



RESEARCH ARTICLE

Construction and validation of a knowledge test on flood adaptation strategies among rice and wheat farmers

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Abstract

Floods pose a persistent threat to agricultural productivity in flood-prone regions of India. The country experiences floods annually, with 12 % of its land (40 m ha) being flood prone. These events cause substantial soil erosion, extensive crop losses and livelihood disruptions for farmers. Therefore, effective adaptation strategies are crucial for minimising flood losses, sustaining livelihoods and building long-term resilience. However, knowledge gaps among farmers hinder their adoption. This study constructed and validated a standardised test to measure the knowledge level of the rice and wheat cultivators regarding floods and their structural as well as non-structural adaptation strategies. Following standard scale development procedures, 55 initial items were sourced from literature, expert consultations and pilot studies. Content validity was established through expert ratings with relevancy weightage (RW) > 0.75 and mean relevancy score (MRS) > 2.5. Item analysis of 60 flood-affected farmers from non-sampled villages of the Baleshwar district yielded difficulty indices (30–80 %), discrimination indices (0.25–0.55) and significant point-biserial correlations. The refined 37-item dichotomous test showed strong internal consistency, with a Kuder-Richardson formula 20 (KR-20) reliability coefficient of 0.805. The validated instrument provides a reliable tool for assessing knowledge levels, identifying extension needs and informing policy interventions in both Odisha and Bihar and was applied to 480 flood-affected farmers in the study locale. By bridging knowledge deficits, it supports sustainable flood management, improves farm resilience and contributes to food security in vulnerable agro-ecosystems. This methodology offers a replicable framework for similar climate adaptation research.

Keywords: agricultural knowledge assessment; flood adaptation strategies; reliability; rice; validity; wheat

Introduction

India has a unique climate diversity, with approximately 80 % of its annual rainfall concentrated during the short monsoon season, typically spanning less than 100 days (1, 2). Climate change exacerbates these vulnerabilities through increasingly erratic monsoons and intensified extreme rainfall events (3, 4). Regions receiving excess precipitation experience extensive flooding during this period. Consequently, floods represent one of the most recurrent hydrological phenomena and devastating natural hazards, affecting approximately 40 m ha of land and causing substantial losses to lives, livelihoods and infrastructure, with annual economic losses exceeding billions of dollars (2, 5, 6).

Flood events disproportionately impact India's agrarian population, inflicting crop and livestock losses, inducing widespread crop failures and disrupting agricultural calendars (7). These shocks influence income declines, curtail household consumption and

perpetuate poverty traps (8). Moreover, they often trap farmers in cycles of indebtedness. Therefore, flood coping and adaptation strategies are necessary because the floods impose a significant burden on the farming community.

Globally, numerous studies have been conducted and have documented various adaptation strategies adopted by farmers to cope with climate extremes (1, 6, 8–17). An extensive literature review reveals that effective flood adaptation includes structural interventions such as embankments, check dams and raised platforms alongside non-structural measures like early warning systems, crop diversification, flood-resistant varieties and flood plain zoning policies (8, 18, 19). However, persistent knowledge gaps among farmers hinder adoption, resulting in low uptake of these adaptation practices. Assessing their level of knowledge is therefore essential to identify gaps and design targeted extension interventions.

In this context, a knowledge test was developed to measure farmers' knowledge of major flood adaptation practices. Although

several studies have earlier standardised knowledge tests related to climate change and adaptation, most focus broadly on climate change adaptation rather than flood-specific strategies (20–25). This limitation restricts empirical insights into farmers' cognitive preparedness for flood adaptation. The present study addresses this void by constructing and validating a scale specifically designed to measure farmers' knowledge of adaptation strategies for effective flood management. The developed instrument offers a replicable framework for assessing knowledge levels, identifying extension gaps and informing interventions amid escalating flood risks. By bridging cognitive barriers, it supports resilient farming, sustainable livelihoods and food security in vulnerable agro-ecosystems.

Materials and Methods

Farmers' knowledge tests on adaptation strategies for floods are essential because knowledge directly drives the effective adoption of flood-resilient practices. The procedure to construct a valid knowledge test is illustrated in Fig. 1.

Procedure to construct a knowledge test

Item collection: A knowledge test comprised several statements or questions called items. Primarily, items pertaining to adaptation strategies were sourced from diverse origins, including pilot studies, review papers, research papers, articles published in peer-reviewed journals, discussions with experts in the concerned field, panel discussion and the researcher's professional experience. These items were developed to address key domains, namely general knowledge of floods, structural adaptation strategies and non-structural adaptation strategies.

Item selection: During item selection, the statements were chosen effectively to discriminate between well-informed and less-informed respondents, exhibit varying difficulty levels and encourage critical thinking rather than rote memorisation (26). Initially, a total of 55 statements pertaining to adaptation practices were selected.

Judgement and screening of items: For expert evaluation, knowledge test items were mailed to 40 experts, who rated each item on a three-point continuum: most relevant (3), relevant (2) and

least relevant (1). Of these, 30 valid responses were received, based on which item screening was conducted. Relevancy weightage (RW) and mean relevancy score (MRS) were computed using the following formulas:

$$RW = \frac{MR+R+LR}{MPS}, MRS = \frac{MR+R+LR}{n} \quad (\text{Eqn. 1})$$

Where, MR = Most relevant, R = Relevant, LR = Least relevant, MPS = Maximum possible score ($30 \times 3 = 90$) and n = number of judges. Items with $RW > 0.75$ and $MRS > 2.5$ were retained, resulting in 45 qualified items.

Item analysis: For scale computation, 60 flood-affected farmers from Chaumukh village in the Baleshwar district, Odisha, were randomly selected; these respondents were excluded from the final study to avoid testing effects. Before proceeding to the study area, all items were translated into the Odia language for the farmers' convenience and with the researcher's assistance, the respondents completed the interview schedule. Each of the 60 respondents was administered the test and scored 1 or 0 for each item, depending on whether their response was correct or incorrect. The item analysis of the test typically yielded three key metrics: the item difficulty index, item discrimination index and item validity index. After obtaining responses for the 45 items, the item difficulty index was calculated.

Item difficulty index: The difficulty of an item pertains to the level of challenge or effort experienced by respondents in providing a correct answer to the question. It was assessed by determining the proportion of respondents giving a correct answer to that particular item (26). The item difficulty index was calculated by:

$$P_i = \left(\frac{n_i}{N_i} \right) * 100 \quad (\text{Eqn. 2})$$

Where, P_i = difficulty index in percentage for the i^{th} item, n_i = total number of the respondents answered correctly to the i^{th} item and N_i = total number of the respondents included in the study (i.e., 60).

Item discrimination index: The discrimination index was computed to gauge the extent to which an item discriminates the



Fig. 1. Graphical representation of construction of knowledge test.

Table 1. Grouping of respondents for item analysis

Group of respondents	G ₁	G ₂	G ₃	G ₄	G ₅	G ₆
Range of scores	42–33	32–28	27–25	24–22	21–19	17–10
No. of respondents	10	10	10	10	10	10

respondents who possess greater knowledge about the topic from those who lack such knowledge. The total scores obtained by the 60 respondents across all 45 items were arranged in descending order of magnitude. Table 1. showed that these respondents were subsequently divided into six equal groups, namely G₁, G₂, G₃, G₄, G₅, G₆ of 10 respondents in each, ordered from highest to lowest score. For the item analysis, the middle two groups (i.e., G₃ and G₄) were eliminated and four groups with high scores (G₁ and G₂) and low scores (G₅ and G₆) were considered. The item discrimination index was calculated by “ $E^{1/3}$ ” formula (27):

$$E^{1/3} = \frac{[(S_1 + S_2) - (S_5 + S_6)]}{N/3} \quad (\text{Eqn. 3})$$

Where, S₁, S₂, S₅ and S₆ denotes frequencies of correct answers given by groups G₁, G₂, G₅ and G₆ respectively and N = the total number of respondents included in the study.

Point-biserial correlation: Point-biserial correlation coefficient measured the correlation between variables with continuous and dichotomous response (28). It was used to determine the internal consistency of the items. Following the formula, the correlation for each of the items was calculated:

$$r_{pb} = \frac{M_p - M_q}{SD} * \sqrt{pq} \quad (\text{Eqn. 4})$$

Where, r_{pb} = point-biserial correlation, M_p = mean of the total scores of the respondents who answered the items correctly, M_q = mean of the total scores of the respondents who answered the items incorrectly, SD = standard deviation of the entire sample, p = Proportion of respondents giving the correct answer to the item, q = Proportion of respondents giving an incorrect answer to the item or $(1 - p)$

Selection of the final statements: Items that satisfied all the criteria with difficulty index scores between 30 % and 80 %, discrimination index scores between 0.25 and 0.55 and r_{pb} coefficients significant at the 5 % and 1 % levels, were retained for the study.

Reliability of the test: Reliability referred to the consistency of results obtained from repeated measurements. For tests with dichotomous items (scored as correct/incorrect, 1 or 0), the Kuder-Richardson formula 20 (KR-20) provided an appropriate measure of internal consistency reliability, calculated using the following formula:

$$KR - 20 = \frac{K}{K-1} \left(1 - \frac{\sum pq}{\sigma^2} \right) \quad (\text{Eqn. 5})$$

Where, K = number of items, p = proportion of respondents who answered the items correctly, q = proportion of respondents who answered the items incorrectly, σ^2 = variance.

Validity of the test: Two methods were used to establish test validity: jury opinion and point-biserial correlation. Content validity was initially confirmed through expert evaluation of each item's relevancy weightage and mean relevancy score. Subsequently, the point-biserial correlation for each item substantiated the test's construct validity.

Results

Item analysis

A pilot study was conducted by randomly selecting 60 flood-affected farmers from Chaumukh village in the Baliapal block of Baleshwar district, Odisha. The village lies adjacent to the Subamarekha a river and the Bay of Bengal and is frequently impacted by floods and cyclones. This non-sampled area was chosen to administer the 45 validated items for computing the respective indices. Subsequently, key indices namely, item difficulty, item discrimination and point-biserial correlation, were derived. Table 2 illustrates their computation using item 4 and item 7 as examples.

Acceptable ranges for each item were set arbitrarily, with item difficulty constrained between 0.30 and 0.80 to avoid items that were either too easy or excessively difficult (29). The discrimination indices (0.25–0.55) confirmed strong ability of the items to differentiate between high- and low- knowledge respondents. Discrimination indices were restricted to the range of 0.25 to 0.55, indicating a satisfactory capacity of the items to distinguish between respondents with high and low levels of knowledge. Items exhibiting a minimum point-biserial correlation ($r > 0.20$) and statistical significance at the 5 % and 1 % levels were retained for the study, thereby ensuring a satisfactory internal consistency (30). Items with a 5 % level of significance denoted by “*”, while those with a 1 % level of significance are marked with “***”. The results are portrayed in Table 3. clearly indicate that 37 knowledge items met all the aforementioned criteria for inclusion in the final knowledge test.

Content validity

The content validity of the test was established through a systematic, multi-phase development procedure. An initial item pool of 55 items was generated based on a thorough review of scientific literature, panel discussions, expert consultations and field-level experience. These items were subsequently reviewed by 30 subject-matter experts with respect to their relevance; only those items meet the criteria of an RW greater than 0.75 and an MRS exceeding 2.5 were retained. This procedure ensured that the final set of 45 items comprehensively represented the conceptual domain of flood adaptation strategies, thereby demonstrating strong content adequacy.

Construct validity

Construct validity was examined using r_{pb} . Items that showed

Table 2. Computation of difficulty index, discrimination index and point-biserial correlation

Sl. no. of items	Frequency of correct answers from G ₁ , G ₂ , G ₅ , G ₆ group				Total frequency of correct answers (N = 60)	Difficulty index (30–80)	Discrimination index (0.25–0.55)	R _{pb} (> 0.20)
	S ₁	S ₂	S ₅	S ₆				
I ₄	8	6	2	1	22	36.67	0.55	0.522**
I ₇	6	7	5	3	36	60.00	0.25	0.463*

Table 3. Item difficulty (p), discrimination ($E^{1/3}$) and point-biserial correlation (r_{pb}) scores of each item

Sl. no.	Items	p	$E^{1/3}$	r_{pb}	Decision select/reject
A General knowledge about flood					
1	Which of the following is the most common cause of flooding in agricultural areas?	75.00	0.30	0.317*	Selected
2	What type of flood occurs due to prolonged heavy rainfall in river basins?	78.33	0.40	0.350**	Selected
3	Which of the following is an early warning tool used for flood prediction?	63.33	0.45	0.466**	Selected
4	Which organisation is responsible for issuing flood warnings in India?	63.33	0.25	0.602**	Selected
5	Integrated flood management involves	60.00	0.25	0.463*	Selected
6	Which traditional water harvesting method is commonly used in Bihar to manage excess water?	28.33	0.10	0.124	Rejected
7	What should be done first when a flood warning is issued?	53.33	0.30	0.261*	Selected
8	Excessive sand deposition in fields after floods improves soil fertility	70.00	0.30	0.157	Rejected
9	The National Disaster Management Authority (NDMA) is an apex body that responsible for flood disaster preparedness in India.	71.67	0.25	0.225**	Selected
10	Flood adaptation strategies aim to reduce the vulnerability of communities to flood-related hazards	50.00	0.40	0.540**	Selected
11	Which organisation issues flood alerts through its national flood forecasting network?	48.33	0.30	0.311*	Selected
12	Major rainfall occurs in your area due to which monsoon?	41.67	0.35	0.356**	Selected
13	A floodplain is the flat land adjacent to a river that experiences _____ during monsoons	50.00	0.25	0.029	Rejected
B Structural adaptation strategies					
1	Structural adaptation measures are those that involve physical infrastructure, while non-structural measures focus on policies and awareness	63.33	0.40	0.335**	Selected
2	The practice of constructing earthen embankments along rivers to prevent floods is known as	73.33	0.30	0.263*	Selected
3	Which of the following is an indigenous flood adaptation practice used by farmers in Bihar and Odisha?	41.67	0.05	0.166	Rejected
4	What is the primary function of a check dam in flood control?	46.67	0.30	0.291*	Selected
5	Which of the following is an example of a structural flood management strategy?	53.33	0.25	0.323*	Selected
6	What type of buildings are best suited for flood-prone areas?	56.67	0.35	0.372**	Selected
7	Raised platforms for livestock and food storage during floods are commonly called as	41.67	0.40	0.233	Rejected
8	What is the primary purpose of constructing embankments along rivers?	48.33	0.40	0.398**	Selected
9	One disadvantage of using concrete embankments as a flood adaptation strategy is	60.00	0.50	0.417**	Selected
10	What is the most effective structural measure to reduce flood impact in rural areas?	45.00	0.35	0.311*	Selected
11	Which of the following facilitates the quick removal of excess water from agricultural fields?	58.33	0.40	0.345**	Selected
12	The construction of check dams helps in controlling floods by reducing surface runoff.	53.33	0.40	0.406**	Selected
13	The construction of large dams is the only solution for flood control	61.67	0.30	0.256*	Selected
C Non-structural adaptation strategies					
1	Which of the following is a sustainable practice for flood-prone farming?	55.00	0.45	.370**	Selected
2	Mulching helps reduce flood impact by	48.33	0.30	0.244	Rejected
3	Why is crop diversification an important flood adaptation strategy?	58.33	0.45	0.473**	Selected
4	Early warning systems for floods are essential because they	45.00	0.45	0.418**	Selected
5	Community participation is important in flood adaptation because	61.67	0.40	0.382**	Selected
6	Which flood-resistant paddy variety is recommended for flood-prone areas in Bihar and Odisha?	66.67	0.35	0.356**	Selected
7	What is an effective way for farmers to prepare for flood-related disasters?	60.00	0.45	0.472**	Selected
8	What is an effective cropping strategy for flood-prone regions?	81.67	0.40	0.462**	Rejected
9	The floodplain zoning method helps in	38.33	0.30	0.304*	Selected
10	Which of the following is a non-structural measure for flood adaptation?	56.67	0.50	0.616**	Selected
11	What is the most effective way for farmers to receive early flood warnings?	51.67	0.40	0.516**	Selected
12	What is an effective adaptive strategy for flood-prone regions?	71.67	0.30	0.597*	Selected
13	What is the advantage of using raised-bed farming in flood-prone areas?	30.00	0.35	0.445**	Selected
14	What type of crops are best suited for flood-prone areas?	36.67	0.55	0.522**	Selected
15	The method of growing crops that are resistant to waterlogging is called	31.67	-0.10	-0.003	Rejected
16	Farmers can protect their livestock during floods by	43.33	0.35	0.444**	Selected
17	Which approach is most effective in minimising flood-related health risks?	60.00	0.30	0.471*	Selected
18	The practice of maintaining buffer zones around rivers is an effective flood adaptation strategy	58.33	0.35	0.642**	Selected
19	The use of chemical fertilisers increases soil permeability and helps in flood control.	70.00	0.45	0.442**	Selected

* Significant at $P < 0.05$ (2-tailed); ** Significant at $P < 0.01$ (2-tailed).

statistically significant correlations at either the 1 % and 5 % levels were finalized, indicating that these items were well aligned with the underlying construct and effectively discriminated between respondents with higher and lower levels of knowledge.

Reliability analysis

The internal consistency of the knowledge test was assessed using the KR-20 formula, a reliability coefficient particularly suited to knowledge-based assessments comprising dichotomously scored items. The KR-20 coefficient value ranges from 0 to 1; the obtained reliability coefficient of 0.805 (> 0.80) falls within the “excellent” range according to established reliability criteria. This strong level of internal consistency indicates that the instrument yields stable and dependable scores and is therefore well suited for application in further empirical research.

Discussion

This study sought to construct a statistically robust and content-valid test for assessing farmers' knowledge of adaptation strategies in effective flood management. Findings confirm that the meticulous methodology from item collection and expert validation to index evaluation yielded a dependable and high-quality measurement tool. The whole test is divided into three domains, namely general knowledge of floods, structural adaptation strategies and non-structural adaptation strategies.

In the preliminary stage, the initial item pool comprised 18 items on general knowledge, 16 items on structural adaptation strategies and 21 items on non-structural adaptation strategies, totaling 55 items. Following the relevancy test, 10 items were eliminated from the test battery, yielding a refined set of 45 items (13 on general knowledge, 13 on structural adaptation strategies and 19 on non-structural adaptation strategies). This set underwent index calculations, after which items meeting the selection criteria were finalized, resulting in a 37-item knowledge test comprising 10 items on general knowledge, 11 items on structural adaptation strategies and 16 on non-structural adaptation strategies. Validity, a critical attribute of any test, was established through assessments of both content validity (via expert evaluation) and construct validity (via r_{pb}). Additionally, the KR-20 coefficient of 0.805 falling within the excellent range, further confirming the strong internal consistency of the knowledge test developed through this structured, multi-stage process.

Conclusion

This study successfully constructed and validated a standardised knowledge test to measure farmers' knowledge of flood management and both structural and non-structural adaptation strategies. The instrument addresses critical knowledge gaps that impede the effective adoption of these strategies. The test comprehensively assesses the multidimensional aspects of adaptation strategies, ranging from physical engineering measures to policy, planning and behavioural approaches of the farmers. The final knowledge test serves as a scientifically validated tool for researchers, extension personnel, policymakers and training institutions to assess farmers' adaptive capacities and promote the adoption of effective flood management strategies.

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Authors' contributions

BM¹ led the writing of the manuscript. SD and MPN conceptualised the research framework and provided overall study supervision. SKM contributed to the design of the research methodology, data validation and refinement of the manuscript. BM² contributed to data analysis and interpretation. AD assisted in statistical analysis, interpretation of results and the development of data visualisations. KKS coordinated the drafting process and ensured clarity. All authors have read and approved the final version of the manuscript [BM¹ stands for Biswajit Mallick and BM² stands for Bishnupriya Mishra].

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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