>6,000</td>
</tr>
<tr>
<td>2017</td>
<td>5,000</td>
<td>5,000</td>
</tr>
</tbody>
</table>

The combination of a seeding implement that sows without the need to remove (paddy) stubble from field. Works best with a straw spreader attached to combine harvester that evenly spreads paddy residue.

How this tech is a win-win for farmers, environment

Stubble Burning: Combination Of SMS & Happy Seeder Way Forward

The Times of India
India announces new plan to help farmers stem air pollution

By Huizhong Wu, CNN

Updated 12:35 PM EST, Thu February 01, 2018

Fight against stubble pollution gets budget boost with special scheme

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NEW DELHI: Union finance minister Arun Jaitley on Thursday announced a special scheme to support the governments of Delhi and neighbouring states in tackling high levels of air pollution that have led to public health emergencies in the region over the last three winters.

The poor air quality in the National Capital Region has been blamed partly on the burning of crop stubble by farmers in Punjab, Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh during winter. In speech on Thursday, the Centre told the Supreme Court that it will provide a subsidy of Rs 1,000 crore to support individual farmers and cooperatives, and a Rs 1,000-crore special poll-free fund to support the farmers and the states.

Centre has decided to provide subsidies to farmers to purchase machines like happy seeder and rotavators
- These cut and lift rice straw and simultaneously sow wheat into the bare soil
- Machinery would be supplied to farmers by end of September before harvesting of kharif crops

A flat subsidy of 50% of purchase price will be given through a direct benefit transfer mechanism to individual farmers willing to buy the machines

In case of cooperative societies, farmer groups or gram panchayats, a subsidy of 75% of the cost of the machinery will be provided.

The total area of cultivation in Punjab and Haryana is 44 lakh hectares

The production of paddy straw has been around 28.5 million tonnes, of which 20.1 million tonnes are burnt by farmers to clear the agricultural land for Rabi crops.
Adoption of Farm Innovations Efficiency and sustainability Agricultural Systems Depends on Complex Interactions

- Physical resources (Land, water etc)
- Biological resources (Agro-biodiversity)
- Environmental resources
- Social Resources (human capital, economic, market etc)
- Management inputs/systems

Efficiency and Sustainability Agricultural Systems

Complex Interactions
One Size Doesn’t Fit All-Technology Targeting is a Must

Farm household typologies and food security: An ex-ante assessment from Eastern India

Climate smart agriculture, farm household typologies and food security
An ex-ante assessment from Eastern India

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Innovative business models for scaling CA

- Enhancing the role of private sector in scaling up CSAP
- Three types of business models: **back end** (service providers), **front end** (markets /export purpose), **end-to-end** (value chain approach)
Happy Seeder Business Model

Enabling Factors

- Stakeholders
- Market
- Financial

Service Process

- Value chain
- Upscaling & Development
- Mobilizing resources & partners

Outcomes

- CC Mitigation & adaptation
- Youth employment
- Profitability

IMPACT

- Environment sustainability
- Food security
- Improved livelihood
The Business Model

Key Partners
- Suppliers of the Happy Seeder Machine (Avtar Kalsi Agro Works, Kamboj Mech Works or other)
- Storage providers
- Insurance company

Key Activities
- To provide service in the direct seeding of wheat or rice

Value Propositions
- To provide a service that increases yields in wheat or rice, and reduces input costs such as labour and irrigation water in order to implement climate smart solutions through the use of the Happy Seeder machine.

Customer Relationships
- Personal direct service
- Communities
- Innovation platforms

Customer Segments
- Producers of wheat
- Producers of rice

Key Resources
- A Happy Seeder Machine
- Tractor
- Driver
- Storage space
- Diesel

Channels
- Direct contact, word of mouth
- Through innovation platforms
- Applied science projects (Universities)
- Governmental organisations

Cost Structure
1st year: (125,000 - 50,000 + 12,500 + 6,250 + 6,250) + 500 per acre
2nd year: (12,500 + 6,250 + 6,250) + 500 per acre

Revenue Streams
1,200 Rupees per acre in service costs

Social & Environmental Cost
No added environmental costs compared to current practises. Loss of jobs due to mechanisation.

Social & Environmental Benefit
Water smart, climate smart, less use of labour, time saving, energy saving, reduction of air pollution when combined with mulching.
Cost and Knowledge Intensive Technology have made impact at Scale with Business Models: Example of Laser Land Leveling

<table>
<thead>
<tr>
<th>Introduced in India during 2000-01 (RWC/CIMMYT and ICAR-NATP)</th>
<th>Adoption: ~4 million ha in India</th>
<th>Direct employment generation: 350 person days/unit/yr</th>
</tr>
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<tbody>
<tr>
<td>At current level (&gt;35000 units): 10.5 million person days/yr</td>
<td>Indirect employment: manufacturing, transport, services</td>
<td>Yield gains in RW system (3.5 mha, 0.5 t ha-1 yr-1): 1.75 mt yr-1; ~US$ 20 million yr-1</td>
</tr>
<tr>
<td>Electricity saving for irrigation in RW systems of IGP (3.5 mha): ~US$ 70 million yr-1</td>
<td>Water saving in RW system (3.5 mha, 18 ha-cm ha-1 yr-1) = 6.5 km3 yr-1</td>
<td>Other possible benefits: GHG mitigation, savings in subsidy bill etc</td>
</tr>
</tbody>
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Source: Jat et al, 2006; 2009a,b; 2011; 2015; Aryal et al, 2015
The Happy Journey of Happy Seeder (2002-2018)

The Happy Seeder revolutionized drilling of wheat into rice stubble and has been instrumental in improving agricultural productivity. Over the years, the technology has evolved, with modifications and updates to meet the changing needs of farmers. The images show the progression from 2002 to 2018, highlighting the growth and development of the Happy Seeder technology. TheHappy Seeder is an innovative solution that helps in reducing stubble burning and improving the sustainability of farming practices.
Sustainable Solutions to Wheat Stubble Burning
Simple changes in crop management can deliver cost-effective opportunities for climate change mitigation in India

- Technical Mitigation potential: 55.5 MtCO2e/year
- Mitigation potential of cost saving options: 46.5 MtCO2e/year
- With additional yield benefit considered: 50 MtCO2e/year

Sapkota, Sylvia, Jat, Sirohi, Singh, Sirsath---
------Stirling, Global Change Biology-Forthcoming
• If I were given one hour to save the planet, I would spend 59 minutes defining the problem and one minute resolving it—**Albert Einstein**

• We need to understand the root cause of our problems in farming

• We Need to Evolve our Thinking and People Need to Change Their Mindset

• Enabling policies
Intensive Policy Level Campaign
Thank you for your interest!

Sincerely acknowledge the team, institutes and collaborators

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