Mysore J. Agric. Sci., 60 (2) : 367-376 (2026)

Development of Perception Scale to Assess Farmers' Perception about the Impact of Agrochemicals on the Environment

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Received : October 2025
Accepted : December 2025

ABSTRACT

Farmers'perceptions regarding the impact of agrochemicals on the environment are important for sustainable agriculture. This study aims to develop, validate and standardise a scale to portray the way perception of farmers on the effect of agrochemical usage on the environment. At the initial stage, 135 items were developed, and content validation was performed through expert feedback to check content relevance. After expert review, refined items were administered among 190 farmers across three different agro-climatic regions of West Bengal. To identify the underlying factor arrangement, Exploratory Factor Analysis (EFA) was performed on the dataset. The result suggests retention of 20 items through varimax rotation. Factor loading threshold is considered 0.50 as significant. Further, the scale contained 20 items, was tested for its reliability with Cronbach's alpha and split-half analysis. Both test values suggest acceptable internal consistency. Reliability analysis suggests retention of 19 items for the scale validation test. At the last stage, correlation analysis was performed to check scale validity, which confirms that items are significant. Analysis suggests items are relevant, valid and reliable for the newly developed scale for assessing farmers' perception. Moreover, these newly developed scales assist researchers in quenching their search for farmers'perception studies.

Keywords : Agro-chemical, Farmers, Environment, Perception scale, Factor analysis, Cronbach's alpha

IN contemporary times, farmers' perception towards the impact of agrochemical use has turned out a very important parameter from the perspective of a sustainable environment. In different countries, few studies focus on farmers'perception, indicating the gaps between their awareness and actual practice related to pesticides. A study among Ethiopian smallholder farmers showed that they know that some health risks are associated with the use of improper pesticide handling and disposal; however, practices are still prevalent in this area (Ocho *et al*., 2016). Study by Ngowi *et al.* (2002) reported that vegetable farmers of Ghana perceived pesticides as essential for agriculture, but they have a lack of awareness related to long-term environmental risk.

A research conducted in Tunisia revealed that educated farmers were more likely to consider environmental risks during pest management decision (Sharifzadeh *et al*., 2018). Role of education in increasing awareness about toxicity and environmental impact, related to personal protective equipment (PPE) use and safe practices of disposal among Turkish farmers (Taskir and Tiryaki, 2024).

These outcomes extended over Africa and Asia, validating that perception is an important determining factor of agrochemical behaviour. So it is important to know farmers' perception and understanding in the Indian context; therefore development of a specific perception scale is essential. This study aims to prepare a scale and validate that particular scale, pertaining to farmer perception related to agrochemical impact on the environment.

In India, where the population is very high, a significant portion of population engages in agricultural activity. Now a day, the use of agrochemicals is gradually increasing to meet the growing demand for production. However, such agrochemicals are indiscriminately used by farmers, which results in disruption of the ecological balance and harm to the environment. A study by Shetty *et al*. (2010) revealed that farmers with limited knowledge resulted in excessive and unsafe pesticide use. In villages of southern India, farmers' with limited perception and awareness leads to high health risks related to pesticide exposure (Satya Sai *et al.,* 2019). Farmers' awareness related to agriculture was insufficient. Some of the farmer does not align with the practice (Mohanty *et al.,* 2013). A study by Sindhu & Shivalingaiah (2023) revealed a positive association between scientific orientation and farmer knowledge related to pollinators and pollination.

Another study by Sarkar *et al.* (2011) shows that agrochemical over use potential to cause harmful effects, such as soil degradation, biodiversity loss and health issues. Banarjee (2014) highlights that farmers' perception is important in making an adaptation plan related to climate variability. A study in Karnataka shows farmer perception regarding functioning of Raitha Samparka Kendras associated with education, scientific orientation, risk orientation and mass communication (Darshan *et al*., 2019). Most of the vegetable growers show that the majority of them were unaware of the guidelines provided by the Central Insecticides Board and Registration Committee (CIBRC) related to pesticide bottle labels (Brar *et al*., 2018).

There is a vital gap in understanding what farmers themselves perceive on environmental impact related to agrochemicals. Many researchers tried to capture attitude, perception, but difficult to address the need for a standardised scale. Therefore present study tries to capture and measure farmers' perception by developing a standardised scale on this topic.

Methodology

The perception scale was developed through a multistage process, which involved item development, content validity through expert validation, construct validity through exploratory factor analysis and reliability analysis, calculating Cronbach's alpha value as outlined by Boateng *et al*. (2018). First and foremost step was, construct a list of items based on previous research reports, literature and researchers' Knowledge and field visits. In many research studies, Likert scaleswere widely used to measure perception and attitude, as this method allows respondents to express different levels of agreement and disagreement with a set of statements (Allen & Seaman, 2007). To measure the perception of farmers regarding agrochemicals' impacts on the environment, this study used a 5-point Likert scale. Jin *et al.* (2017) followed a similar method to quantify farmer risk perception related to agrochemical use. In 2024, Boora *et al.* followed this method to capture farmers' attitudes towards drip irrigation.

After that, 135 items in Likert scale format categories as 'Most relevant, Relevant, Undecided, Less Relevant, Least Relevant' were sent to 70 experts across different institutions across India for judges' opinion. Out of 70 experts, 30 responded with a suggested recommendation. Based on this content validity was assessed. Items with less than 85 per cent relevancy level were excluded and a total of 28 items were retained for the scale.

The Revised Scale with 28 items was sent to the 190 farmers to check its validity and reliability. These farmers were from different districts selected randomly from three agro-climatic regions of West Bengal, namely Jhargram from the undulating Red and Laterite Zone, North 24 Parganas from the Gangetic Alluvial Zone and South 24 from the Coastal Saline Zone as outlined by IMD

(India Meteorological Department), Govt. of India. Among those 50 respondents were fertiliser sellers and also actively engaged with farming. To perform exploratory factor analysis (EFA), a Statistical tool, viz. SPSS version 22, has been used. The data from the primary survey were considered for testing with exploratory factor analysis (EFA) to examine the cluster arrangement. A 0.5-factor loading criteria threshold level was set for EFA. Out of 20 items, 20 items loaded in 7 components were selected for the scale.

After factor analysis, a scale reliability method, the split-half test, was performed to assess internal consistency. The item's correlation value of 0.20 was set for item extraction. Finally, 19 items were retained for the scale.

Results and Discussion

Relevancy Test

In scale development, the relevancy test is very important as it ensures scale items are relevant, clear and appropriate for measuring the scale. Fields like social science, agriculture extension generally use this method for scale development. To obtain the Relevancy percentage formula, use:

In this formula judge's opinion is used to rate each item on basis of 5 point likert scale. Here obtained score is the sum of ratings for each item and the maximum possible score means, sum of the most relevant scores for each item. Some researchers used this formula in their studies. Like Beig *et al.* (2021) used this method to analyse constraints of mixed dairy farming perceived by the field veterinarians.

Following the above method, on the basis of a pre-determined percentage, items were excluded. Usually, items with 75 per cent assume high relevancy based on the judge's opinion and those are included for the next stage of validation. According to Boateng *et al.* (2018), through item evaluation by an expert, Content validity is mainly assessed.

In this study, items were sent to 70 experts and 30 responded within the particular time frame. Responses from these 30 experts were used to calculate the Mean Relevancy Score and Relevancy Percentage. As per Table 1, in the item analysis, out of 135 statements, 28 statements exceeded the relevancy score 85 per cent were retained for further consideration. Furthermore, 6 repetitive statements were identified, excluded and reworded as per the experts' suggestions to avoid ambiguity.

Table 1

Relevance of the item

Item No	Statement	Relevancy (%)
1	Agrochemicals are harmful to the Environment	95.33
3	Agrochemicals significantly impact biodiversity	89.33
4	Farmers need knowledge regarding the proper use of agrochemicals	94.67
5	Agrochemical residues can seep into groundwater and affect its quality.	92.67
7	Tube well water is at risk of contamination from nearby agrochemical use.	88.00
9	Runoff from fields treated with agrochemicals can pollute nearby surface water.	89.33
10	Fish and other aquatic life are impacted by agrochemical pollution in surface water.	94.67
11	Agrochemical residues in surface water can accumulate in the food chain.	86.67
12	The health of river ecosystems is affected by agrochemical contamination.	86.67
13	The presence of agrochemicals in rivers can affect the biodiversity of aquatic species.	88.00

Continued....

Table 1 Continued....

Item No	Statement	Relevancy (%)
16	The use of agrochemicals affects soil quality.	93.33
17	Prolonged use of agrochemicals can degrade soil structure.	90.67
19	The use of agrochemicals impacts the organic matter content in the soil.	84.67
20	Agrochemical use affects soil fertility over time.	91.33
21	Soil microorganisms important for fertility are harmed by agrochemicals.	89.33
22	The long-term use of agrochemicals can lead to decreased soil productivity.	88.67
23	Changes in soil pH due to agrochemicals can impact plant health.	85.33
31	Agrochemical residues in the environment can affect the health of livestock.	88.67
32	Domestic animals can ingest agrochemicals through contaminated food or water.	90.67
34	Agrochemical use affects the presence of beneficial insects in nearby fields.	88.00
37	Agrochemical runoff can alter the nutrient availability for plants in adjacent fields.	88.00
38	The use of agrochemicals can harm bird health.	90.00
39	The use of agrochemicals can contribute to the extinction of certain bird species.	86.67
40	The use of agrochemicals can harm insect health.	90.00
41	Agrochemicals can kill beneficial insects such as pollinators.	90.67
42	The use of agrochemicals can contribute to the extinction of certain insect species.	90.00
45	The use of agrochemicals affects the quality of vegetables.	91.33
47	The use of agrochemicals can lead to nutrient imbalances in the soil, affecting crop health.	86.00

Relevancy Percentage = (Obtained Score / Maximum Possible Score) × 100

Item Analysis

Item analysis was conducted using Exploratory Factor Analysis (EFA) based on responses from 190 Farmers across three districts: Jhargram, North 24 Parganas and South 24 Parganas. Among these respondents, 50 were fertiliser sellers were are also actively engaged in farming activities. Exploratory factor analysis was used to check dimensionality and interrelationship among variables (Pituch and Stevens, 2015).

Here Table 2 represents the data suitability of the dataset for factor analysis of the perception scale was examined using Exploratory Factor Analysis (EFA), with varimax rotation. The initial analysis of the R-matrix indicated a substantial number of the coefficients were above 50. The Kaiser-Mayer-Olkin (KMO) index was 0.648, which is mediocre, exceeding the recommended value of 0.6 (Kaiser, 1974) Bartlett's Test of Sphericity ($p<.05$) was considered significant (Williams *et al.,* 2010).

Table 2

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.648
Bartlett's Test of Sphericity	Approx. Chi-Square	902.070
	df	190
	Sig.	.000

TABLE 3

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Q1				.625			
Q3				.601			
Q4				.782			
Q9	.693						
Q10	.722						
Q11					.537		
Q12		.801					
Q13						.598	
Q16						.829	
Q17							
Q19							.809
Q20		.606					
Q21	.719						
Q31					.652		
Q38					.625		
Q39							.841
Q40		.745					
Q41			.755				
Q42			.779				
Q45					.521		

Extraction Method : Principal Component Analysis.
Rotation Method : Varimax with Kaiser Normalization.
[A]a. Rotation converged in 17 iterations

Table 2 represents the value of Bartlett's Test of Sphericity (x_c=902.070, df=190, p<.001), indicating significance at 1 per cent (p<0.01) is appropriate for factor analysis (Bartlett, 1954, as cited in Ali *et al.,* 2021). The results of the initial analysis revealed 7 components with Eigen values over 1, explaining 18.75, 28.63, 36.91, 44.98, 52.26, 58.95 and 64.50 per cent of the variance, respectively.

Table 3 represents the Rotated Component Matrix using the Principal Component Analysis method. Here varimax rotation method is used with Kaiser Normalisation rotation converged in 17 iterations. By maximizing the variance square loading, varimax rotation reduces the number of variables that have high loading on each factor (Yong and Pearce, 2013). The results shows, out of 28 statements, 20 statements were retained for further analysis. These items were grouped into seven components with a minimum factor loading limit of 0.50.

Table 4 represents item communalities extraction with the help of the Principal Component Analysis method. For all items initial value is 1. It means that during extraction, principal component analysis (PCA) considers that all variance is common (Suhr, 2006). Extraction of variance suggests that, retained items are enough to justify the component. Hence, construct validity is supported by the communalities analysis.

TABLE 4

Communalities

Item	Initial	Extraction
Q1	1.000	.551
Q3	1.000	.520
Q4	1.000	.695
Q9	1.000	.721
Q10	1.000	.652
Q11	1.000	.690
Q12	1.000	.668
Q13	1.000	.590
Q16	1.000	.745
Q17	1.000	.638
Q19	1.000	.675
Q21	1.000	.673
Q31	1.000	.704
Q38	1.000	.572
Q39	1.000	.779
Q40	1.000	.605
Q41	1.000	.619
Q42	1.000	.681
Q45	1.000	.532
Q20	1.000	.588

Extraction Method: Principal Component Analysis

TABLE 5
Reliability Statistics

(Guttman Split-Half Coefficient)			
Cronbach's Alpha	Part 1	Value	.644
		N of Items	10 [a]
	Part 2	Value	.541
		N of Items	10 [b]
		Total N of Items	20
Correlation Between Forms			.569
Spearman-Brown Coefficient		Equal Length	.726
		Unequal Length	.726
Guttman Split-Half Coefficient			.726

a. The items are: Q1, Q3, Q4, Q9, Q10, Q11, Q12, Q13, Q16, Q17.
b. The items are: Q19, Q20, Q21, Q31, Q38, Q39, Q40, Q41, Q42, Q45

Reliability of the Scale

Reliability is a measurement of internal consistency. This internal consistency is confirmed by the Cronbach value. A satisfactory Cronbach value must cross the threshold of 0.7 (Shrestha, 2021).

Table 5 represents the split-half method was used to measure reliability. After the EFA analysis, 20 items were retained for the scale. These items were divided into two parts; one half represents odd numbers and the other half represents even numbers. In the next stage, it was administered to 190 farmers across three districts of West Bengal. Reliability statistics show that, in the 1st part and 2nd part, Cronbach's Alpha value is .644 and .541, respectively, showing moderate consistency.

Table 6 represents the overall Cronbach's Alpha value for 20 items is .740, showing a good level of reliability. Furthermore, Cronbach's Alpha value on standardised items is .762 confirming good internal consistency. Tavakol and Dennick (2011) remarked that alpha values between 0.70 and 0.90 are commonly considered as an acceptable range for newly developed scales. Correlation value (r =0.569) indicates a moderate positive relationship between the two parts of the scale. The Spearman-Brown and Guttman coefficients both have a value of 0.726, suggesting acceptable split-half reliability (Savage, 2017).

Table 7 represents item-wise correlation analysis that was performed to assess individual item performance. Most items showed corrected item-total correlation values that crossed the 0.20 threshold level, suggesting consistency in farmers' responses. Though, one item showed a remarkably low correlation (0.168). Therefore, it is excluded from the final scale. The final version retained 19 items. Cronbach's Alpha value, if each item is deleted,

TABLE 6
Reliability Statistics

(Cronbach's Alpha)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.740	.762	20

TABLE 7

Item-wise relevance for scale

Item	Statement	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Remarks
1	Agrochemicals are harmful tothe Environment	0.307	0.729	Retain
3	Agrochemicals significantly impact biodiversity	0.44	0.721	Retain
4	Farmers need knowledge regarding the proper use of agrochemicals	0.217	0.736	Retain
9	Runoff from fields treated with agrochemicals can pollute nearby surface water.	0.316	0.73	Retain
10	Fish and other aquatic life are impacted by agrochemical pollution in surface water.	0.334	0.729	Retain
11	Agrochemical residues in surface water can accumulate in the food chain	0.385	0.723	Retain
12	The health of river ecosystems is affected by agrochemical contamination.	0.375	0.724	Retain
13	The presence of agrochemicals in rivers can affect the biodiversity of aquatic species	0.361	0.725	Retain
16	The use of agrochemicals affects soil quality.	0.32	0.729	Retain
17	Prolonged use of agrochemicals can degrade soil structure.	0.332	0.729	Retain
19	The use of agrochemicals impacts the organic matter content in the soil.	0.168	0.747	Excluded
20	Agrochemical use affects soil fertility over time.	0.205	0.737	Retain
21	Soil microorganisms important for fertility are harmed by agrochemicals.	0.31	0.729	Retain
31	Agrochemical residues in the environment can affect the health of livestock.	0.385	0.726	Retain
38	The use of agrochemicals can harm bird health.	0.312	0.729	Retain
39	The use of agrochemicals can contribute to the extinction of certain bird species.	0.255	0.736	Retain
40	The use of agrochemicals can harm insect health.	0.346	0.727	Retain
41	Agrochemicals can kill beneficial insects such as pollinators.	0.294	0.731	Retain
42	The use of agrochemicals can contribute to the extinction of certain insect species.	0.314	0.73	Retain
45	The use of agrochemicals affects the quality of vegetables.	0.323	0.728	Retain

showing reliable mean all items are reliable for the scale.

Validity of the Scale

Using Pearson's product-moment correlation, item-total correlation was calculated to determine how each item of the scale aligned with the overall scale item. Table 8, shows that the sample size is 190; therefore, the degrees of freedom (df) for Pearson correlation were 188, calculated using the formula (df=N-2). According table extracted from (Bert *et al.,* 2012), Pearson's critical value for df = 188 is not given; therefore, we considered the df = 150 value to check statistical significance at the 95 per cent confidence interval (0.05, two - tailed test) is 0.1593.In this scale development, all 20 items were retained because all items exceeded the minimum threshold for significance at p <0.01. It validates that each item on the scale is meaning fully explained by the overall scale and it also supports the internal consistency of the scale.

This study aimed to develop a standardised scale to measure farmers' perception in connection with agrochemicals impact on the environment. Items are developed based on the literature. Content validity assessed through expert analysis. Out of 135 items, only 28 items were retained, which crossed 85 per cent relevancy and 6 items were removed to avoid ambiguity as per expert suggestion. Retained items were then administered among 190 farmers for construct validity. Exploratory factor analysis was performed considering a 0.50 threshold and varimax rotation. The Kaiser-Mayer-Olkin (KMO) index

Table 8
Correlations

Item no	Item Total Correlation Value (Pearson Correlation)	Sig. (2-ailed)	N	Df	Minimum Coefficient Value at 95% C.I
Q1	.318 **	.000			
Q3	.521 **	.000			
Q4	.273 **	.000			
Q9	.410 **	.000			
Q10	.414 **	.000			
Q11	.543 **	.000			
Q12	.538 **	.000			
Q13	.449 **	.000			
Q16	.408 **	.000			
Q17	.405 **	.000	190	188	0.1593
Q20	.358 **	.000			
Q21	.422 **	.000			
Q31	.486 **	.000			
Q38	.425 **	.000			
Q39	.351 **	.000			
Q40	.518 **	.000			
Q41	.406 **	.000			
Q42	.407 **	.000			
Q45	.452 **	.000			

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed)

0.648 suggeststhat Bartlett's Test value also suggests data are adequate for factor analysis. The rotated component suggests retention of 20 items that cross the threshold. These items are then selected for a reliability test where Cronbach's alpha 0.740 for over all items value and split-half test value for odd-even items 0.726 suggest both acceptable values reflect high internal consistency. Although the item total correlation suggests the exclusion of one item that is below 0.2. Correlation was performed to check scale validity, which confirms all 19 items are significant and valid.

In this study, we try to develop a standardised scale that can capture farmers' perceptions of agrochemicals impact towards the environment. For this study, a systematic multistage approach was taken to derive the outcome. This process involves item development, validation from judges, field testing with 190 farmers in 3 different agro-climatic regions of West Bengal and a reliable 19-item scale was finally selected for the scale. Scale statistical validation was tested through Cronbach'salpha value is 0.740, confirming acceptable internal consistency and Spearman-Brown coefficient value is 0.726, indicating strong split-half reliability.

In conclusion, this newly developed scale canwork as a valuable resource for researchers, extension workers policy makers to understand farmers' perception levels and also help build to awareness-building curriculum. Although this study's field testing is limited to 3 agro-climatic regions, the outcomes set a benchmark for future research and promote sustainable farming practice.

Acknowledgement : This research is financially supported by the University Grant Commission (UGC), Ministry of Education, Governmentof India. This supports us in exploring farmer perception in Indian rural settings. It also provides necessary research aid for constructing a standardised perception scale.

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