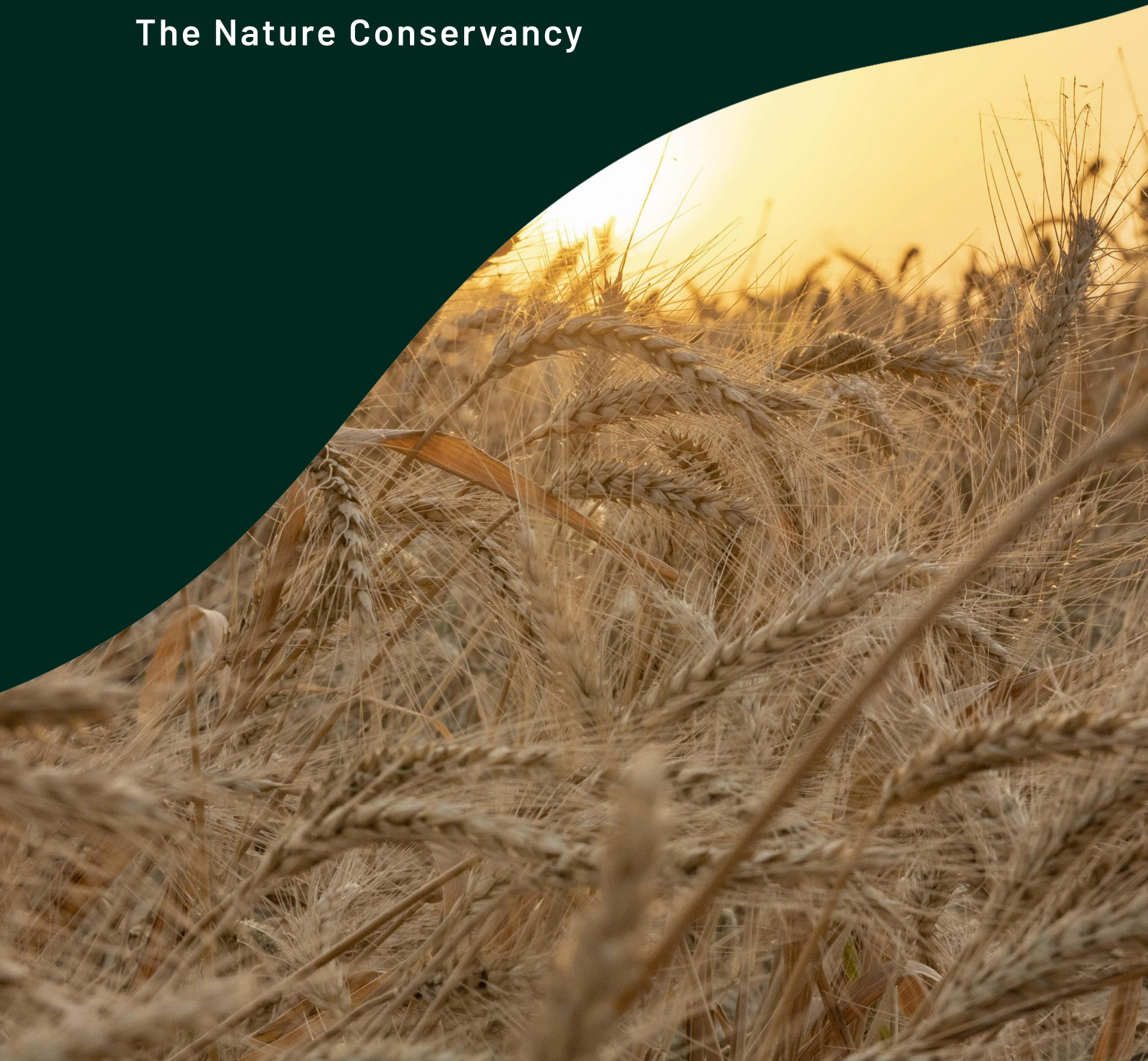


Charting a Course for Effective Crop Residue Management in Punjab – Key Learnings from TNC's PRANA Project

The Nature Conservancy



Introduction

Punjab, often referred to as the 'Granary of India', produces large amounts of food crops such as wheat and rice that feed India. In the agricultural year 2022-23, Punjab contributed an impressive 122 lakh metric tonnes (~21%) of rice to the Food Corporation of India's central pool¹. However, this production, which generates some 20 million² metric tonnes of crop residue annually, presents significant environmental and health challenges to people from residue burning across Northwest India.

Crop residue burning (CRB) in Punjab continues to be a pressing concern for policy makers because of resulting effects on air pollution and soil degradation. Punjab has the highest share of greenhouse gas (GHG) emissions from crop residue burning in India³, with around 1.6 million hectares of agricultural land burnt in 2020⁴. These black carbon emissions impact human health in multiple ways⁵. The practice also hurts farmers⁶ as it reduces soil nutrients like carbon and nitrogen and increases soil temperature.

Since 2018-2019, the government has subsidized various in-situ and ex-situ machines used for mulching, incorporating, and removing residues from the field without the conventional practice of burning. This has increased farmers' access to over 100,000 crop residue management (CRM) machines in Punjab⁷, both directly and through Custom Hiring Centers (CHCs) and cooperatives. For this and other reasons, fire events from burning paddy residues declined by ~50 per cent from 2021 to 2023⁸.

To tackle the pressing issue of crop residue burning, The Nature Conservancy launched Project PRANA (Promoting Regenerative and No-burn Agriculture), a large-scale behavioral and extension services intervention aimed at reducing CRB and promoting sustainable crop residue management practices in 2022. In its second year of implementation, PRANA expanded its reach to 5200 villages across 18 districts of Punjab, up from 1704 villages in 12 districts in the first year. The project's holistic efforts included farmer training and field demonstrations, facilitated access to machinery, behavior change communication campaigns and local stakeholder engagement to create a more supportive ecosystem for sustainable agricultural practices.

¹Severe Air Pollution: Punjab's Shift From Paddy May Hit Fci's Rice Procurement Ops | Chandigarh News - Times of India (indiatimes.com)

²<https://www.downtoearth.org.in/agriculture/stubble-burning-a-problem-for-the-environment-agriculture-and-humans-64912>

³Deshpande, M. V., Kumar, N., Pillai, D., Krishna, V. V., & Jain, M. (2023). Greenhouse gas emissions from agricultural residue burning have increased by 75% since 2011 across India. *Science of the Total Environment*, 904, 166944

⁴<http://creams.iari.res.in/pdf/bulletinsp20/05RiceResidueBurnStatistics2020.pdf>

⁵Air quality impacts of crop residue burning in India and mitigation alternatives

⁶Shyamsundar, P., Springer, N. P., Tallis, H., Polasky, S., Jat, M. L., Sidhu, H. S., ... & Somanathan, R. (2019). Fields on fire: Alternatives to crop residue burning in India. *Science*, 365(6453), 536-538

⁷Press Release: Press Information Bureau (pib.gov.in)

⁸<https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1981276>

Over the last two years, PRANA staff reached out to more than 400,000 farmers across 5000 villages to promote the use of alternative rice production strategies such as direct seeded rice and short duration paddy varieties, and in-situ crop residue management. Farmer field days, and field schools set up across 2000+ demonstration sites, built capacity in in-situ CRM methods among more than 60,000 farmers. In partnership with local institutions, a pool of 2000+ in-situ CRM machinery service providers was technically trained and supported in establishing connections to farmers during the crucial crop residue burning season.

Assessing changes in crop residue management

In order to capture trends in crop residue burning activities, a baseline (in 2021, before the project start) and a midline (in 2024) survey of farmers was undertaken. Results from these surveys provide valuable insights into changes in farmer actions over time, the effectiveness of project interventions, and steps required to further scale the initiative. Key metrics such as area under no burning, cost of cultivation and usage of CRM machinery were measured.

The surveys used a stratified two-stage clustered sampling methodology, where the primary sampling unit is a village. Farmers were randomly selected from each village, while maintaining the state-level ratio of small, marginal, medium, and large farmers. The analysis presented is based on a sample size of 1414 farmers across 10 districts.



Overall trends in crop residue management

a) Farmers in Punjab are moving away from crop residue burning as a practice of paddy residue management.

Between 2021 and 2023, there was a 19% reduction in farmers burning crop residue (Fig 1). The shift in burning practices is largely driven by a transition away from complete burning of crop residues (only 6 per cent of the farmers reported complete burning in 2023) to other practices, including partial burning, incorporation and ex-situ practices. Partial burning of residues continues to be practiced by 25 per cent of the survey farmers.

Incorporation of residues the most prevalent CRM practice, witnessed an increase of 3 per cent between 2021-23.

b) Short duration rice varieties, which provide farmers with more time to dispose crop residue, are increasingly cultivated (Fig 2).

The percentage of plots cultivating the short duration PR-126 variety increased from 19 percent in 2021 to 51 per cent in 2023 among the surveyed farmers, with an accompanying decline in plots cultivating longer duration Pusa 44 and Pili Pusa varieties.

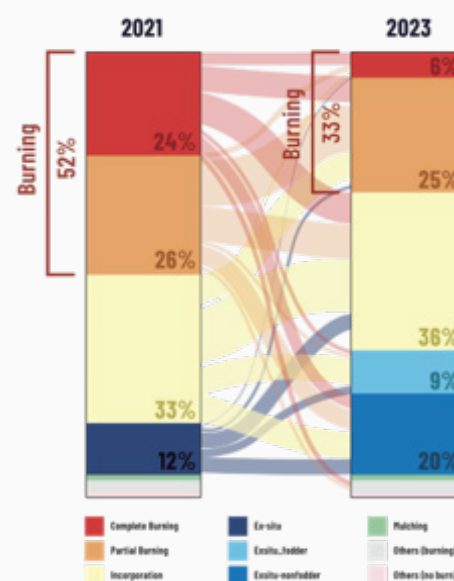


Figure 1: Share of sampled farmers practicing different methods of crop residue management

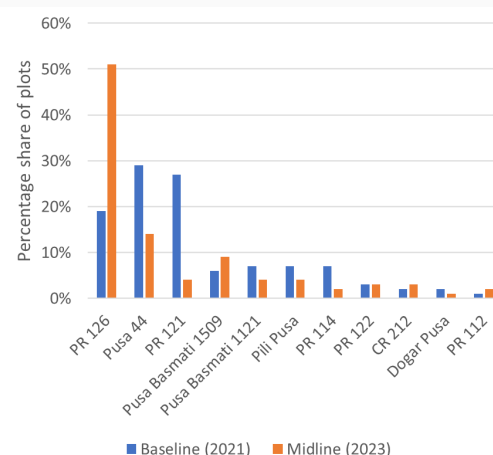


Figure 2: Share of plots cultivating different rice varieties in the survey areas

c) The use of traditional machinery that accompany burning practices (seed-drill, plunker, stubble shaver, roto-drill and rotavator) declined by 11% over the two-year period of the survey (Fig 3).

The use of super seeders, machines that help reduce crop burning through incorporating the straw, increased by some 46% between 2021-2023, while the traditional rotavator declined by 75%. The share of farmers using balers and rakers, typically used when residue is removed from the fields for alternate use, increased by 17%. The usage of the Straw Management System mounted combine harvester, useful for managing straw as mulch, declined by 4 per cent.

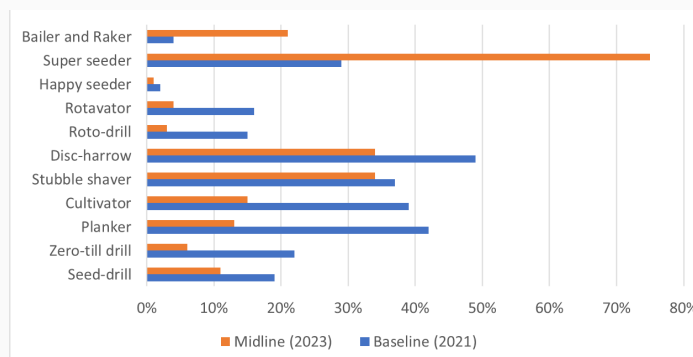


Figure 3: Share of farmers using CRM and traditional machines during two periods across the survey regions

d) Farmers are more likely to own traditional machines and rent CRM machinery, suggesting growth in rental markets.

The use of CRM machinery rental increased by 11%. Super seeders are popular machines to rent, with 85 percent of the farmers using super seeders renting the machine from Cooperatives, fellow farmers or rental service providers in 2023. This reflects a 17% increase over two years in the share of farmers renting the machine. Custom Hiring Centers (CHCs) do not appear to be a common source for renting.

e) Ex-situ management gained significant traction among farmers, with a 2.5-fold increase since 2021.

Ex-situ removal of residue, which is mainly done through the use of private entrepreneurs (80%), is used as fodder or as raw material for power plants. Some 69 per cent of the surveyed farmers who practiced ex-situ management of residue, said that the residue had been used for non-fodder purposes in 2023.

f) There is significant variation in the average cost of machinery used across different land preparation and sowing practices, with the average cost being highest for ex-situ practices followed by incorporation.

The total cost of machinery used follows a similar trend. Further, for ex-situ practices, the average cost varies the most. The cost is high for farmers who pay to have residue removed, it is lower for farmers whose residue are removed by external stakeholders free of cost, and lowest for farmers who use their residue as fodder.

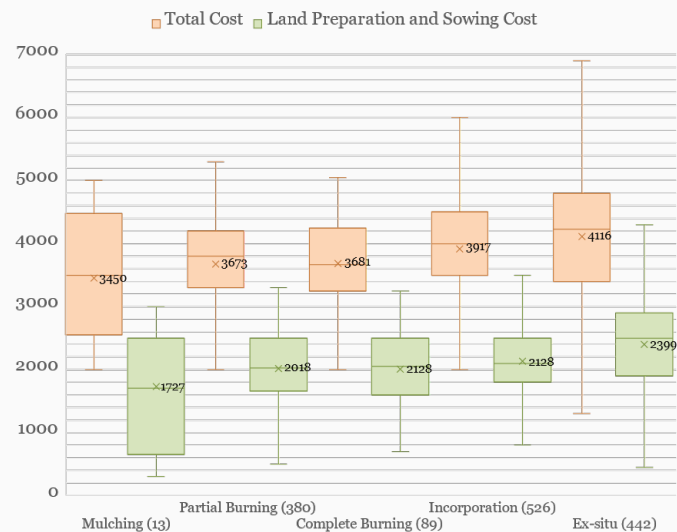


Figure 4: Average cost incurred by farmers for land preparation and sowing and total cost of machinery usage across different CRM practices.

*The total cost of machinery includes cost of harvesting in addition to land preparation and sowing.

Trends in interventions regions of the PRANA project

There was a 6% overall decline in farmers undertaking burning in the PRANA intervention areas relative to non-intervention areas during the period 2021-23. Complete burning declined by some 9% among farmers in project areas relative to no-project areas over the two-year period. Changes in partial burning between project and non-project areas are not statistically significant.

Residue incorporation increased in the PRANA intervention areas by 8% between 2021-23, contrasting with a noticeable 6% decline in non-intervention areas. The usage of super seeders by farmers for incorporating residue increased by 9% points in project areas over the two-year period.

Ex-situ management of rice residue increased in project and non-project areas. The increase in ex-situ management strategies was higher in non-project areas, with 5% more farmers using ex-situ residue management in non-project areas relative to project areas.



Figure 5: Share of farmers practicing different CRM methods in intervention vis-s-vis non-intervention regions.

*The difference in changes in intervention and nonintervention groups is statistically significant except for partial burning.

Discussion

Crop residue burning is on the decline since 2021. Farmers have shifted away from complete burning of residues to other practices such as incorporation (the most prevalent method of residue management practiced in 2023) and ex-situ residue management.

A quarter of the surveyed farmers in 2023 practiced partial burning. Though the share of farmers in this category remained almost similar across two periods (Fig 1), some have shifted away from this practice while others have taken it up. The continued presence of partial burning may be because of difficulties farmers face in incorporating all the straw into their lands, resulting in them burning the top portions of the straw before incorporation. Another reason motivating partial burning may be agronomic issues associated with the increased presence of pests and rodents in the residue left on the ground.

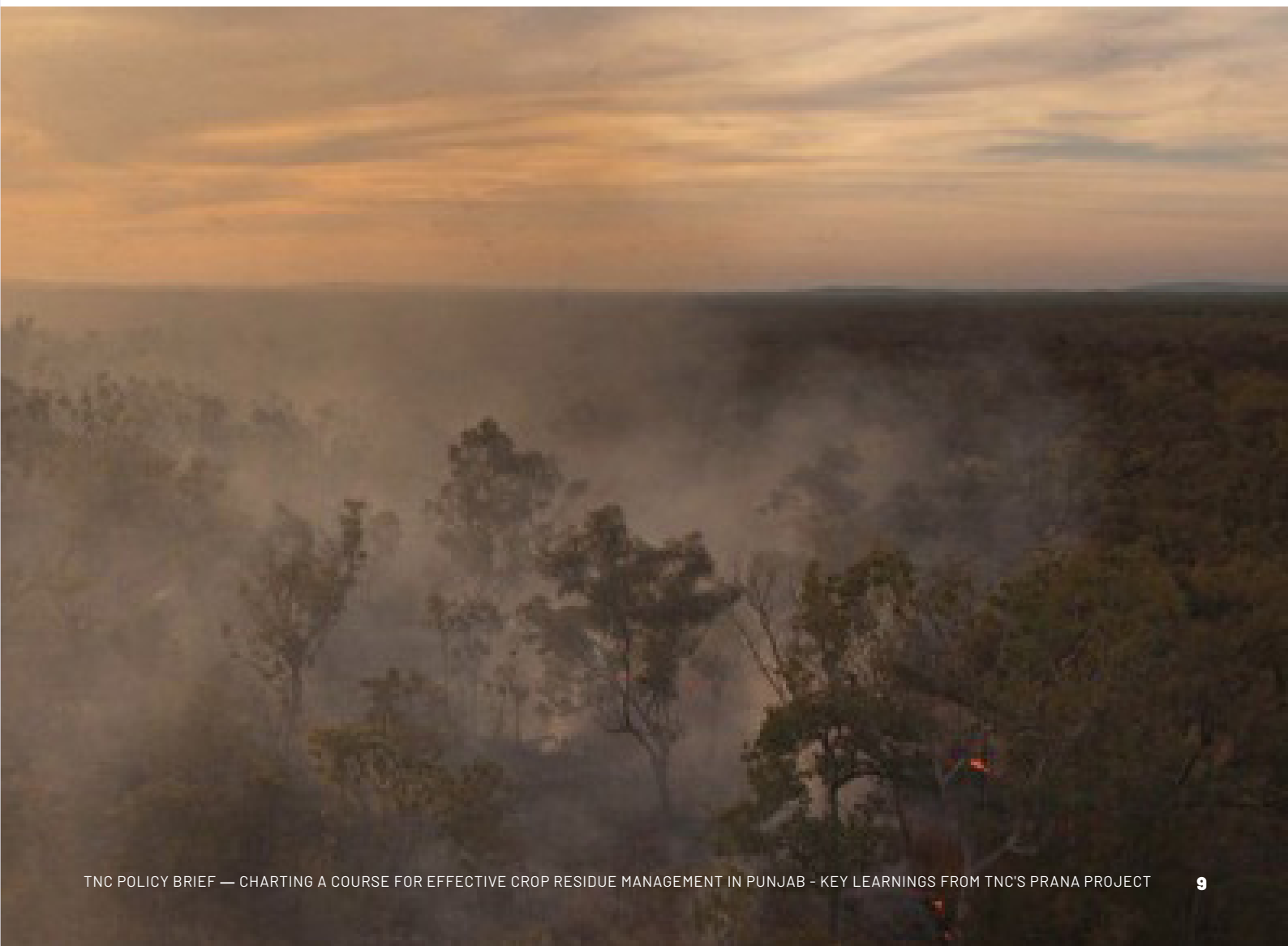
The decline in residue burning can be partially attributed to changes in the variety of paddy being cultivated. More than half the plots with long-duration paddy varieties were associated with complete or partial burning of residues in 2023, whereas only one-fourth of the plots cultivating short-duration varieties were burnt. This is because there is less stubble associated with shorter duration paddy varieties. Similarly, only 16% farmers cultivating basmati burned their residues, relative to 36% of non-basmati paddy growers. This reflects the common use of basmati residue as animal fodder. Survey data suggests that farmers are moving away from cultivating long duration varieties of paddy as there was a 23% reduction in plots with long duration rice between 2021-23.



Another important reason for reduction in burning is the increasing use of both in-situ and ex-situ CRM machinery. The dominant use of super seeder machines (by 75% of farmers in 2023) is tied to both reductions in complete burning and the continued presence of partial burning. Farmers like this machine as it helps incorporate residue into the soils and provides a clean view of the field. In 2023, 80 per cent of the farmers doing partial burning and incorporation used super seeders in addition to 56 per cent of those practicing ex-situ.

The adoption of ex-situ residue management practices has stepped up significantly over the two years, with 20 percent of the farmers in our survey removing the residues from the fields for non-fodder uses in 2023. The usage of balers and rakers, which helps remove residue for ex-situ use, increased by a massive 17 per cent in the two years. The presence of private entrepreneurs in ex-situ markets seems to influence this trend, as they provided services to around 85 percent of the ex-situ farmers.

The growth in rental markets for CRM machinery is contributing to options that help farmers reduce burning. The rental market includes fellow farmers, service providers/private entrepreneurs, Custom Hiring Centers and cooperatives. The share of farmers renting the CRM machines like super seeders, balers and rakers increased by 11 percent over two years, the highest growth being observed in the ex-situ service provision. Custom Hiring Centers do not appear to be a common source for renting. Still, lack of access to machinery is a major reason cited by nearly half the farmers who continue to burn their crop residues in 2023. This highlights a need to further strengthen the linkages between machinery service providers and farmers.



Policy recommendations

1. Continue existing government schemes that support farmers as residue burning, overall, is trending downward. One concern is the persistent practice of partial burning, which needs to be further understood to design appropriate solutions. Another aspect to be explored is the benefits from current subsidy programs to small farmers to identify what additional incentives (if any) might be needed to support the transition for them.
2. Provide agronomic support for the farmers to support no-burn transitions. One-fourth of the farmers practice partial burning of residues, which has remained steady through the study years. Fifty percent of farmers who burned residue in 2023 point to concerns related to agronomic challenges emerging from weeds and pests. This suggests a continued need to provide agronomic support to farmers to learn new farm management practices.
3. Mobilize shifts toward adoption of Short Duration Rice Varieties from Long Duration Varieties such as Pusa 44. As the paddy variety cultivated significantly impacts the residue burning occurrence, the government's latest move to ban long duration Pusa varieties will likely help in decreasing burning. It will support farmer transitions by reducing the amounts of biomass to be managed, decrease clogging of in-situ machines and provide additional benefits by saving ground water.
4. Continue to strengthen access to In-situ machinery. Though lack of access to machinery no longer remains the most cited reason to practice residue burning, it is still identified as a pertinent challenge by farmers who continue to burn. It is also found that most of machinery owners (often provide CRM services to other farmers), are not able to utilize these machines in full capacity. Innovative financing models such as pay for result for machinery rental providers and improving the services provided by Custom Hiring Centers may help increase access.
5. Sustainable ex-situ residue management options such as biochar that increase soil nutrients need policy consideration. Ex-situ management practices have broadly gained traction in the state. Some 69% of farmers surveyed indicated that residue is removed from the fields to be used in power plants, cardboard factories, and other similar uses; however, such practices may contribute to nutrient losses and yield reductions over time.

Acknowledgement

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