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RESEARCH ARTICLE

Development of a psychometric scale for measuring farmers' attitudes toward crop residue management practices

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Abstract

This research presents the Attitude Scale for Crop Residue Management (AS-CRM), a validated tool designed to measure farmers' psychological tendencies toward crop residue management practices. Addressing the pressing need for reliable instruments in agricultural sustainability research, the AS-CRM was developed using Likert's summated rating scale method through a structured three-stage process: item generation, item selection and statistical validation. An initial pool of 70 statements was created through a literature review and expert consultations. Following expert evaluation, 45 items were selected and administered to 60 farmers in a non-sample area for item analysis. Based on t-test values (≥ 2.05), 20 items were retained for the final scale. The instrument demonstrated high reliability (Guttman Split-Half Coefficient = 0.947) and strong content validity confirmed by expert judgment. The final 20 item scale is scored on a five-point continuum ranging from strongly agree to strongly disagree. Key findings highlighted positive attitudes in areas related to environmental awareness and soil health benefits, whereas scepticism remained around labour intensity and economic feasibility. The AS-CRM offers a robust framework for understanding farmer perceptions, facilitating the design of targeted behavioural interventions and policy measures. By providing a standardized assessment mechanism, it supports evidence-based decision making for promoting sustainable crop residue management practices and advancing climate-resilient agriculture.

Keywords: attitude scale; crop residue management; farmers' perception; likert scale; reliability; sustainable agriculture; validity

Introduction

In the 21st century, whether a foreign property or domestic industry, utilising farm output in the face of significant global challenges is crucial for ensuring food safety for a growing global population and promoting climate change mitigation and environmentally sustainable farming practices. Crop residue management has become a critical issue at the intersection of agriculture productivity, environmental stewardship and rural livelihoods within this complex web (1, 2). Crop residues, the unused part of crops after harvest, represent a vast but frequently underutilized resource. Global estimates place annual crop residue production at 3.8 billion metric tons, with cereals accounting for 74 % (3). Management of crop residues significantly affects soil health, water quality and air pollution (4). Traditionally, farmers managed crop residues by burning or incorporating them into the soil, using them as animal feed and removing them from the field for off-farm uses. Nevertheless, the sustainability of these practices is controversial due to their environmental consequences and the increasing acceptance that residues have a potential value for sustainable agriculture systems (5).

Crop residue emissions constitute a significant problem in many parts of the world, with the top three emitters being China, India and the United States. Together, they account for over 50 % of all crop residue emissions. The other countries in the top 10 are Brazil, Russia, France, Canada, Argentina, Indonesia and Germany**.** Direct emissions (N_2O) from all crops from 1990 to 2020, with annual emissions increasing from approximately 600 kilo tonnes to 900 kilo tonnes. One of the key drivers of the growth in crop residue emissions is the expansion of agricultural land. Between 1990 and 2020, the global agricultural area increased by approximately 10 % (Fig. 1, 2).

The average annual emissions by crop type in the world from 1990-2020. The total average annual emissions are approximately 100,000 metric tons. The three crop types with the highest emissions are wheat (27.6 %), maize (corn) (21.2 %) and rice (16.7 %). These three crops account for over 65 % of all crop residue emissions. Other crop types with significant emissions include soybeans (9.7 %), barley (6.2 %) and sorghum (2.8 %). These crops account for an additional 18.7 % of all crop residue emissions. The remaining 16.1 % of crop residue emissions are from other crops, such as potatoes, oats and millet. The emissions from crop residues have increased over time. Between 1990 and 2020, emissions increased by approximately 10 % (Fig. 3).

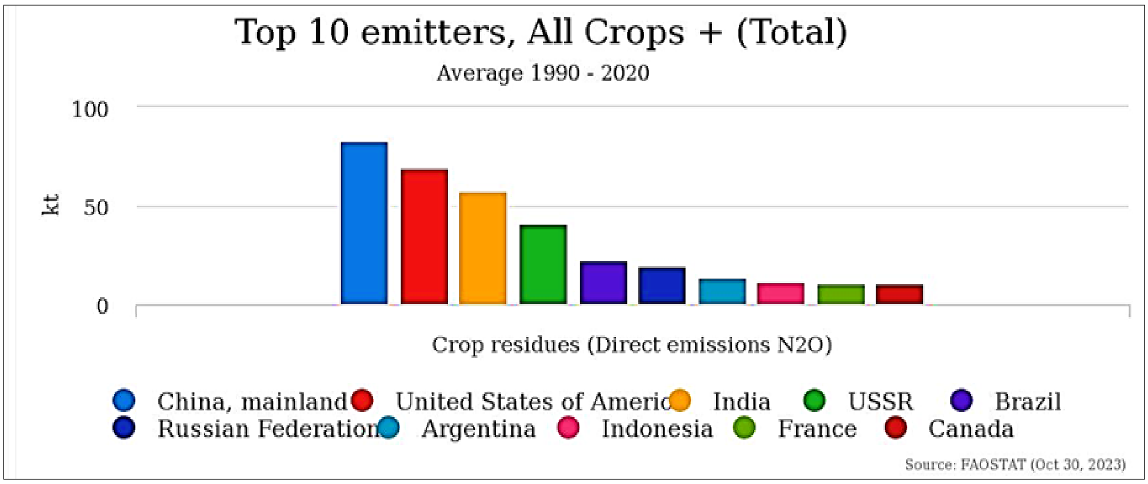

Fig. 1. Top 10 N_2O emitting countries due to crop residue management.

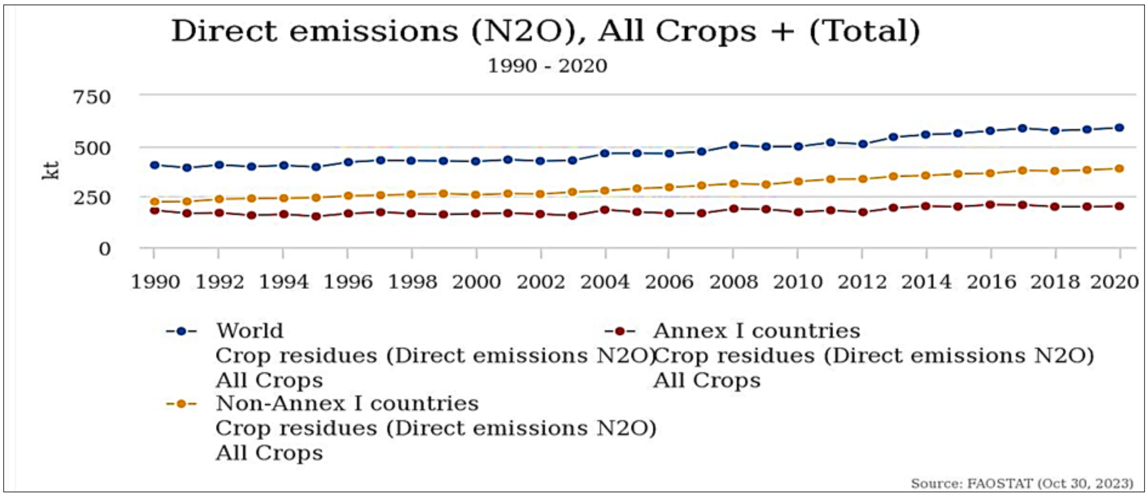

Fig. 2. Direct N_2O emissions from all crops (1990-2020).

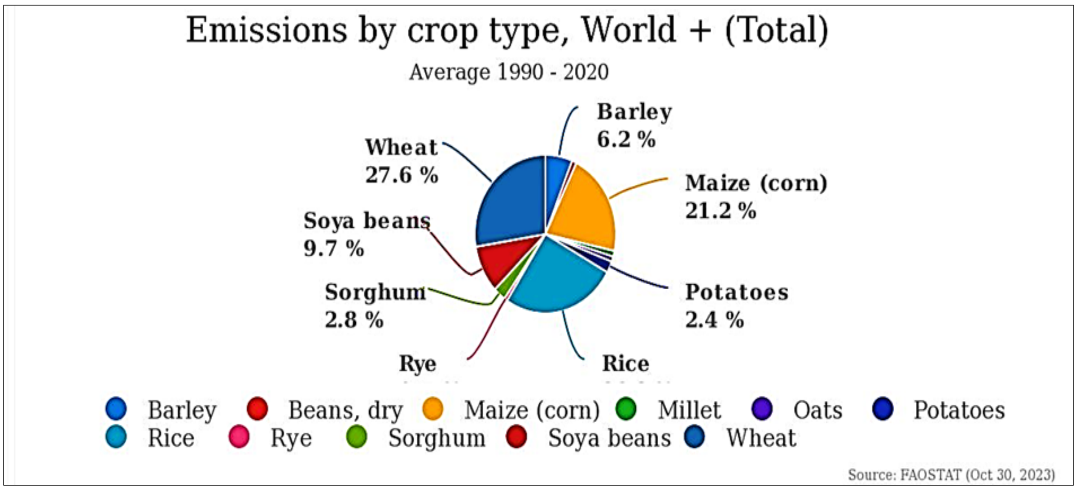

Fig. 3. Average annual N_2O emissions by crop type worldwide (1990-2020).

India produces more than 686 million tonnes (Mt) of crop residue yearly, of which 368 Mt comes from cereal crops (6). Among cereal crops, rice and wheat are the dominating crops, contributing about 154 and 131 Mt respectively, to the total crop residue production. In India, crop residue is mainly used as cattle feed and cooking fuel. In contrast, in countries like China, Indonesia, Thailand, Bangladesh and Sri Lanka, it is utilized as feedstock in bioenergy generation, organic fertilizers and the paper industry (7).

Managing rice residue in the Indo-Gangetic Plains of India is challenging mainly due to the popular rice-wheat cropping system, which leads farmers to prioritize the timely sowing of wheat in fields where paddy has been harvested (8, 9). Farmers in this region incinerate rice residue because of the limited timeframe between rice harvesting and wheat planting, the lack of timely access to appropriate residue management machinery and the labor-intensive nature of manual residue removal (10). India's yearly surplus agricultural waste output is estimated at 178 million tons, of which 87 million tons are incinerated. Rice residue is the predominant portion of total crop residue incinerated, contributing to the rise in CH_4, N_2O and CO_2 equivalent (CO_2-eq) emissions, exacerbating global warming potential annually.

This study aims to investigate the extent of farmers' attitudes toward crop residue management, examining their perceptions of its benefits, challenges and impacts on agricultural sustainability. Effective crop residue management plays a crucial role in soil health, environmental conservation and sustainable farming practices, aligning with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action) and SDG 15 (Life on Land). The study will develop a standardised scientific tool to measure farmers' attitudes toward crop residue management and address this. It provides a reliable tool for assessing their perspectives and guiding policy interventions that promote sustainable agricultural practices.

Materials and Methods

The present study followed the Likert method of summated rating (11) to develop the desired tool. A summated rating scale is a set of perception statements, all considered to have approximately equal perception value. To each, subjects respond with degrees of agreement or disagreement, carrying different scores. This method was adopted for the present study because using a single statement to represent concepts is avoided. Instead, several statements as indicators representing different facets of the concept can be used to obtain a more well-rounded perspective. The details of the steps followed in the construction of Likerts (1932) type scale for measuring the attitude of the farming community towards crop residue management have been discussed below (Fig. 4).

Item Collection

The constructs governing farmers' attitudes towards crop residue management (CRM) were identified as key determinants influencing their decision-making and adoption behaviour. Initially, a thorough review of relevant literature and expert consultations was undertaken to generate a comprehensive pool of statements reflecting the multifaceted dimensions of CRM. These statements were carefully derived from peer-reviewed academic journals, government reports, extension bulletins and expert inputs to ensure contextual relevance and scientific rigor. The process aimed to capture the broad spectrum of environmental, economic, technical, institutional and behavioural aspects associated with crop residue management practices, forming a robust foundation for developing a reliable and valid attitude instrument.

Editing the statements

These statements were edited as per 14 criteria (12-14). Consequently, out of 70 statements, 25 statements were eliminated. The remaining 45 statements were included in the proforma. These statements were framed so that they could express positive or negative perceptions.

Expert's response to raw statements for the relevancy test

The proforma containing these statements on a three-point continuum ranging from highly relevant (HR), relevant (R) and least relevant (LR) was mailed by email. Google Docs form was also handed over personally to the judges. These judges were experts about the research stations, universities, institutes and extension education experts working in this area. They were requested to add or delete any statements deemed fit for the conclusion or deletion. They were also asked to check the statements for favourable or unfavourable attitudes toward residue management. Out of 190 judges, only 70 experts returned the same statements after duly recording their judgments and were considered for the analysis. After analysis, the statements were rewritten considering the criticism and comments of the experts. In this way, a total of 45 statements were finally retained. Efforts were made to select a equal number of positive and negative statements. Then, these statements were administered to the selected farmers under study and their responses were analyzed to calculate item discrimination.

Selection of items

The responses of judges were tabulated and analyzed to work out the Relevancy percentage, relevancy weighted and mean relevancy score for all the statements.

Relevancy percentage (RP)

It was worked out by summing up the scores of Very relevant and relevant categories, which were converted into percentages. The calculated value of RP was found in the range of 55.00 (minimum) to 100.00 (maximum) percentages.

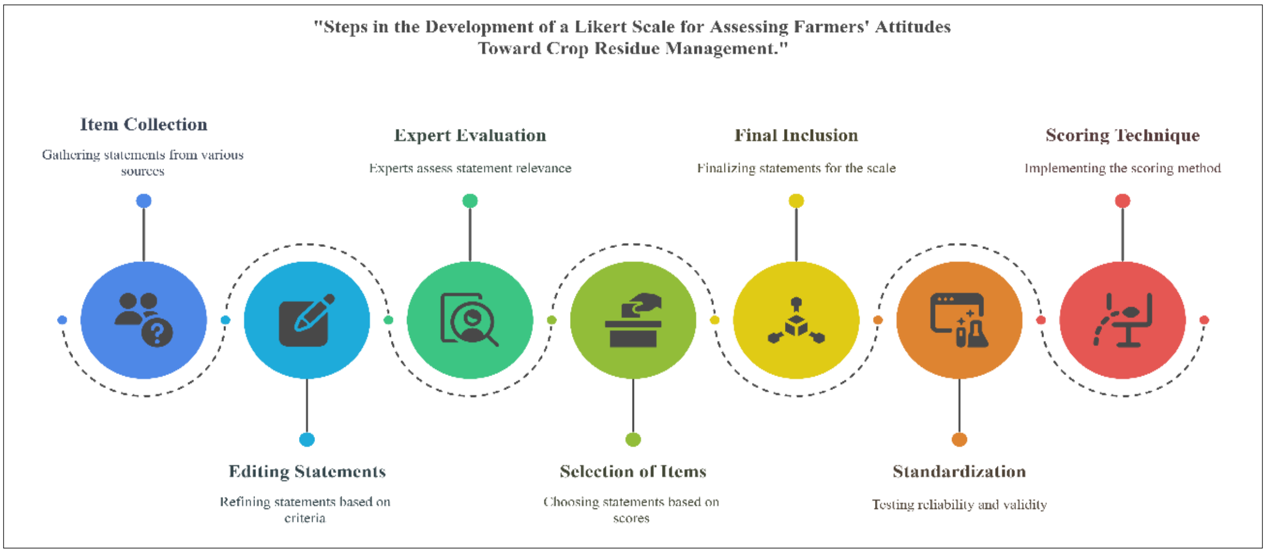

Fig 4. Steps involved in the development of the scale.

Relevancy weightage (RW)

The range of actual scores obtained to the maximum possible obtainable score by each respondent. The calculated value of RW was found in the range of 0.56 (minimum) to 0.89 (maximum).

Mean relevancy score

It was obtained by the standard formula. The calculated value of MRS was found in the range of 1.68 (minimum) to 2.67 (maximum) and the value of the overall mean relevancy score (OMRS) is 2.25.

Final inclusion of statements

Using these three criteria, the statements were screened for relevancy. Accordingly, statements with a relevancy percentage of > 70, relevancy weightage > 0.70 and overall mean relevancy score > 2.29 were considered for the final selection of statements (11). Accordingly, 42 statements were selected, suitably modified and rewritten per the experts' comments (Table 1).

Item analysis

A questionnaire consisting of 45 statements was prepared and responses were collected from 60 farmers in the sample areas. These farmers were selected on the criteria that they are farmers or belong to the farming community. The farmers were asked to indicate their degree of agreement on a five-point continuum, namely strongly agree, agree, undecided, disagree and strongly disagree, with scores of 5, 4, 3, 2, 1 for each positive statement and 1, 2, 3, 4 & 5 for each negative statement respectively. The perception score of a respondent was obtained by summing the score of all items; thus, the total score obtained by each respondent was calculated. The respondents were arranged in descending order. For item analysis, 25 % of the respondents are in the highest total score group and the bottom 25 % are in the low group, so these two groups provide criterion groups for evaluating the individual statements (14). Thus, out of 60 farmers to whom the items were administered for the item analysis, 15 farmers with the lowest and 15 with the highest scores were used as criterion groups to evaluate individual items. The critical ratio, that is, the 't' value, which measures the extent to which a given statement differentiates between the high and low groups of the respondents for each statement, was calculated using the formula suggested by Edward (1957) (13).

The calculated t-value was found to be distributed from 0.27 to 4.58. Later, the statements with 't' value of 2.05 and above were considered for final inclusion. These 20 statements were quantified in the final scale (Table 2).

Standardization of the scale

The developed scale was further standardized by establishing its reliability and validity.

Reliability

Reliability is the ability of a test instrument to generate consistent results from one set of measures to another. A good instrument should evoke valid responses and yield nearly the same results if administered twice to the same respondents (15). Reliability is the accuracy or precision of a measuring instrument (16). The split-half method was used to assess the internal consistency of the scale developed. The scales were split into two halves based on random numbers and the sets of statements were administered to 60 selected numbers of respondents. Thus, two sets of scores were obtained. The half-test reliability coefficient was calculated using Cronbach's Alpha in SPSS 24. The alpha values of set 1 were 0.875 and set 2 was 0.870 and the correlation between these two was 0.901. Thus, the reliability coefficient indicated high internal consistency of the attitude scale constructed for the study. The result was further confirmed using the Guttman Split-Half Coefficient, which was also found to be 0.947 (Table 3). To further confirm these findings, the Guttman Split-Half Coefficient was computed, which provides an estimate of reliability by correlating the two halves of the test. The coefficient was found to be 0.947 (Table 3), reaffirming the strong reliability of the constructed attitude scale. Collectively, these results demonstrate that the instrument is both stable and internally consistent for measuring farmers' attitudes toward crop residue management.

Validity

Content validity is the representativeness or sampling adequacy of a measuring instrument's content substance, the matter and the topics. All the edited statements were given to 92 judges for their expert guidance in developing the scale. The suggestions of the experts were incorporated into the scale. Hence, the present scale satisfied the content validity. Finally, 20 items were selected to determine farmers' attitudes toward crop residue management and arranged so that positive and negative statements appear randomly to avoid biased responses.

Scoring technique

The selected 20 statements (Table 4) for the final format of the perception scale are randomly arranged to avoid response biases, which might contribute to low reliability and direction from the scale's validity. Against each of the 20 statements, there were five columns representing a five-point continuum of agreement or disagreement with the statements (11). The points on the continuum were strongly agreed, agree, undecided, disagree and strongly disagree, with a weight of 5,4,3,2, and 1 respectively, for favourable (positive) statements and with a weight of 1,2,3,4, and 5 respectively, for unfavourable (negative) statements (Table 4).

For this study, perceptions are categorized as strongly agree (SA), Agree (A), Undecided (UN), Disagree (D) and strongly disagree (SD). A range was identified with the lowest score of 20 (rating 1 on each of 20 items) and the highest possible score of 100 (rating 5 on each of 20 items).

Results

Table 4 presents the validated AS-CRM, comprising 20 carefully selected items designed to measure farmers' attitudes across key dimensions such as environmental awareness, soil health benefits, economic feasibility and labour intensity. These items were retained based on item analysis, with t-values ≥ 2.05, indicating strong discriminatory power. The finalized scale exhibits high internal consistency and reliability, as demonstrated by the split-half method, yielding Cronbach's

Table 1. Selection of statements based on judges (n=80): Relevancy Percentage (RP), Relevancy Weightage (RW) and Most Relevancy Score (MRS)

S. No.	Statements	RP	RW	MRS
1	Crop residue burning significantly contributes to air pollution. (+)	95.0	0.89	2.67
2	Managing crop residues properly improves soil health. (+)	97.50	0.85	2.56
3	Crop residue management positively impacts local biodiversity. (+)	96.25	0.80	2.41
4	Burning crop residues adversely affects the quality of groundwater. (-)	60.00	0.59	1.77
5	Incorporating crop residues into the soil reduces the need for chemical fertilisers. (-)	68.75	0.67	2.02
6	Crop residue management plays a crucial role in mitigating climate change. (+)	96.25	0.82	2.47
7	Proper residue management helps conserve soil moisture. (+)	98.75	0.83	2.50
8	Burning crop residues causes the loss of beneficial soil microorganisms. (+)	95.00	0.81	2.45
9	Crop residue management helps reduce soil erosion. (+)	88.75	0.76	2.30
10	Smoke from burning crop residues poses health risks to nearby communities. (+)	95.00	0.84	2.52
11	Adopting crop residue management practices is financially beneficial in the long run. (+)	93.75	0.84	2.52
12	The initial cost of residue management techniques is too high for most farmers. (-)	70.00	0.66	1.98
13	Crop residue can be a valuable resource for generating additional income. (-)	68.75	0.66	1.98
14	Government subsidies are essential for the widespread adoption of residue management. (+)	93.75	0.81	2.45
15	Proper residue management leads to higher crop yields in subsequent seasons. (+)	91.25	0.78	2.35
16	The time required for residue management is not justified by its economic benefits. (-)	60.00	0.58	1.75
17	Using crop residues for biofuel production can provide additional income. (+)	90.00	0.75	2.27
18	The cost of machinery for residue management is a significant barrier to adoption. (+)	93.75	0.80	2.41
19	Crop residue management practices help lower the overall cost of cultivation. (-)	67.50	0.63	1.91
20	There is a growing market for products made from crop residues. (-)	80.00	0.70	2.13
21	I understand various crop residue management techniques well. (+)	92.50	0.80	2.40
22	Operating machinery for residue management requires specialised skills. (+)	91.25	0.77	2.32
23	I am aware of the latest technologies available for crop residue management. (+)	91.25	0.77	2.32
24	Proper training is essential for effectively implementing residue management. (+)	98.75	0.84	2.52
25	Adapting my farming practices to include residue management is challenging. (-)	66.25	0.62	1.88
26	Information about crop residue management is readily available to farmers. (-)	63.75	0.61	1.85
27	I am confident in my ability to implement residue management practices . (+)	90.00	0.76	2.30
28	The complexity of residue management techniques discourages farmers from adopting them. (+)	90.00	0.75	2.26
29	I regularly seek information on new residue management practices. (-)	68.75	0.65	1.97
30	Agricultural extension services provide adequate support for learning residue management techniques. (+)	92.50	0.80	2.41
31	My community supports the adoption of crop residue management practices. (-)	72.50	0.70	2.10
32	Traditional farming practices are more reliable than modern residue management techniques. (-)	66.25	0.66	1.98
33	I feel pressure from other farmers to adopt residue management practices. (-)	56.25	0.57	1.73
34	Crop residue burning is a traditional practice in my community. (-)	70.00	0.64	1.93
35	Adopting residue management practices improves a farmer's social status. (-)	67.50	0.65	1.97
36	My family encourages me to adopt proper residue management. (-)	67.50	0.64	1.92
37	I am willing to collaborate with other farmers to implement effective residue management. (-)	75.00	0.70	2.10
38	Religious beliefs influence my decisions about crop residue management. (-)	55.00	0.56	1.68
39	I am open to changing traditional practices for better residue management. (-)	73.75	0.67	2.02
40	Younger family members support adopting new residue management techniques. (-)	75.00	0.70	2.10
41	Government policies effectively promote crop residue management practices. (+)	98.75	0.87	2.61
42	There should be stricter enforcement of laws against crop residue burning. (+)	98.75	0.82	2.47
43	Agricultural institutions provide adequate support for implementing residue management. (+)	95.00	0.82	2.46
44	Current policies on residue management do not address farmers' practical challenges. (-)	62.50	0.64	1.93
45	More research is needed to develop effective residue management strategies. (+)	96.25	0.80	2.42
46	Local agricultural officers are helpful in guiding farmers on residue management. (+)	95.00	0.77	2.33
47	More incentives are needed for farmers who adopt proper residue management. (+)	91.25	0.77	2.33
48	The government should invest more in infrastructure for residue management. (-)	72.50	0.70	2.10
49	Current residue management policies are well-communicated to farmers.(-)	70.00	0.65	1.97
50	Farmer cooperatives play an important role in promoting residue management practices. (+)	92.50	0.77	2.32
51	The benefits of crop residue management outweigh the challenges involved. (+)	93.75	0.78	2.35
52	Adopting residue management improves the overall quality of farm produce. (+)	91.25	0.78	2.35
53	Residue management practices are too time-consuming to implement. (-)	68.75	0.67	2.02
54	Proper residue management reduces pest and disease problems.(+)	92.50	0.81	2.43
55	The benefits of residue management are not immediate enough to justify the effort. (+)	91.25	0.80	2.42
56	Implementing residue management practices gives me a sense of environmental responsibility. (+)	92.50	0.80	2.42
57	Residue management practices are compatible with my current farming system. (+)	95.00	0.80	2.41
58	The risk of crop failure increases when adopting new residue management techniques.(-)	62.50	0.61	1.85
59	Proper residue management enhances the long-term sustainability of my farm.(+)	98.75	0.84	2.53
60	The challenges of residue management vary significantly across different crops.(+)	100.00	0.81	2.45
61	I plan to increase my efforts in crop residue management in the coming years. (+)	97.50	0.84	2.53
62	The future of agriculture depends on effective residue management practices.(+)	92.50	0.78	2.35
63	I am optimistic about new technologies that will simplify residue management. (+)	97.50	0.85	2.55
64	Younger farmers are more likely to adopt advanced residue management practices.(+)	96.25	0.82	2.47
65	Climate change will make crop residue management more critical in the future. (+)	91.25	0.77	2.31
66	I believe crop residue management will become a standard practice for all farmers in the next decade.(+)	96.25	0.82	2.46
67	Future government policies will likely make crop residue management mandatory.(+)	97.50	0.85	2.56
68	The market for crop residue-based products will expand significantly in the coming years. (+)	92.50	0.77	2.32
69	Integrating crop residue management with precision agriculture will be crucial for future farming.(+)	92.50	0.80	2.41
70	I anticipate that community-based approaches to residue management will become more prevalent. (+)	100.00	0.84	2.52
	OMRS - 2.25			

(+) Selected statement

(-) Non-selected statement

Table 2. The statements of item analysis by farmers of non-sample area

S. No.	Statement	t-Value	Included (+) / Not Included (-)
1	Crop residue burning significantly contributes to air pollution.	0.22	(-)
2	Managing crop residues properly improves soil health.	3.06	(+)
3	Crop residue management positively impacts local biodiversity.	3.06	(+)
4	Crop residue management plays a crucial role in mitigating climate change.	1.30	(-)
5	Proper residue management helps conserve soil moisture.	0.26	(-)
6	Burning crop residues causes the loss of beneficial soil microorganisms.	1.69	(-)
7	Crop residue management helps reduce soil erosion.	0.73	(-)
8	Smoke from burning crop residues poses health risks to nearby communities.	2.27	(+)
9	Adopting crop residue management practices is financially beneficial in the long run.	0.27	(-)
10	Government subsidies are essential for the widespread adoption of residue management.	1.67	(-)
11	Proper residue management leads to higher crop yields in subsequent seasons.	0.73	(-)
12	Using crop residues for biofuel production can provide additional income.	1.55	(-)
13	The cost of machinery for residue management is a significant barrier to adoption.	0.00	(-)
14	I understand various crop residue management techniques well.	1.02	(-)
15	Operating machinery for residue management requires specialised skills.	0.00	(-)
16	I am aware of the latest technologies available for crop residue management.	0.22	(-)
17	Proper training is essential for effectively implementing residue management.	2.32	(+)
18	I am confident in my ability to implement residue management practices.	0.77	(-)
19	The complexity of residue management techniques discourages farmers from adopting them.	0.23	(-)
20	Agricultural extension services provide adequate support for learning residue management techniques.	0.76	(-)
21	Government policies effectively promote crop residue management practices.	2.41	(+)
22	There should be stricter enforcement of laws against crop residue burning.	2.17	(+)
23	Agricultural institutions provide adequate support for implementing residue management.	3.35	(+)
24	More research is needed to develop effective residue management strategies.	1.00	(-)
25	Local agricultural officers are helpful in guiding farmers on residue management.	2.82	(+)
26	More incentives are needed for farmers who adopt proper residue management.	2.82	(+)
27	Farmer cooperatives play an important role in promoting residue management practices.	2.82	(+)
28	The benefits of crop residue management outweigh the challenges involved.	1.95	(-)
29	Adopting residue management improves the overall quality of farm produce.	0.71	(-)
30	Proper residue management reduces pest and disease problems.	2.82	(+)
31	The benefits of residue management are not immediate enough to justify the effort.	-2.37	(-)
32	Implementing residue management practices gives me a sense of environmental responsibility.	1.29	(-)
33	Residue management practices are compatible with my current farming system.	1.97	(-)
34	Proper residue management enhances the long-term sustainability of my farm.	4.58	(+)
35	The challenges of residue management vary significantly across different crops.	4.58	(+)
36	I plan to increase my efforts in crop residue management in the coming years.	4.58	(+)
37	The future of agriculture depends on effective residue management practices.	4.58	(+)
38	I am optimistic about new technologies that will simplify residue management.	4.58	(+)
39	Younger farmers are more likely to adopt advanced residue management practices.	1.74	(-)
40	Climate change will make crop residue management more critical in the future.	4.02	(+)
41	I believe crop residue management will become a standard practice for all farmers in the next decade.	1.42	(-)
42	Future government policies will likely make crop residue management mandatory.	2.99	(+)
43	The market for crop residue-based products will expand significantly in the coming years.	1.38	(-)
44	Integrating crop residue management with precision agriculture will be crucial for future farming.	3.06	(+)
45	I anticipate that community-based approaches to residue management will become more prevalent in the future.	3.06	(+)

Table 3. Reliability test (Split half)

Reliability Statistics			
Cronbach's Alpha	Part 1	Value	.875
		N of Items	23[a]
	Part 2	Value	.870
		N of Items	22[b]
	Total N of Items		45
Correlation Between Forms			.901
Spearman-Brown Coefficient	Equal Length		.948
	Unequal Length		.948
Guttman Split-Half Coefficient			.947

a. The items are: VAR00001, VAR00002, VAR00003, VAR00004, VAR00005, VAR00006, VAR00007, VAR00008, VAR00009, VAR00010, VAR00011, VAR00012, VAR00013, VAR00014, VAR00015, VAR00016, VAR00017, VAR00018, VAR00019, VAR00020, VAR00021, VAR00022, VAR00023.

b. The items are: VAR00023, VAR00024, VAR00025, VAR00026, VAR00027, VAR00028, VAR00029, VAR00030, VAR00031, VAR00032, VAR00033, VAR00034, VAR00035, VAR00036, VAR00037, VAR00038, VAR00039, VAR00040, VAR00041, VAR00042, VAR00043, VAR00044, VAR00045.

Table 4. Final statement of scale

Statement No.	Statement	SA	A	UN	D	SD
1	Managing crop residues properly improves soil health.					
2	Crop residue management positively impacts local biodiversity.					
3	Smoke from burning crop residues poses health risks to nearby communities.					
4	Proper training is essential for effectively implementing residue management.					
5	Government policies effectively promote crop residue management practices.					
6	There should be stricter enforcement of laws against crop residue burning.					
7	Agricultural institutions provide adequate support for implementing residue management.					
8	Local agricultural officers are helpful in guiding farmers on residue management.					
9	More incentives are needed for farmers who adopt proper residue management.					
10	Farmer cooperatives play an important role in promoting residue management practices.					
11	Proper residue management reduces pest and disease problems.					
12	Proper residue management enhances the long-term sustainability of my farm.					
13	The challenges of residue management vary significantly across different crops.					
14	I plan to increase my efforts in crop residue management in the coming years.					
15	The future of agriculture depends on effective residue management practices.					
16	I am optimistic about new technologies that will simplify residue management.					
17	Climate change will make crop residue management more critical in the future.					
18	Future government policies will likely make crop residue management mandatory.					
19	Integrating crop residue management with precision agriculture will be crucial for future farming.					
20	I anticipate that community-based approaches to residue management will become more prevalent in the future.					

SA-strongly agree; A- agree; UN-undecided; D-disagree; SD-strongly disagree

alpha coefficients of 0.875 and 0.870 for Set 1 and Set 2 respectively and an inter-set correlation of 0.901. The Guttman Split-Half Coefficient was computed at 0.947, further substantiating the internal reliability of the instrument.

Content validity was established through expert review involving professionals from agricultural research institutions and academia, who evaluated the items for clarity, relevance and construct representation. Their feedback was used to refine the scale, ensuring it accurately captures the multidimensional attitudinal domains associated with crop residue management. The finalized items are rated on a five-point Likert continuum ranging from Strongly Agree to Strongly Disagree, enabling nuanced assessment of farmers' perspectives. This methodology is consistent with validated approaches used in the development of other agricultural attitude scales, such as the scale for natural farming attitudes by Deepika et al., which employed Likert scaling, expert validation and reliability testing to ensure psychometric robustness (17).

Correlation matrix analysis revealed moderate inter-item correlations, supporting construct validity by confirming that while the items are conceptually related, they measure distinct aspects of farmers' attitudes without redundancy. The scale encapsulates a broad spectrum of constructs, including environmental awareness (Statements 1-3), institutional and policy support (Statements 5-8), economic and incentive-related perceptions (Statements 9-10), agronomic concerns such as pest and productivity impacts (Statement 11) and forward-looking views on climate and sustainability (Statements 14-20). This multidimensional coverage reflects the theoretical complexity of the construct and its practical relevance in agricultural decision-making.

The AS-CRM not only assesses present attitudes but also captures expectations regarding the future role of crop residue management in climate resilience and farm sustainability. Items related to institutional support and incentive-based policies reveal moderate positive correlations with behavioural intentions, indicating that trust in external support systems is a meaningful determinant of adoption likelihood. Additionally, items focusing on soil health and pest control align with established empirical evidence, reinforcing the environmental rationale behind residue management practices.

Overall, the AS-CRM emerges as a scientifically robust, contextually grounded and empirically validated psychometric tool. Its rigorous development process and validated structure make it suitable for use in baseline attitude assessments, impact evaluations of extension programs and the formulation of targeted policy interventions. The scale can also be adapted for use in other agro-ecological regions with minimal contextual modifications, thereby supporting broader applications in the promotion of sustainable residue management practices across diverse farming communities.

Conclusion

Crop residue management (CRM) plays a pivotal role in sustainable agriculture by enhancing soil health, supporting biodiversity and improving farm productivity. However, widespread adoption of effective CRM practices remains limited, particularly among small and marginal farmers in India, primarily due to resource constraints and lack of awareness. The development of this AS-CRM offers a scientifically validated tool for assessing farmers' attitudes and behavioural orientations toward CRM. It holds significant utility for researchers, policymakers and extension personnel in conducting baseline surveys, designing targeted interventions and formulating evidence-based policies. Farmers who exhibit negative or uncertain attitudes toward CRM can be systematically identified and prioritized for focused training and capacity-building initiatives. Furthermore, with appropriate contextual modifications, the scale can be adapted for use in other agro-climatic regions to facilitate cross-regional comparisons and strategic planning.

Looking ahead, the AS-CRM can serve multiple functions. In farmer training programs, it can diagnose knowledge gaps and attitudinal constraints, enabling tailored educational content. In policy formulation, it provides empirical insights into farmers' mindsets, informing the development of localized incentives and institutional support mechanisms. For broader regional deployment, the scale can guide extension agencies in understanding local perceptions and aligning strategies with ground realities. Integrating this tool into regular extension and policy frameworks can promote more inclusive, context-sensitive and sustainable adoption of crop residue management practices across diverse farming systems.

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Authors' contributions

AV conducted extensive field visits and collected primary data, ensuring the accuracy and reliability of the research process. RKD conceptualised the research framework, provided critical inputs throughout the study and approved the final manuscript. AW contributed to the refinement of the research concept and performed formal editing of the manuscript. NRM was instrumental in revising the manuscript, ensuring clarity and coherence. VC assisted in summarising the findings and revising the manuscript for consistency. GK played a key role in editing and enhancing the manuscript. SS supported summarising and revising the manuscript, contributing to its final quality.

Compliance with ethical standards

Conflict of interest: The authors do not have any conflict of interest to declare.

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