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Environmental and health awareness versus practical knowledge: A comparative assessment of farmers' understanding of crop residue management in Gwalior district, Madhya Pradesh, India

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Abstract

This descriptive survey, conducted in Gwalior, Madhya Pradesh between 2025 and 2026, aimed to assess farmers' awareness of the environmental and health hazards of crop residue burning and compare it against their knowledge of crop residue management (CRM) alternatives. Using purposive sampling, personal interviews were conducted with 147 farmers registered for CRM machinery under the Custom Hiring Centre scheme. The results revealed a significant gap between awareness and practical know-how: while a majority of respondents (61.24%) demonstrated high awareness of the dangers of residue burning, only 19.73% possessed a high knowledge of CRM practices, with 53.74% showing only medium-level knowledge. This 41-percentage-point disparity highlights that while farmers understand why burning is harmful, they lack adequate knowledge of how to manage it, particularly regarding unconventional alternatives like biogas, mushroom production, and bio-decomposers. The study concludes that agricultural extension strategies relying solely on hazard-awareness messaging have reached their limit. To effectively eliminate crop residue burning and bridge this gap, policymakers must pivot toward hands-on, demonstration-based training that equips farmers with practical knowledge of specific CRM technologies.

Keywords: Crop residue burning, awareness, knowledge, crop residue management, farmers, Gwalior

1. Introduction

The world's agriculture has grown in terms of total crop production and diversification, which has resulted in the generation of a huge quantity of crop residue as a byproduct of the harvesting process. Globally, agricultural activities generate more than 5 billion tons of crop residue per year (FAO, 2024) ^[6]. India contributes approximately 650 million tons annually (NITI Aayog, 2023) ^[9]. While a portion of this enormously produced residue is traditionally used as fodder, fuel, roofing material and compost, a significant share still continues to be disposed of through open-field burning or stubble burning, an exercise that lets farmers clear their fields swiftly and cheaply ahead of the next sowing season.

Residue burning eventually offers a low-cost solution to a genuine time constraint faced by the farmers that arises between harvesting of the current crop and sowing for next season, but on the other hand it carries serious environmental and health consequences. Burning releases several harmful gases like carbon dioxide, carbon monoxide, and oxides of nitrogen and sulphur, along with particulate matter, into the atmosphere, and destroys nutrients and beneficial micro-organisms present in the soil (Bhuvaneshwari *et al.*, 2019) ^[2].

Madhya Pradesh has alarmingly emerged as a hotspot for this malpractice and shockingly surpassing Punjab and Haryana state. Madhya Pradesh astonishingly reported to account for a substantial share of India's paddy stubble-burning cases in recent years (Times of India, 2024) ^[14].

Extension literature on crop residue management has generally examined farmers' overall awareness regarding the hazards of stubble burning and their knowledge of alternative management practices as two connected but distinct dimensions of behaviour. Several studies report comparatively high awareness of the harmful effects of burning: Anuradha *et al.* (2021) ^[1] recorded high awareness among farmers of the Indo-Gangetic plain regarding effects on soil health, air quality and human health, and Ravi *et al.* (2022) ^[10] and Choudhary *et al.* (2022) ^[4] reported predominantly high to moderate awareness among farmers in Telangana and Haryana, respectively. Yang *et al.* (2025) ^[15] confirmed that a majority of farmers in Punjab perceived stubble burning as a serious air-quality problem.

At the same time, numerous studies suggest that this awareness does not automatically translate into a working knowledge of the various alternatives to stubble burning.

Reddy *et al.* (2024) ^[11] found that a significant share of the farmers remained unaware of specific scientific CRM practices such as composting, and Erbaugh *et al.* (2024) ^[5] observed that even farmers who acknowledged the harmful effects of burning often lacked the practical means and methods or proper knowledge to shift away from this malpractice. Kathpalia *et al.* (2026) ^[8] similarly reported a marked gap between farmers' knowledge of a CRM technology in principle and their understanding of its correct technical operation. These findings point to a possible disconnection between the hazard-recognition dimension of farmer behaviour and its technical, practice-oriented dimension — a distinction that has received limited direct empirical comparison within a single farmer sample.

Farmers in Gwalior district of Madhya Pradesh, many of whom have sought access to CRM machinery such as the Happy Seeder, Super Straw Management System (Super SMS) and zero-tillage equipment through the Custom Hiring Centre scheme, represent a population where such a comparison is particularly relevant, since their direct engagement with the subsidy system provided by the government suggests an intention to move away from burning that may or may not be matched by adequate technical understanding. Against this background, the present study was undertaken with the objectives to - (i) assess farmers' awareness of the adverse environmental and health effects of crop residue burning, (ii) assess their knowledge of CRM practices, and (iii) compare the two to determine whether a gap exists between what farmers recognise as harmful and what they know about the alternatives.

2. Materials and Methods

2.1 Locale of the study

The study was conducted during 2025–26 in Gwalior district of Madhya Pradesh, India, located in the Gird (Chambal) agro-climatic region of the state (26.22° N, 78.18° E). All four blocks of the district — Bhitwar, Morar, Dabra and Ghatigaon — were covered, as farmers seeking CRM machinery under the Custom Hiring Centre scheme of the Department of Agricultural Engineering, Gwalior, were distributed across all four.

2.2 Sampling procedure

A purposive, non-probability sampling technique was adopted. The sampling frame consisted of farmers which were the registered applicants with the Department of Agricultural Engineering, Gwalior, over the preceding twelve years (2012- 2024) to obtain or rent various CRM machinery such as the Happy Seeder, Super SMS and zero-tillage machines. The total registered applicants in this twelve-year span were finally considered the respondents for the study. As the size of this registered population matched the requirements of the study, all listed applicants were included, yielding a final sample of 147 farmers: 63 from Bhitwar, 41 from Morar, 28 from Dabra and 15 from Ghatigaon (Table 1). Because the sample was drawn specifically from farmers already engaged with the subsidy system for CRM machinery, the findings are most directly applicable to this subsidy-engaged population rather than to the district's farmers in general.

Table 1: Block-wise distribution of the sample (n = 147)

S. No.	Block	Number of respondents	Percentage (%)
1	Bhitwar	63	42.86
2	Morar	41	27.89
3	Dabra	28	19.05
4	Ghatigaon	15	10.20
	Total	147	100.00

2.3 Measurement of variables and data collection

Primary data were collected through face-to-face interviews by using a pre-tested and structured schedule administered in Hindi language to minimise ambiguity in communication. Awareness of the adverse environmental and health effects of crop residue burning was measured using ten dichotomous (yes/no) statements covering air pollution, greenhouse-gas release, respiratory and other health effects, and impacts on soil fertility, beneficial micro-organisms and biodiversity. Each correct response was scored 1 and each incorrect response 0 (possible range 0–10). Respondents were classified into low, medium or high awareness categories using the sample mean and standard deviation: below (mean – SD) as low, within (mean $\pm$ SD) as medium, and above (mean + SD) as high.

Knowledge of CRM practices was measured using twelve true/false statements covering the general utility of CRM as well as specific technical aspects of individual practices and machinery, including composting, biogas and mushroom production from residue, zero-tillage, the Happy Seeder, the Super SMS machine and the Pusa Decomposer. Scoring and classification into low, medium and high knowledge categories followed the same mean $\pm$ SD procedure used for awareness.

2.4 Statistical analysis

Data were compiled and analysed using Microsoft Excel. Frequency and percentage described responses to individual statements and the category-wise distribution of respondents, while arithmetic mean and standard deviation established the low–medium–high classification boundaries for both awareness and knowledge.

3. Results and Discussion

3.1 Awareness of farmers towards adverse environmental and health effects of crop residue burning

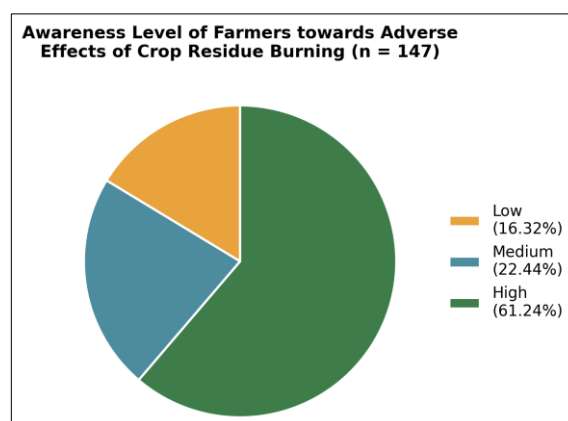


Fig 1: Distribution of respondents by level of awareness of the hazards of crop residue burning (n = 147)

Table 2: Distribution of respondents according to their awareness of the adverse environmental and health effects of crop residue burning (n = 147)

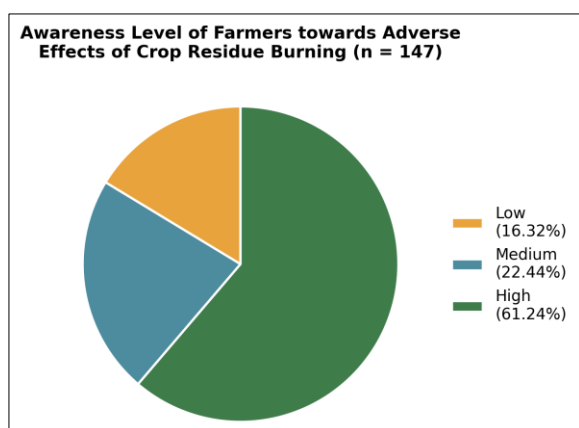
S. No.	Statement	Yes (%)	No (%)
1	Aware that burning crop residues increases air pollution	84.35	15.65
2	Know that burning releases harmful gases (CO ₂ , CO) into the atmosphere	76.87	23.13
3	Aware that smoke from residue burning can cause respiratory problems	61.90	38.10
4	Know that residue burning can cause eye irritation and headache	65.99	34.01
5	Aware that burning destroys beneficial soil micro-organisms	70.06	29.94
6	Know that residue burning reduces soil fertility	80.95	19.05
7	Disagreed that burning does not adversely affect biodiversity	91.16	8.84
8	Know that residue burning harms the health of nearby people	90.47	9.53
9	Disagreed that burning has no negative health effect on children/elderly	83.68	16.32
10	Know that burning reduces the earthworm population in the soil	87.07	12.93

a Negatively worded statement; the percentage shown is the percentage of respondents who correctly disagreed.

Table 3: Distribution of respondents according to their overall level of awareness (n = 147)

S. No.	Category	Frequency	Percentage (%)
1	Low awareness level (up to 6 score)	24	16.32
2	Medium awareness level (7–8 score)	33	22.44
3	High awareness level (above 8 score)	90	61.24
	Total	147	100.00

(Mean = 8.48; S.D. = 1.15)

**Fig 1:** Distribution of respondents by level of awareness of the hazards of crop residue burning (n = 147)

The statement-wise results (Table 2) show that the respondent farmers were utmost aware of the more visible and widely publicised effects of residue burning: 84.35 per cent recognised its contribution to air pollution, 90.47 per cent were well aware of its harmful effects on the health of nearby people, and 87.07 per cent knew that it reduced the earthworm population in the soil. Awareness was comparatively lower, though still held by a majority, on the more clinical health effects of burning, with 61.90 per cent

aware that residue-burning smoke could cause various kind of respiratory issues.

On the overall classification (Table 3, Fig. 1), a majority of respondents (61.24%) fell in the high awareness category, followed by 22.44 per cent in the medium category and only 16.32 per cent in the low category (mean = 8.48, SD = 1.15). This finding is broadly consistent with earlier studies. Anuradha *et al.* (2021) ^[1] similarly reported high awareness among farmers of the Indo-Gangetic plain, while Ravi *et al.* (2022) ^[10] and Choudhary *et al.* (2022) ^[4] also recorded predominantly high to medium awareness among farmers in Telangana and Haryana, respectively. Singh *et al.* (2024) ^[13] likewise found that a large majority of farmers recognised the pollution, soil-nutrient and biodiversity effects of residue burning, and Yang *et al.* (2025) ^[15] reported that a majority of farmers in Punjab regarded stubble burning as a serious air-quality issue. This consistency across regions of northern India suggests that awareness of the hazards of residue burning is now fairly widespread among farmers with reasonable exposure to extension messaging and mass media, even though, as Erbaugh *et al.* (2024) ^[5] cautioned, such awareness does not by itself guarantee a shift away from the practice.

3.2 Knowledge of farmers towards crop residue management practices

Table 4: Distribution of respondents according to their knowledge of crop residue management practices (n = 147)

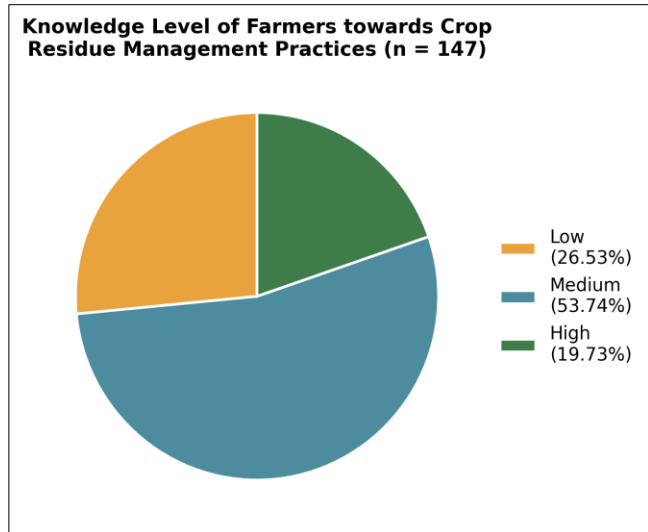
S. No.	Statement	Yes (%)	No (%)
1	CRM promotes sustainable agriculture	87.75	12.25
2	Crop residue can be used in mushroom production	58.50	41.50
3	CRM machines are rented from Custom Hiring Centres	95.91	4.09
4	Disagreed that residue can only be used for burning	92.52	7.48
5	Crop residue can be used in biogas production	38.09	61.91
6	Crop residue can be used as animal fodder	89.79	10.21
7	Crop residue can be used to make compost	76.19	23.81
8	Disagreed that zero-tillage is not helpful in CRM	68.71	31.29
9	Disagreed that burning is an advanced management practice	87.08	12.92
10	Pusa Decomposer speeds up decomposition of residue	34.69	65.31
11	Wheat can be sown without removing residue using a Happy Seeder	72.10	27.90
12	Super SMS machine spreads residue evenly in the field	85.71	14.29

a Negatively worded statement; the percentage shown is the percentage of respondents who correctly disagreed.

Table 5: Distribution of respondents according to their overall level of knowledge (n = 147)

S. No.	Category	Frequency	Percentage (%)
1	Low knowledge (up to 8 score)	39	26.53
2	Medium knowledge (9–10 score)	79	53.74
3	High knowledge (above 10 score)	29	19.73
	Total	147	100.00

(Mean = 9.35; S.D. = 1.39)

**Fig 2:** Distribution of respondents by level of knowledge of crop residue management practices (n = 147)

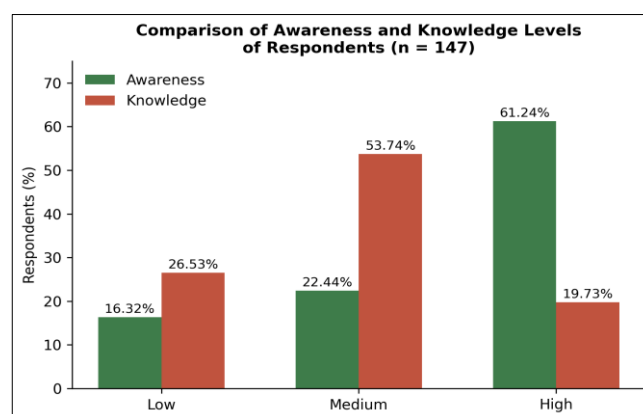
Farmers demonstrated strong knowledge of the more institutionally visible aspects of CRM (Table 4): 95.91 per cent knew that CRM machinery could be rented from Custom Hiring Centres, and 92.52 per cent correctly rejected the idea that burning was the only use for crop residue. Knowledge fell away sharply, however, on the more technical and less traditional CRM options: only 38.09 per cent knew that residue could be used in biogas production, and only 34.69 per cent were aware that the Pusa Decomposer accelerated decomposition.

On the overall classification (Table 5, Fig. 2), 53.74 per cent of respondents fell in the medium knowledge category, 26.53 per cent in the low category, and only 19.73 per cent achieved a high level of knowledge (mean = 9.35, SD = 1.39). This predominance of medium-level knowledge is consistent with Reddy *et al.* (2024) ^[11], who reported that a considerable proportion of farmers remained unaware of composting and decomposer-based residue management, and with Ge *et al.* (2026) ^[7], who found that farmers' knowledge of residue utilisation was largely confined to traditional options such as fertiliser and fodder use. Bikkannavar *et al.* (2024) ^[3] similarly reported that farmers' knowledge tended to concentrate around the more immediately visible benefits of residue management, and Kathpalia *et al.* (2026) ^[8] identified a distinct technical knowledge gap even among farmers otherwise well aware of a CRM machine's general purpose. Taken together with Singh *et al.* (2024) ^[13] and Reddy *et al.* (2025) ^[12], who reported that farmers' residue-management repertoire remained dominated by a narrow set of traditional practices, the present results suggest that farmers' technical knowledge of CRM has not kept pace with the range of practices now available to them.

3.3 Comparative assessment: the awareness–knowledge gap

Table 6: Comparative distribution of respondents by awareness and knowledge category (n = 147)

Category	Awareness — Frequency (%)	Knowledge — Frequency (%)
Low	24 (16.32)	39 (26.53)
Medium	33 (22.44)	79 (53.74)
High	90 (61.24)	29 (19.73)
Total	147 (100.00)	147 (100.00)

**Fig 3:** Comparison of awareness and knowledge levels of respondents (n = 147)

A direct comparison of Tables 3 and 5, summarised in Table 6 and Fig. 3, brings out the central finding of this study. While 61.24 per cent of respondents showed a high level of awareness of the hazards of residue burning, only 19.73 per cent showed a correspondingly high level of knowledge of CRM practices — a gap of over 41 percentage points at the high category. Correspondingly, only 16.32 per cent of respondents fell in the low awareness category, compared with 26.53 per cent in the low knowledge category.

This divergence indicates that the hazard-recognition dimension of farmer behaviour — understanding why burning is harmful — had developed considerably further among the sampled farmers than the technical, practice-oriented dimension of understanding what to do about it. A plausible explanation lies in the nature of extension communication: messaging on the ill effects of burning circulates widely through mass media, government campaigns and social channels, whereas the correct technical operation of specific CRM machinery is typically transmitted through direct, hands-on contact with extension personnel or Custom Hiring Centre staff, to which farmers have comparatively limited and uneven exposure. This interpretation is consistent with Erbaugh *et al.* (2024) ^[5], who noted that awareness of harm does not translate into behavioural change without accompanying economic and

technical support, and with Kathpalia *et al.* (2026) ^[8], who documented a similar technical knowledge gap despite general awareness of a CRM technology.

The gap carries a direct implication for extension planning. Since the sampled farmers had already sought access to CRM machinery through the Custom Hiring Centre subsidy scheme, their limited technical knowledge is unlikely to stem from a lack of interest in moving away from burning; it more plausibly reflects insufficient exposure to practice-oriented training. Extension efforts confined to reinforcing hazard awareness are therefore unlikely to yield substantial further gains. Greater returns may instead be expected from demonstration-based training targeted at the specific practices where knowledge remains weakest, namely biogas and mushroom production from residue and the operation of decomposer-based technologies.

4. Conclusion

This study assessed and compared farmers' awareness of the adverse environmental and health effects of crop residue burning with their knowledge of crop residue management practices among 147 farmers in Gwalior district of Madhya Pradesh who had engaged with the Custom Hiring Centre subsidy scheme for CRM machinery. Awareness of the hazards of burning was high among a majority of respondents (61.24%), while practical knowledge of CRM practices remained predominantly at a medium level (53.74%), with only 19.73 per cent of farmers reaching a high level of knowledge. This gap suggests that farmers' recognition of the problem of residue burning has outpaced their technical understanding of the alternatives available to address it, particularly less conventional practices such as biogas production, mushroom cultivation from residue, and decomposer-based technologies. Extension agencies working in the region would benefit from shifting emphasis away from further hazard-awareness campaigns and towards hands-on, demonstration-based training on specific CRM technologies, so as to convert farmers' existing awareness of the problem into working knowledge of its solutions. As the sample was drawn specifically from farmers already registered for CRM machinery subsidies, similar studies among the wider, non-subsidised farming population of the district would help establish whether the awareness-knowledge gap identified here is more or less pronounced among farmers with less institutional engagement.

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Competing Interests

Authors have declared that no competing interests exist.

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