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Understanding Farmers' Adoption of Crop Residue Management Practices: Barriers Beyond Awareness

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Abstract

Crop residue burning continues to be prevalent in India despite warnings for decades. This article discusses a field survey of 150 farmers in three villages of Raipur district in Chhattisgarh on their knowledge and adoption of Crop residue management (CRM) practices. Findings indicate a shocking gap: despite being aware of the environmental degradation caused by burning, 93.33% of farmers still do not practice sustainable alternatives like mulching, composting or Happy Seeder technology. Structural constraints, costly machinery, delayed subsidies, and limited technical training come to dominate the list of barriers, dwarfing attitudinal resistance. The study posits that closing this awareness-adoption gap must involve intervention on the infrastructure and financial levels, rather than more general environmental messages, lessons that go beyond Chhattisgarh's fields.

Keywords: Crop residue burning; Crop residue management (CRM); Farmer awareness; Technology adoption; Chhattisgarh.

A Familiar Haze, a Familiar Habit

Every year, as the paddy fields of central India are stripped bare after harvest, a thin grey haze descends upon villages and towns. It is the smell of stubble burning, a practice so ingrained into Indian farming that it is invisible to the people who practice it even as it becomes more visible on satellite maps and air-quality indices. For years, agricultural scientists have warned of the price to be paid for this quick, cheap method of clearing fields between crops: depleted soils, dirty air and an increasing contribution to climate change. But farmers continue to use these matches anyway because the alternative is often too hard, too expensive, or too little understood.

A recent field study by three villages of Raipur district in Chhattisgarh - Dharampura, Pirda and Nakati, set out to unravel this paradox. Interviewing 150 farmers face-to-face on their own farms and in their homes during the 2025–26 season, the study asked a deceptively simple question: how much do farmers actually know about crop residue management, and how much of that knowledge translates into action? The answers reveal a story that is less about ignorance and more about the gap between awareness and access.

Methodology at a Glance

Raipur district was chosen for the study on grounds of accessibility, and four villages were shortlisted, of which Dharampura, Pirda, and Nakati were randomly selected. Fifty farmers were interviewed in each village 150 in total through structured personal interviews conducted in a relaxed, confidential setting designed to encourage candid responses about both what farmers knew and what they actually practised on their land.

Why Residue Management Matters More Than Ever

India's agricultural success story built on mechanization, irrigation, and high-yielding varieties has an unglamorous byproduct. Intensive cropping systems such as rice-wheat and rice-chickpea rotations generate hundreds of millions of tonnes of crop residue every year, according to estimates from the Indian Council of Agricultural Research. Rice straw, wheat straw, maize stover, and sugarcane trash are not waste in any meaningful sense; they are reservoirs of nitrogen, phosphorus, potassium, sulphur, and organic carbon that, if returned to the soil, could sustain fertility for generations.

Burned instead, this biomass releases its nutrients into the air rather than the earth. Nitrogen and sulphur volatilise and vanish; the carbon that could have built soil organic matter goes up as carbon dioxide, methane, and nitrous oxide, alongside particulate matter fine enough to penetrate deep into human lungs. The widespread practice of open-field crop residue burning is illustrated in Figure 1. The Central Pollution Control Board has repeatedly documented seasonal pollution spikes tied to residue burning, and the resulting respiratory and cardiovascular health burden extends far beyond the fields themselves, into cities and towns downwind. Over time, repeated burning also degrades soil structure and water-holding capacity, pushing farmers toward greater reliance on synthetic fertilisers and raising both production costs and environmental risk. The widespread practice of open-field crop residue burning is illustrated in Figure 1.

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Figure 1. Open-field burning of crop residues following harvest, a common practice contributing to air pollution, nutrient loss, and greenhouse gas emissions.

The alternative is not simply 'don't burn' it is a suite of technologies and practices collectively known as Crop Residue Management, or CRM. These fall into two broad families. In-situ management keeps residue on or in the field: mulching the surface, incorporating stubble into the soil, or sowing the next crop directly through the residue using machines like the Happy Seeder, Super Straw Management System, zero-till drills, and rotavators. Ex-situ management removes the residue for use elsewhere composting, vermicomposting, livestock fodder, mushroom cultivation substrate, packaging material, or biomass energy. Both pathways offer farmers a way to turn a disposal problem into an asset, but both also demand knowledge, equipment, and sometimes capital that not every farmer has in equal measure. An example of in-situ crop residue management through paddy straw mulching in chickpea is presented in Figure 2.

Figure 2. In-situ crop residue management through paddy straw mulching in chickpea for improved soil conservation and sustainable residue utilization.

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Who Are the Farmers Behind the Numbers?

To understand adoption patterns, the study first mapped the socio-economic profile of its 150 respondents. The picture that emerges is of a farming community in its productive prime, but with limited financial cushioning. More than half (54.67%) of respondents fell into the middle-age bracket of 36 to 55 years, suggesting a population actively engaged in day-to-day decision-making rather than one dominated by either very young or retired landholders.

Education levels were moderate: just 12% were illiterate, while the largest single group (30.67%) had completed secondary schooling, and a further 22.67% had higher secondary education. Landholding told a more constraining story a full 60% of respondents were classified as marginal (up to 1 hectare) or small (1–2 hectares) farmers, the two categories least able to absorb the upfront cost of CRM machinery. Annual income clustered in the 1–3 lakh range for 45.33% of respondents, with just over a quarter earning above 3 lakh. Farming experience was substantial half the sample had between 11 and 25 years in the field and contact with agricultural extension services was 'medium' for 47.33% of farmers, but still low for nearly 30%. Taken together, these figures sketch a population with real farming knowledge and moderate education, but constrained by small landholdings, mid-range income, and inconsistent access to extension advice a combination that, as the results below show, shapes behaviour more than attitude does. The socio-economic profile of the surveyed farmers is summarized in Table 1.

Table 1: Socio-economic snapshot of the 150 surveyed farmers

Socio-economic	Indicator Category	Share of Farmers
Age	Middle-aged (36–55 yrs)	54.67%
Education	Secondary schooling	30.67%
Landholding	Marginal + small (≤2 ha)	60.00%
Annual income	1–3 lakh (medium	45.33%
Farming experience	11–25 years (medium)	50.67%
Extension contacts	Medium level	47.33%

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What Farmers Know: A Story of Uneven Awareness

On the question of awareness, the news is largely encouraging with important caveats. An overwhelming 93.33% of farmers understood that residue burning contributes to environmental pollution, and 88% were aware of its harmful effects more broadly. Knowledge of nutrient loss from burning was also high, at 80%. These are not marginal figures; they indicate that the core environmental message about stubble burning has reached deep into rural Chhattisgarh.

Where awareness thins out is in the specifics the tools and institutional support that could actually change behaviour. Only 46.66% of farmers had heard of Happy Seeder technology, and just half (50.67%) knew about bio-decomposers, the microbial sprays used to accelerate residue breakdown in the field. Awareness of government subsidy schemes stood at 61.33%, meaning nearly four in ten farmers had no idea that financial support for CRM equipment might even exist. Awareness of mulching benefits (73.33%), composting (70%), and mushroom cultivation using paddy straw (65.33%) fell in between solidly promoted concepts, but not yet universal knowledge. When these individual indicators were combined into an overall awareness score, 54.67% of farmers landed in the 'medium' category, with 26.66% classified as highly aware and 18.67% still in the low-awareness bracket. The pattern is clear: farmers grasp the 'why' of residue management far better than the 'how.' They know burning is bad. Fewer know what, precisely, to do instead and even fewer know that help exists to do it. Statement-wise awareness levels of farmers regarding CRM practices are presented in Table 2.

Table 2: Statement-wise awareness of CRM practices (n = 150)

Awareness Statement	% Aware
Environmental pollution from burning	93.33%
Harmful effects of burning (general)	88.00%
Soil nutrient loss due to burning	80.00%
Mulching benefits	73.33%
Composting of residues	70.00%
Mushroom cultivation using straw	65.33%

Government subsidy schemes	61.33%
Bio-decomposers	50.67%
Happy Seeder technology	46.66%

What Farmers Actually Do: Adoption Lags Behind Understanding

If awareness were the whole story, residue burning would already be in retreat. But knowing and doing are separated by a wide and familiar gulf. When the same 150 farmers were asked about their actual practices, adoption of CRM technologies came in noticeably lower than corresponding awareness levels.

Mulching was the most widely adopted practice, used by 48% of farmers a relatively low-cost, low-complexity option that requires no specialised machinery. Mushroom cultivation using straw followed at 40%, offering farmers a direct income stream alongside residue disposal. Compost preparation was practised by 36% of respondents. Further down the list, the more capital-intensive and technically demanding options lagged: bio-decomposer use stood at just 25.33%, and in-situ incorporation using Happy Seeder or manual methods was adopted by only 22.67% of farmers despite Happy Seeder being one of the most heavily promoted CRM technologies in policy circles.

Perhaps most tellingly, 30.67% of farmers reported still practising partial burning, and 18.67% admitted to complete burning of residues. When aggregated into an overall adoption index, only 20% of farmers achieved a 'high' adoption score, while 45.33% sat at 'medium' and a substantial 34.67% remained at 'low' adoption. The gap between the 93.33% who know burning pollutes the air and the 18.67% who still burn everything anyway is the central tension this study lays bare: understanding a problem and having the means to solve it are two very different things.

The Real Barriers: Time, Money, and Machines

Ask farmers why they still burn despite knowing better, and the answers are strikingly practical rather than ideological. The single largest constraint identified was the tight turnaround between harvesting one crop and sowing the next cited by 80% of respondents. In rice-wheat systems especially, the window between crops can be a matter of days, and residue-heavy fields slow down sowing operations considerably unless the right machinery is on hand immediately.

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Machinery cost came a close second: 78.67% of farmers pointed to the high price of CRM equipment as a barrier, and 73.33% said machines simply were not available when needed, even where custom hiring centres exist on paper. Labour shortage compounded the problem for 61.33% of respondents, while 68% cited a lack of subsidy or delays in subsidy disbursement, and 57.33% pointed to insufficient technical knowledge about how to actually operate or benefit from CRM technologies. None of these are attitude problems. They are supply-chain, financing, and logistics problems. The major constraints reported by farmers in adopting CRM practices are summarized in Table 3. A farmer who has ten days to clear a field, cannot book a Happy Seeder in time, and has watched a promised subsidy fail to arrive on schedule will burn the stubble not because they don't understand the consequences, but because the alternative, in that moment, is not actually available to them.

Table 3. Major constraints reported by farmers in adopting CRM *(n = 150)*.

Constraint	**% Reporting**
Time constraint between crops	80.00%
High cost of machinery	78.67%
Non-availability of machinery on time	73.33%
Lack of subsidy / delayed subsidy	68.00%
Labour shortage	61.33%
Lack of technical knowledge	57.33%

Turning Awareness into Action

The study's recommendations follow directly from this diagnosis. Rather than more general awareness campaigns which the data suggest have already achieved considerable reach the emphasis falls on removing structural and financial friction. Strengthening custom hiring centres so that Happy Seeders, mulchers, and Super Straw Management Systems are actually available within the narrow sowing window is a recurring theme. So is ensuring subsidy schemes disburse funds without the delays that currently undermine their credibility.

Equally important is closing the knowledge gap around specific technologies rather than general environmental harm. Field demonstrations, farmer field schools, and hands-on training in

bio-decomposer application or composting technique could move awareness from the abstract ('burning is bad') to the operational ('here is exactly what I do instead'). The study also points to farmer cooperatives and shared machinery ownership as a way for marginal and small landholders 60% of the sample to access equipment they could never justify buying individually. Finally, recognising and publicly rewarding early adopters may harness the same peer-influence dynamics that currently spread burning as the default, redirecting social pressure toward sustainable alternatives instead.

Mass media, mobile messaging, and farmer fairs are recommended as low-cost channels for closing the subsidy-awareness gap specifically since more than a third of farmers currently do not know that financial assistance for CRM equipment exists at all. Combined with more frequent village visits by extension personnel, these channels could shift the 'medium awareness' majority toward the 'high awareness' tier much faster than blanket public messaging alone.

Beyond the Field: Why This Matters to Everyone

The consequences of this awareness-adoption gap extend well past the villages surveyed. Residue burning's particulate matter and greenhouse gas emissions do not respect administrative boundaries; they drift into cities, contribute to regional air-quality crises, and add to the atmospheric carbon load driving climate change. Conversely, every hectare where residue is retained as mulch or incorporated into soil represents a small increment of carbon sequestration, improved water retention, and reduced fertiliser dependence benefits that ripple outward into food security and rural resilience against increasingly erratic weather.

The Chhattisgarh study, small in geographic scope but rich in detail, offers a template for thinking about this problem elsewhere in India. It suggests that the next phase of the fight against stubble burning will not be won primarily through more posters and pamphlets about air pollution farmers have largely absorbed that message already. It will be won through custom hiring centres that actually have machines on the day they're needed, subsidies that arrive before the sowing window closes, and training that teaches not just why residue management matters, but exactly how to do it, practice by practice, tool by tool.

Conclusion

This study demonstrates that the persistence of crop residue burning in rural Chhattisgarh is not a failure of environmental understanding but a failure of enabling infrastructure. Farmers

overwhelmingly recognise the ecological and health costs of burning, yet adoption of sustainable alternatives such as mulching, composting, bio-decomposers, and Happy Seeder technology remains constrained by narrow sowing windows, high machinery costs, delayed subsidies, and uneven technical support challenges concentrated most heavily among the marginal and small landholders who dominate the sample. Bridging this awareness-adoption divide will require less emphasis on generic public messaging and far greater investment in accessible custom hiring centres, timely subsidy disbursement, hands-on technical training, and cooperative machinery-sharing models for resource-poor farmers. If these structural barriers are addressed, the considerable environmental knowledge farmers already possess can finally translate into practice reducing air pollution, rebuilding soil health, and strengthening the long-term resilience and sustainability of India's farming systems.

Source: Field survey of 150 farmers across Dharampura, Pirda, and Nakati villages, Raipur district, Chhattisgarh (2025–2026); data on socio-economic profile, awareness, adoption, and constraints regarding crop residue management practices.