



Up in SMOKE

HAZE SMOTHERS NORTH

Every year during these months, a choking haze envelops North India like a shroud, mainly due to the burning of stubble in fields in Punjab and Haryana. Agriculture to breathe, here's a look at the problem and its causes

ROOT CAUSE SHORT CROP CYCLE IN NORTH INDIA

The burning of stubble in Punjab and Haryana is a result of the short crop cycle in these states. The average length of the growing season in Punjab is 180 days, while in Haryana it is 170 days. This is significantly shorter than the 220-230 days in the rest of India. The short crop cycle is due to the high temperatures in these states, which prevent the crops from growing for a longer period. This leads to a large amount of stubble being left in the fields after the harvest, which is then burned. The burning of stubble releases a large amount of smoke and particulate matter into the air, which causes the haze. The haze is most visible in the morning and evening hours, and it can persist for several days. The haze is not only a nuisance, but it is also a health hazard. It can cause respiratory problems, such as asthma and bronchitis, and it can also cause eye irritation. The haze is also a major cause of air pollution in North India, and it is a significant contributor to the global climate change problem.

THE WAY OUT IS BURNING THE ONLY SOLUTION?

The burning of stubble is the only solution to the problem of air pollution in North India. This is because the burning of stubble releases a large amount of smoke and particulate matter into the air, which causes the haze. The haze is most visible in the morning and evening hours, and it can persist for several days. The haze is not only a nuisance, but it is also a health hazard. It can cause respiratory problems, such as asthma and bronchitis, and it can also cause eye irritation. The haze is also a major cause of air pollution in North India, and it is a significant contributor to the global climate change problem.

CATCH 22 FARMERS SEE NO OPTIONS

Farmers in Punjab and Haryana are caught in a Catch 22 situation. They are faced with the choice of burning their stubble or leaving it in the fields. Burning the stubble releases a large amount of smoke and particulate matter into the air, which causes the haze. Leaving the stubble in the fields can lead to a large amount of water being used to irrigate the crops, which is a major expense for farmers. The farmers see no options for solving this problem, and they are forced to burn their stubble every year.

REMEDIAL MEASURES NOT ORDER

The government has not ordered any remedial measures to solve the problem of stubble burning in Punjab and Haryana. This is because the government is not willing to pay the cost of the remedial measures. The cost of the remedial measures is estimated to be in the billions of dollars. The government is not willing to pay this cost, and the farmers are not willing to pay it either. This is why the problem of stubble burning continues to persist in Punjab and Haryana.

AN EPIPHANY OF IDEAS

The problem of stubble burning in Punjab and Haryana is a complex one, and it requires a comprehensive solution. The government and the farmers need to work together to find a solution that is both effective and sustainable. This requires a change in the way that the government and the farmers think about the problem. It requires an epiphany of ideas that can lead to a better solution.



THE BRIGHTSIDE

The share of stubble burning in Delhi's air dropped by 31.5% this harvest season

No. of stubble burnings in NCR states between Sept 15 and Nov 30; 78,550 in 2021 vs 49,922 in 2022

A total of 53,792 incidents of stubble burning recorded in NCR states between September 15 and November 30; 78,550 in 2021 vs 49,922 in 2022

WEAKNESS NETWORKS p.14

TIMES CITY

How Punjab and Haryana's shot at saving water destroyed air quality

Delaying Paddy Sowing For Rains Left Little Window To Prepare For Next Crop

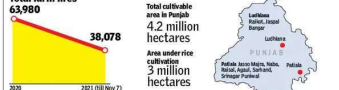
Asked why he opted to break the law by burning paddy straw, Singh who has six acres of land said, "If I use machines (straw management system for combine harvester and happy seeder), it will cost me an additional Rs 3,000 (rent of machines and diesel) per acre. I cannot afford that."



MILES TO GO YET

Though there are signs of change in both Punjab and Haryana where farmers opted for machines for managing paddy straw, the majority of farmers still find the alternative quite difficult.

WHY DELHI CONTINUES TO BREATHE SMOKE



WHY FARMERS RESORT TO STUBBLE BURNING?

Lack of machinery Many farmers don't have balers, happy seeders and other machines. High cost of machinery is often mentioned to them, though cooperatives, but not all villages have such cooperatives.

High-operation cost The process after harvesting requires steps like mowing, ploughing, application of cultivator machines. Each step requires fuel and labour cost for 4-5 days. But if farmers opt for stubble burning, they can directly burn the farm residue after harvesting the crop.

Lack of alternative crops The process after harvesting of 4 million hectares of land cultivated in Punjab, 3 million hectares is for paddy.

Farmers find stubble management less rewarding Many farmers have to spend extra to manage baled stubble and take it to factories.

THE YEAR'S

North India has had a bumper crop of paddy. It is a good thing, but it is also a challenge for farmers to manage the large amount of stubble that is left in the fields. The government and the farmers need to work together to find a solution that is both effective and sustainable.

Burning issue | A look at how States have controlled stubble burning so far

Stubble burning in these States peaks between the last week of October and early November. Burning can, however, last till December.

Between Sept. 15 and Oct. 14, stubble burning dropped 69.49% in Punjab, 18.28% in Haryana and 47.61% in the eight NCR districts of Uttar Pradesh compared with the corresponding period last year.

To check stubble burning, Uttar Pradesh has claimed it will spray bio-decomposer in 10 lakh acres, Haryana in 1 lakh acres, Punjab in 5 lakh acres and Delhi in 4,000 acres.

In 2016, there were nearly 1,00,000 instances of stubble burning in Punjab alone. It reduced to 50,000 in 2019, according to the Economic Survey.



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

Teeth is Proven, Needs Spill For Big Push: Experts

GOOD START OUT A LONG WAY TO GO

ANALYSIS BY SUDHANU GUPTA

THE NATIONAL BUREAU OF AGRICULTURAL EXTENSION (NBAE) HAS REPORTED A FOUR-FOLD INCREASE IN THE USE OF BIO-DECOMPOSERS FOR STUBBLE BURNING IN NORTH INDIA. THE NUMBER OF FARMERS USING BIO-DECOMPOSERS IN PUNJAB AND HARYANA IN 2022 WAS 1,76,400, AS COMPARED TO 44,000 IN 2018. THIS IS A SIGNIFICANT STEP TOWARDS REDUCING STUBBLE BURNING AND IMPROVING AIR QUALITY IN THESE STATES.

Politics Of Stubble Burning

Solving the problem requires us to rethink paddy farming and irrational subsidies

The burning of paddy fields after the harvest, or stubble burning, is a major seasonal contributor to air pollution in North India. It is a problem that has been around for decades, and it is getting worse every year. The burning of stubble releases a large amount of smoke and particulate matter into the air, which causes the haze. The haze is most visible in the morning and evening hours, and it can persist for several days. The haze is not only a nuisance, but it is also a health hazard. It can cause respiratory problems, such as asthma and bronchitis, and it can also cause eye irritation. The haze is also a major cause of air pollution in North India, and it is a significant contributor to the global climate change problem.

To end stubble-burning, Centre announces scheme for farmers

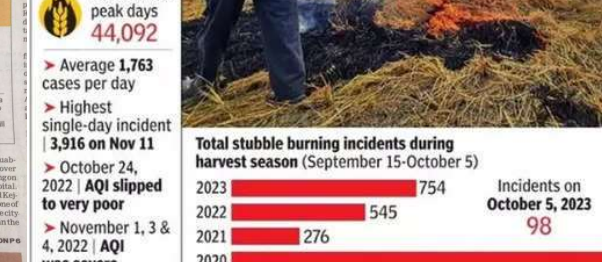
The government has announced a scheme to help farmers in Punjab and Haryana to stop burning their stubble. The scheme will provide subsidies for the purchase of machinery, such as balers and happy seeders, which can be used to manage the stubble in the fields. The government will also provide subsidies for the purchase of bio-decomposers, which can be used to break down the stubble in the fields. The scheme is a step towards solving the problem of stubble burning in Punjab and Haryana, but it is not a complete solution. The government and the farmers need to work together to find a comprehensive solution that is both effective and sustainable.

Centre didn't aid Delhi Govt's plan: Rai

Delhi Environment Minister Gopal Rai blamed the BJP-led Centre for air pollution in the national capital, saying the Centre did not support his plan to reduce stubble burning in Punjab and Haryana. Rai said that the Centre had not provided any financial assistance to the Delhi government to implement his plan. He also said that the Centre had not taken any steps to reduce stubble burning in Punjab and Haryana. Rai's plan was to reduce the amount of stubble that is burned in Punjab and Haryana, which would reduce the amount of smoke and particulate matter that is released into the air. This would help to reduce the haze in Delhi and improve the quality of the air.

BAD LUCK AND TROUBLE FROM PUNJAB

2022 was one of the worst years in terms of stubble burning. October 23 to November 17 saw maximum farm fires. Incidents on peak days reached 44,092. Average 1,763 cases per day. Highest single-day incident 3,916 on Nov 11. October 24, 2022 | AQI slipped to very poor. November 1, 3 & 4, 2022 | AQI was severe.



Haryana to become free from stubble burning soon; Punjab to take time

Haryana is on track to becoming the first north Indian state to end stubble burning. Punjab will take time because farmers there have been relatively slow in adopting new machines, said senior officials of the Indian Council of Agriculture Research (ICAR). Punjab has a large number of farmers who are still using traditional methods of stubble management. This makes it difficult for Punjab to end stubble burning. Haryana, on the other hand, has a smaller number of farmers, and many of them are already using modern machinery. This makes it easier for Haryana to end stubble burning. The government and the farmers in both states need to work together to find a solution that is both effective and sustainable.

CONCERNS REMAIN

Average AQI levels in 8 Punjab stations (from October to November 15) were 168-393. 2017 moderate to very poor. 69-251. 2018 satisfactory to poor. Education (DARE), and director general, Indian Council of Agriculture Research (ICAR). He said in Haryana and Punjab, around 4,500 villages had been declared "zero stubble-burning villages" in the past few years, while many more were in line to becoming so this year. Farmers in Punjab, Haryana, and western Uttar Pradesh burn paddy straw to prepare the field for the next crop around October. The interval between the harvest

Maximum incidents in Amritsar





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Session: *Environmental Impacts of Intensification*

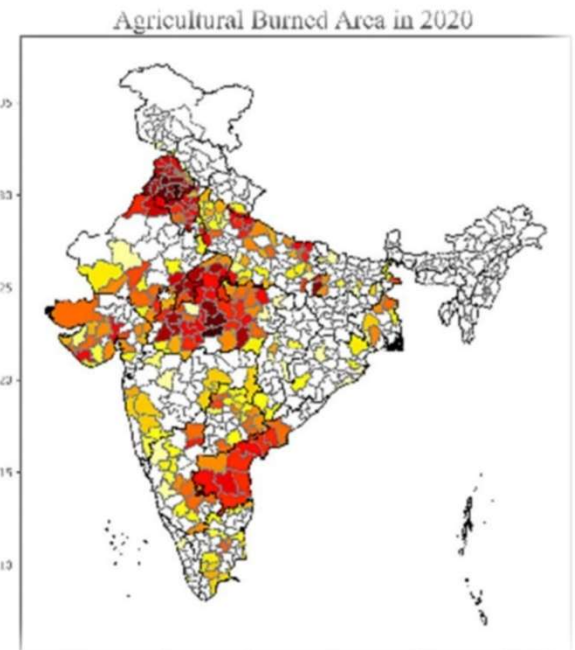
Chair: James Stevenson; Discussant: Joel Ferguson

Beyond Fields: Conservation Agriculture as a Public Good in Reducing Air Pollution

Vijesh V. Krishna, Monish Deshpande,
Dhanyalekshmi Pillai, Adeeth Cariappa,
Christoph Kubitzka, ML Jat & Meha Jain

Introduction

- Agriculture as a net emitter of GHG, a source of negative externalities.
- Difficult to monitor and curtail due to the decentralized nature of emissions.
- Residue burning is a major contributor to air pollution in India, China and SE Asia (Krishna and Mkondiwa, 2023).
- Area under crop residue burning increased by 75% during 2011-2020 (Deshpande et al. 2023)
- Heightened incidents of residue-burning in 2021-2023.
- Why burn residues?

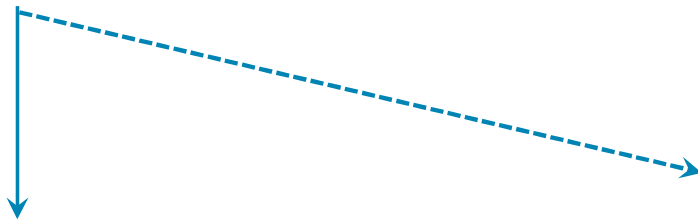


(Deshpande et al. 2023)



The Promise of Conservation Agriculture

- Conservation Agriculture (CA)
- Machines such as “Happy Seeder” to operate under heavy stubble conditions
- Use of excess rice residue as mulch for the next crop, wheat



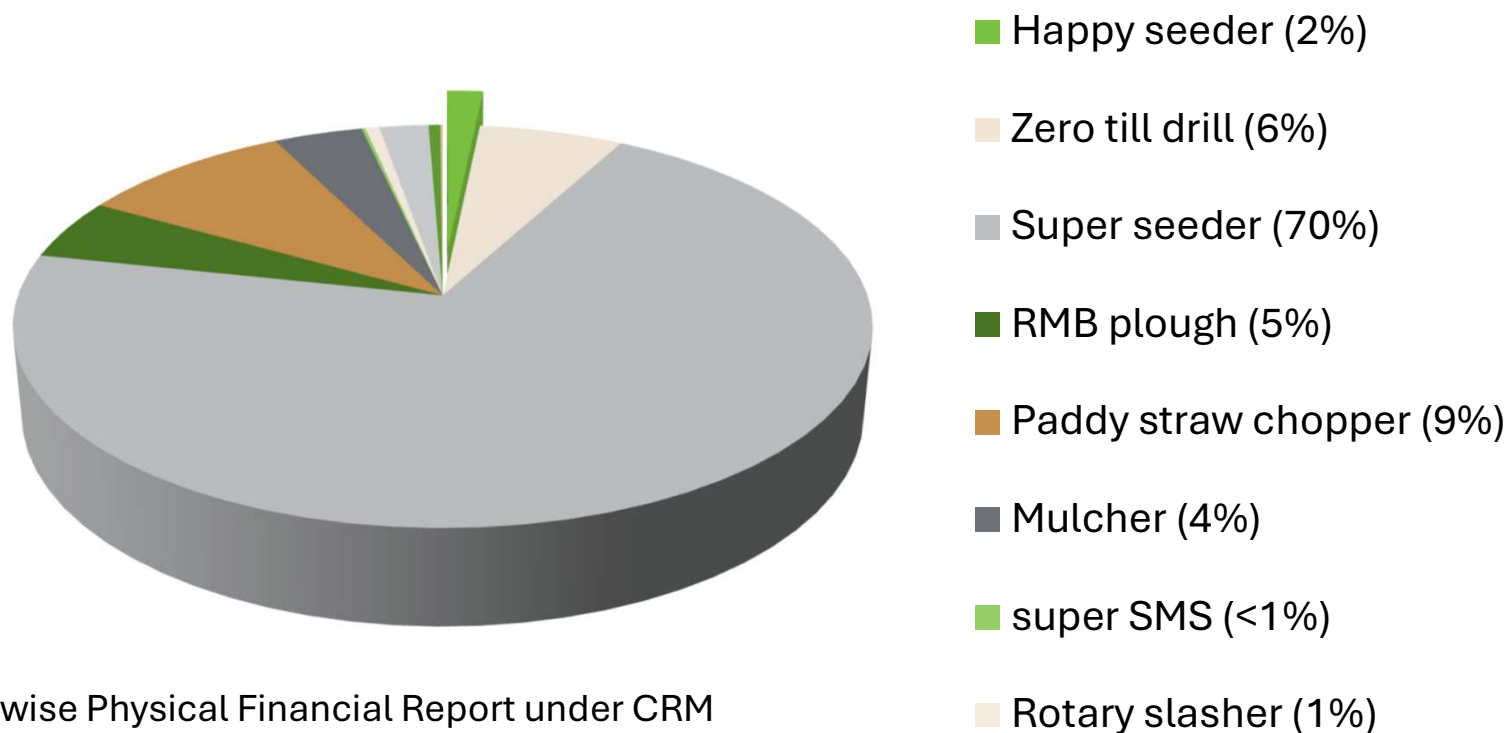
(Proven) **private benefits**

- Improves soil structure and water retention
- No yield penalty
- Lower cost of cultivation
- Higher profitability (?)

(Potential, but largely unproven) **public benefits**

- Reduced GHG emission
- Reduced air pollution → Health
- Groundwater conservation

Subsidy for Sustainable Residue Management



Source: Machine-wise Physical Financial Report under CRM 2021-22 (1.5 billion INR; US\$ 18 million), Punjab State

Research Question

- Some benefits of CA cannot be realized in the short run.
- Adoption of CA practices is not widespread
 - Around 15% wheat area (Deshpande et al. 2024)
- Shallow tillage machines (e.g., super seeder) have rapidly gained popularity.
 - Despite no organized research support or evidence on positive yield benefits

RQ: Does farmer adoption of CA reduce residue burning?

- Relevance of the research question.
- SPIA-funded project (2020-2022).

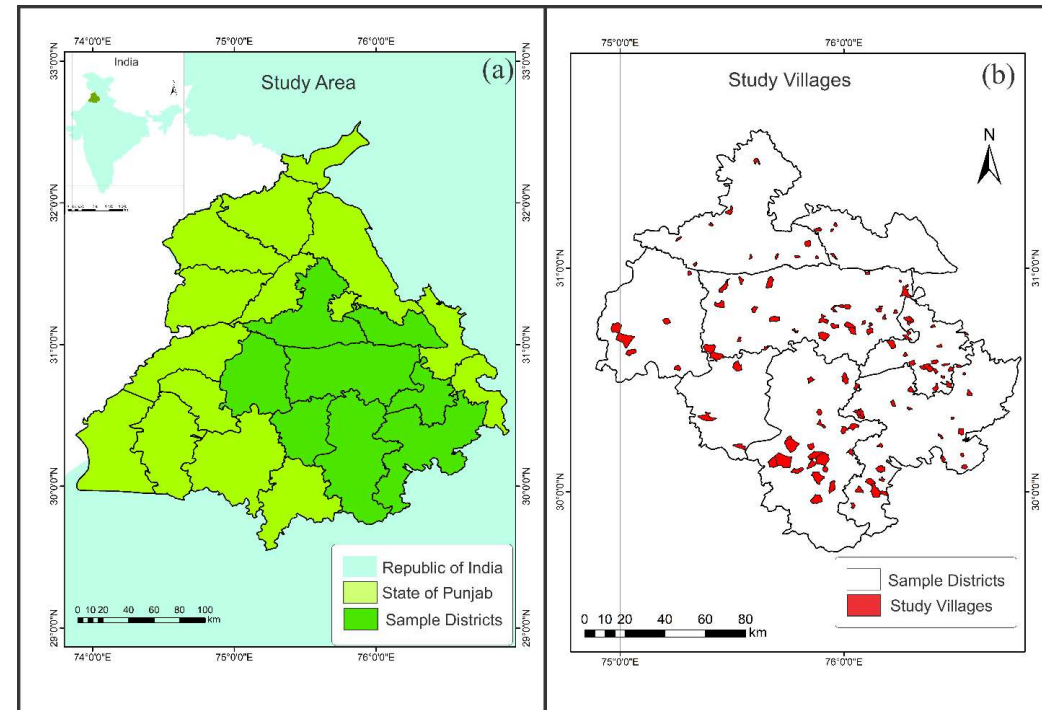
Happy Seeder



Super Seeder

Study Area: Punjab (India)

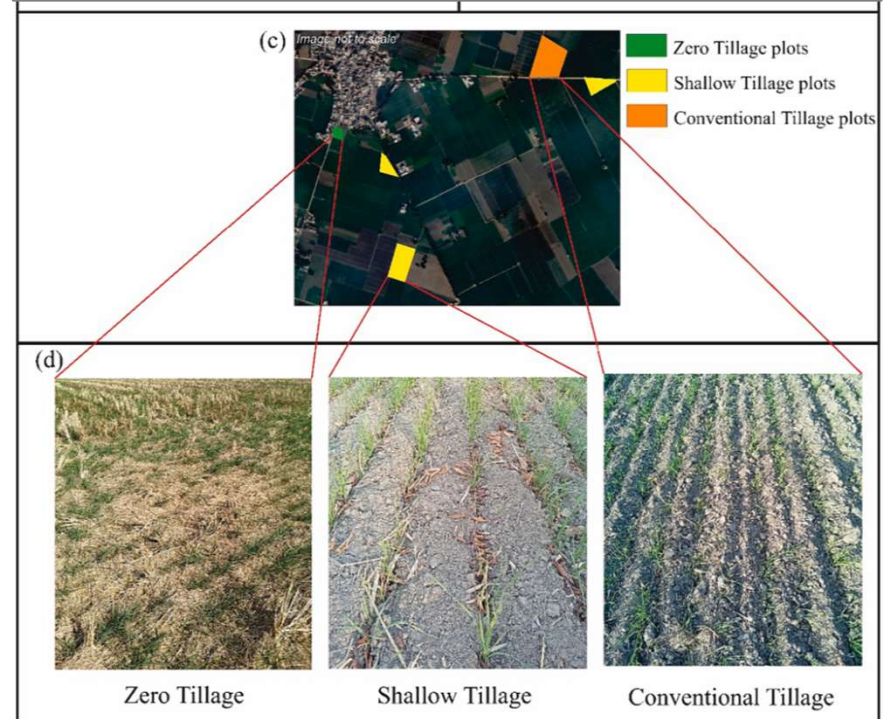
- Scope and limitations of using primary data
- Lack of secondary data on technology adoption
- Used remote sensing (Sentinel-2) data
 - ABA and % area under different tillage practices within village boundaries
- Eight districts and 122 villages for ground-truthing the impact estimation (2020-2022)



Data - Tillage

- ZT mapping in India using Sentinel-2 satellite data, Google Earth Engine (GEE), and a random forest classifier for three years (2020–2022)
- Stratified sampling to collect plots with CT, ZT, and ST (426 plots).
- Our method outperformed traditional binary classification models, achieving 81 % accuracy.
- The analysis indicated that areas under different tillage types changed over time across Punjab.

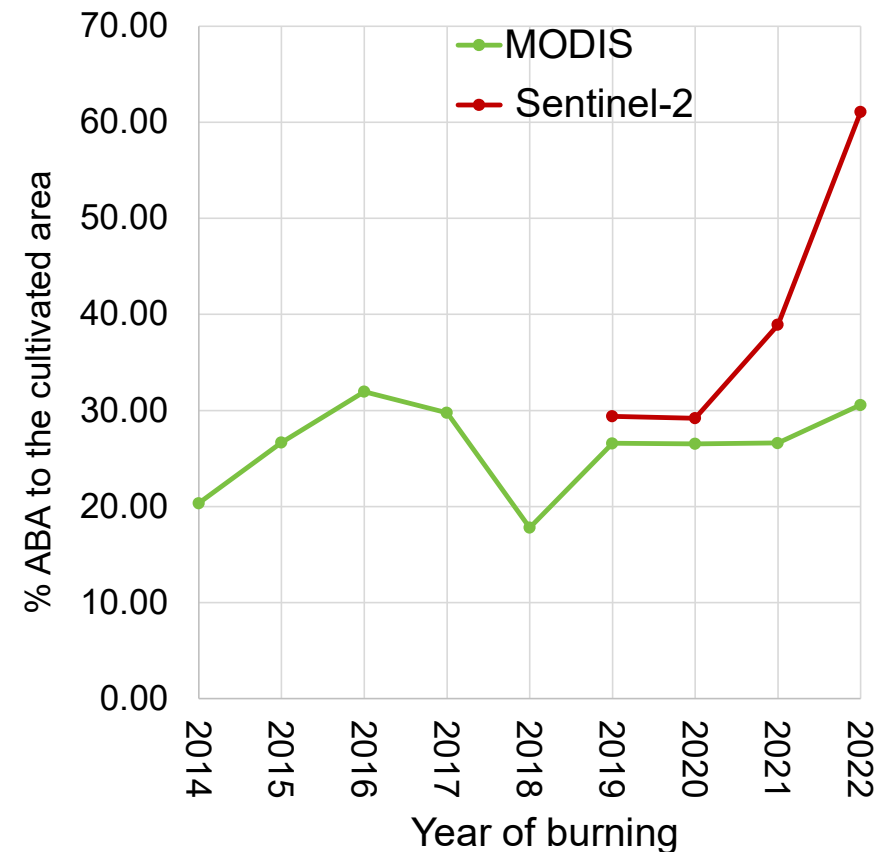
Ground truth sample plots overlaid on high-resolution satellite images for November 2022 in Google Earth



Data – Agriculture Burned Area (ABA)

- Used Sentinel-2 (10m res.) multispectral data to accurately estimate ABA.
- The satellite data – assisted by the virtual sampling method – was used to collect burned and unburned training samples.
- Monthly ABAs were extracted at 10m resolution and were compared with existing global burned area products.
- On average, the derived ABAs were larger than those reported by global burned area products (based on MODIS at 500m and 250m resolutions).
- Effectively captured burning in smallholder crop production systems.

Residue burning in Punjab (before wheat)



Other Datasets

- Household surveys (2018, 2021, 2023) on technology characteristics, input use, and perceived impacts (n = 1000)
- Service provider interviews (2022) to augment the adoption estimates and perceived challenges in the dissemination of CA (n = 384)
- Key informant surveys on soil characteristics, and labour availability in the village (2021; n = 122)
- Field visits to geo-reference the plots under different management practices





Causality Estimation

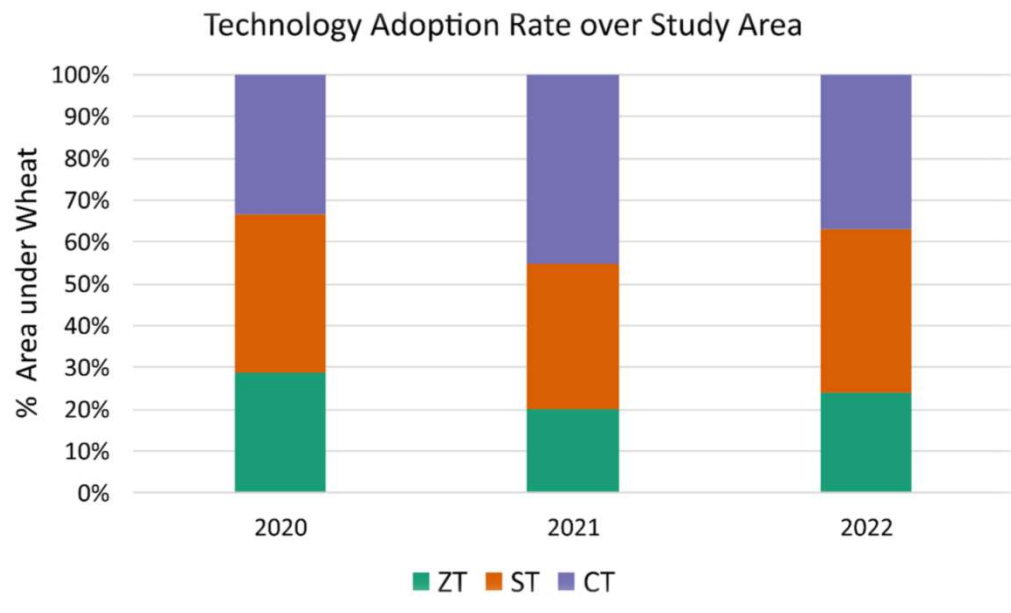
- We got three-year data (2020-2022) on tillage adoption and ABA.
- Time-invariant heterogeneities controlled using village-level fixed effects models.
- Challenge: control for possible time-variant heterogeneities causing endogeneity bias.
 - What time variant heterogeneities affect tillage and residue burning?
- Initial idea: Subsidy data
- Instrumental variable (IV) was developed following Duflo & Pandey (2007).
- IV: Soil type (% sandy soil) in the village interacted with state trend in the adoption of tillage type

Findings

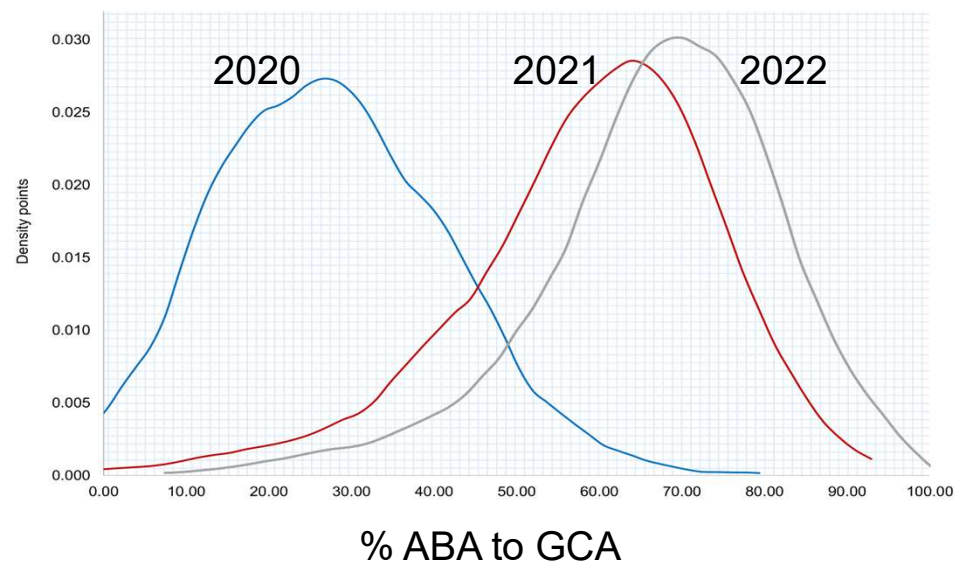


Tillage and Residue Burning over the Study Period

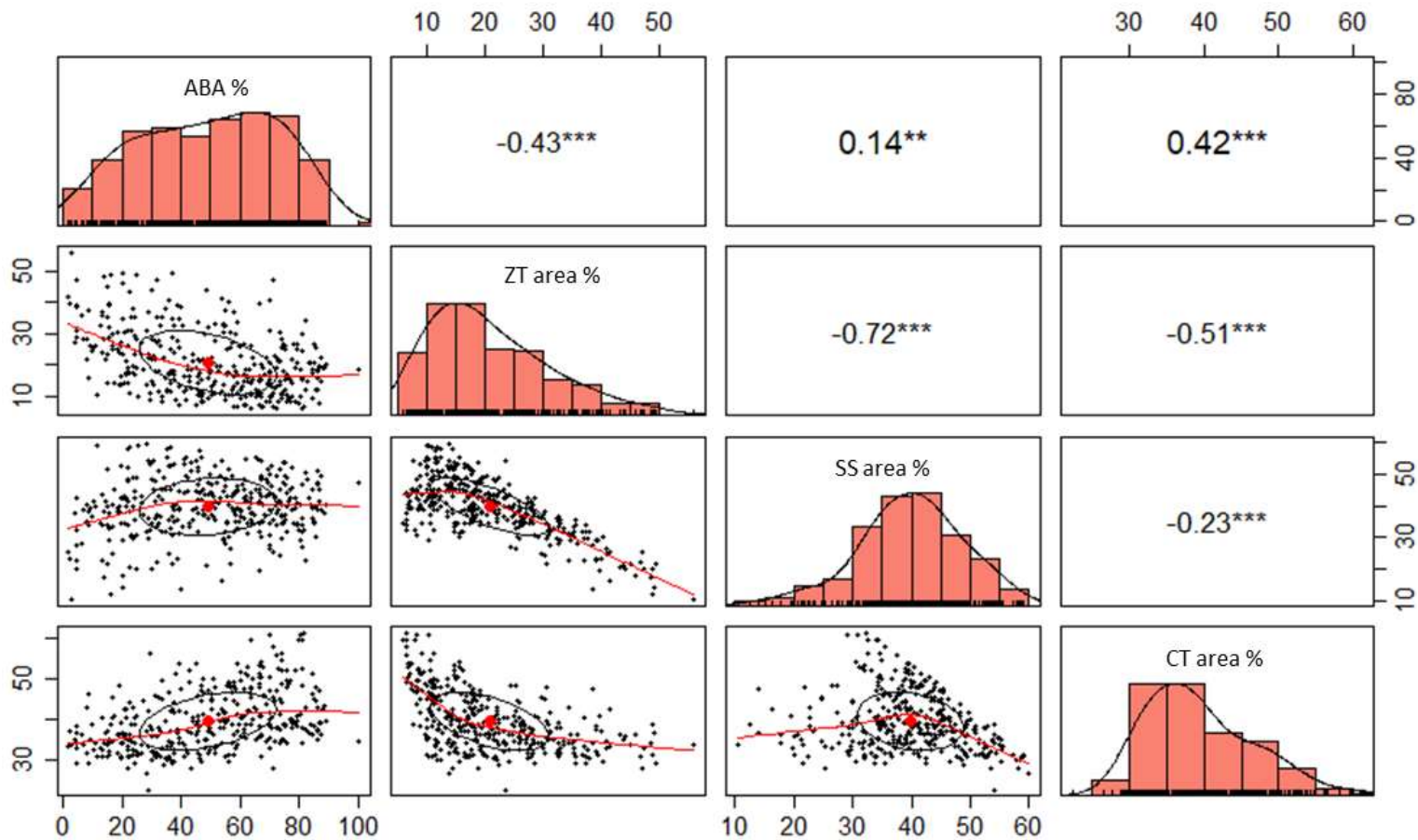
(a) Tillage



(b) Residue burning



Correlation – Tillage and ABA



Village Fixed Effects Models

Dep. Variable: %ABA in the village

	Coeff. (Std. error) of FE Models	
	Sample (n = 366)	All rural villages## (n = 16,686)
% Cultivated area under zero tillage	-0.655*** (0.165)	-0.395*** (0.022)
% Cultivated area under super seeder	-0.639*** (0.121)	-0.479*** (0.017)
Village characteristics	Yes#	No
Year dummies	Yes	Yes
F-statistics	141.41***	5498.39***

Labor-farmer ratio (2021) interacted with year dummies; *** p<0.01

Within 8 study districts of Punjab.

Village IV Fixed Effects Models

Dep. Variable: %ABA in the village

	Coeff. (Std. error) of IV-FE Models	
	Sample (n = 366)	All rural villages ^{##} (n = 16,686)
% Cultivated area under zero tillage	-2.806* (1.178)	-4.362*** (0.372)
% Cultivated area under super seeder	-2.011** (0.746)	-2.854*** (0.179)
Village characteristics	Yes [#]	No
Year dummies	Yes	Yes
Wald Chi ² Statistics	7685.16***	73799.09***

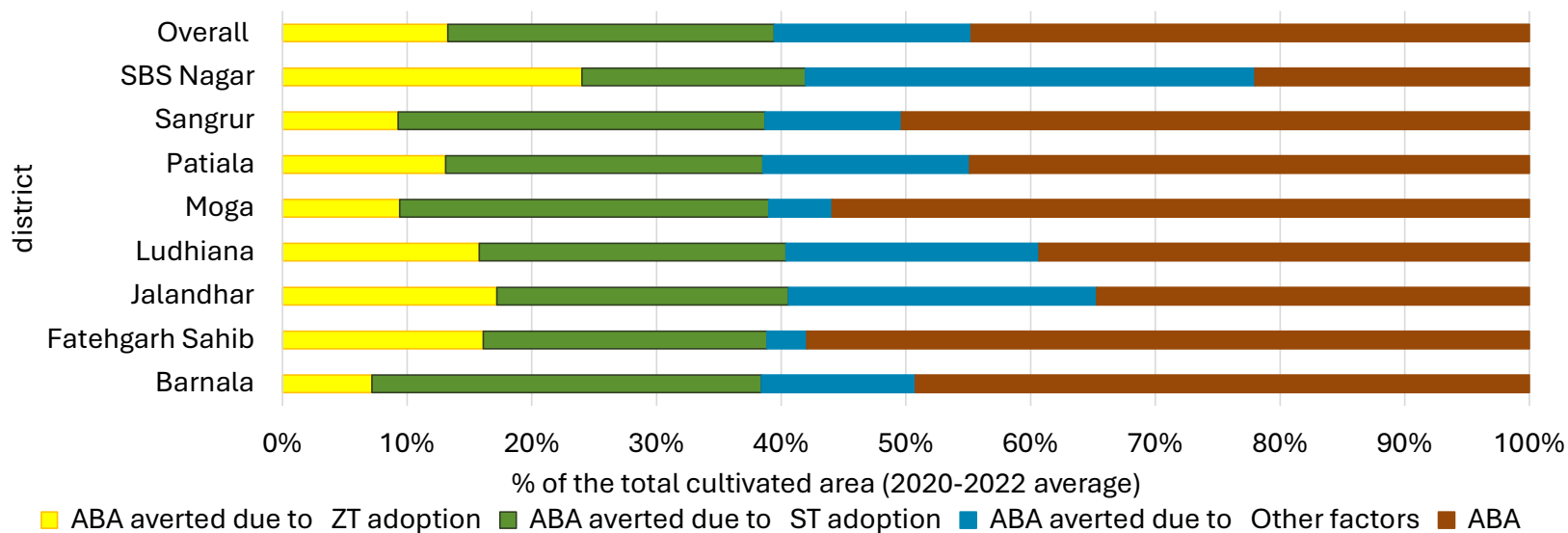
[#] Labor-farmer ratio (2021) interacted with year dummies; *** p<0.01; ** p<0.05; * p<0.10.

^{##} Within the 8 study districts of Punjab.

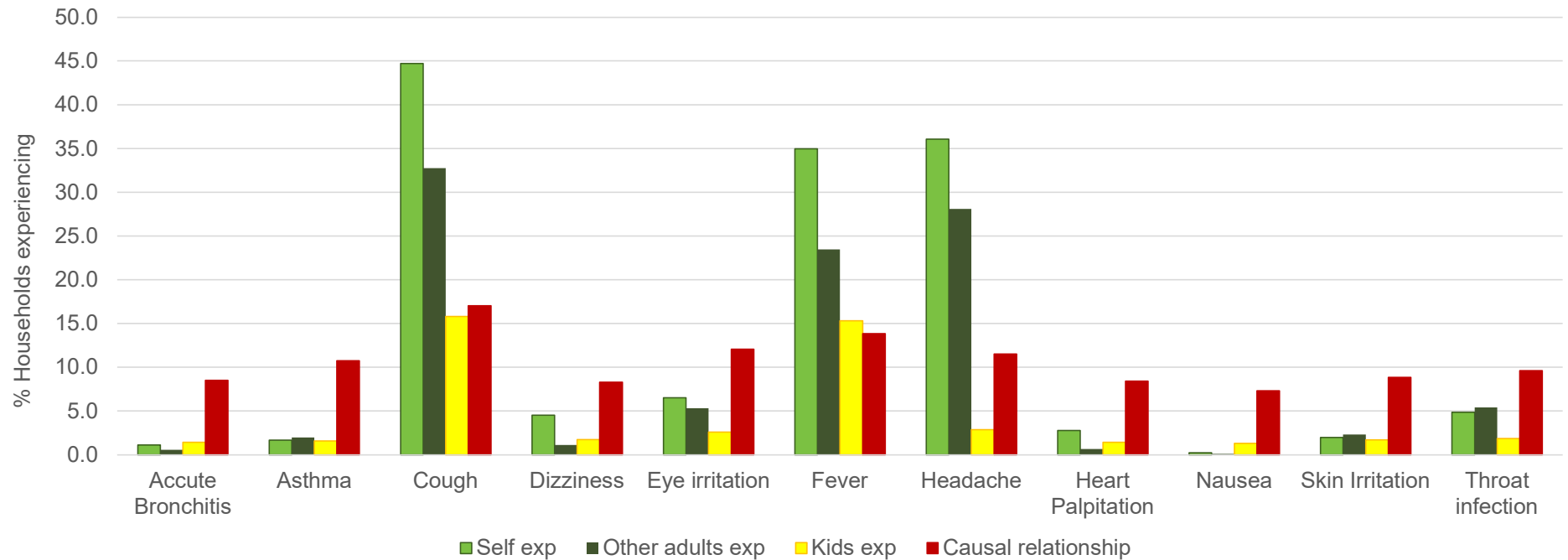
Impact Summary



Technology	ABA Saved (000 ha/yr)	Straw not burned (million tons/yr)	Emission reduction (m tons CO2e/yr)	Value in current C markets (m US\$/yr)
Zero tillage	225.1	1.38	1.88	47.0
Shallow tillage	447.5	2.74	3.74	93.5



Farmer Perceptions on Residue Burning



The figure shows the percentage of households who experienced a health problem during the residue burning time (n = 904 wheat farmers). 78% Did not associate any health problems with burning and resultant air pollution.



Summary

- CA and shallow tillage curtails residue burning in Punjab
- Zero tillage machines get approx. US\$ 1.5 million/year subsidy and generate US\$ 47 million worth of carbon credits.
- Shallow tillage machines: Successful technology, insufficient R&D
- Sub-optimal adoption of CA requires new strategies and policies.
- Problem with the current narrative and regulations.
- Lack of awareness about the local effects of the residue-burning problem
 - Particulate matter significantly reduces life expectancy.
- Sufficient room for generating public goods of CA – need to internalize the positive externalities.

Forthcoming Study: Wider ecological impacts

- No study till now on the effect of residue burning on other organisms.
- But there is proof for:
 - Residue burning causing air pollution
 - Air pollution affecting other living beings (birds, butterflies, bees)
- We are currently doing a preliminary analysis of the effect of residue burning on bird population
- Indicator variable: Levels of ecological and functional diversity of birds.
- Data available on residue burning and bird population over the last 4-5 years in India.





**Thank you for
your interest!**

