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RESEARCH ARTICLE

Development of a scale to assess flood consequence perception among rice and wheat growers in Odisha and Bihar

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Abstract

Floods are emerging as a formidable and recurrent natural hazard, causing multidimensional impacts, including mortality, agricultural damage, economic hardship, infrastructure deterioration, environmental degradation and social disruption. Understanding farmers' perception of flood consequences is therefore essential for designing effective coping and adaptation strategies. Since perception is a psychological construct, it can be more accurately measured using a standardised scale. Accordingly, this study aimed to develop a reliable and valid scale using the scale product method to quantitatively assess farmers' perception. The scale values of Thurstone and the weights of Likert were combined to produce higher reliability of the scale. From identification of the dimensions to final administration, the scale has undergone various steps. Judges showed substantial agreement on dimension selection, as measured by Kendall's coefficient of concordance (W = 0.762, X^2= 182.932, $p \leq 0.01$). Initially, 93 statements were compiled from various sources, of which 66 were retained and distributed to 100 judges for evaluation. The judges were requested to rate the relevance of each item on a seven-point continuum ranging from most unfavourable to most favourable. Following Thurstone's elimination criteria, responses from 60 judges were retained for analysis. Based on the S (median) value (2.5 to 6.5) and Q (quartile) values (1.04 to 1.92), 18 statements were eliminated, leaving 48 final items for the scale. The accuracy and reproducibility of the scale were determined through a content validity ratio (CVR) greater than 0.78 and a reliability coefficient of 0.874. Each statement was then assigned a 4-point response continuum to measure farmers' perceptions.

Keywords: Bihar; flood consequences; Kendall's W; Odisha; perception; scale product method

Introduction

Floods constitute one of India's most recurrent and severe natural hazards, with nearly 28 % of the population (over 400 million people) residing in high-flood-risk areas, positioning the country as the second most flood-affected nation globally after Bangladesh (1). Floods exert substantial adverse effects on agricultural productivity, livestock and rural livelihoods. The agricultural sector, heavily reliant on monsoon rains, is particularly vulnerable, leading to significant economic losses exceeding ₹1119 crore and over 7.2 million hectares of land affected annually and long-term food security challenges (2). In addition to physical damage, floods influence farmers' socio-psychological perspectives, thereby shaping their adaptive behaviours and resilience (3). Perception is the way one interprets and understands sensory information from the environment (4). It is impacted by several things, including expectations, feelings, cultural background and prior experiences. Given the socio-cultural and agro-ecological diversity across India, it is anticipated that farmers' perceptions and adaptation strategies to flood impacts vary significantly across regions (5). Consequently, investigating farmers' perceptions of flood-induced impacts is essential. Their experiential knowledge and awareness of risks fundamentally influence decision-making processes related to farm management, adoption of coping mechanisms and the development of community-centred disaster risk reduction strategies (6). This nuanced understanding is crucial for designing sustainable and locally appropriate interventions to enhance resilience among farming communities. Numerous prior investigations have focused on developing perception scales related to climate change as well as natural disasters in farming communities. Researchers from India (7–10) and abroad (11, 12) studied the perception of the farmers through construction of perception scales. However, to understand the perception towards flood consequences, there is no well-developed scale available among the scientific communities to quantify perception of farmers in Bihar and Odisha states. Recognising the uniqueness of the current study and the factors involved, the present study aims to construct a scale that systematically assesses perceptions regarding the impacts of floods. Of the different methods available for constructing scales, Thurstone's Equal Appearing Interval Scale (13) and Likert's Summated Rating Scale (14) were determined to be the most appropriate techniques.

Materials and Methods

Floods are complex natural processes that have far-reaching consequences across multiple domains. For the present study, 5 major domains, i.e., social, agricultural, economic, psychological and environmental, have been listed (15). In this study, domains are treated as dimensions and consequences are marked as statements. During the scale construction, it is important to quantify the degree of agreement or concordance among multiple judges/ experts, assessing these dimensions, which ensures the scale's reliability. Accordingly, Kendall's Coefficient of Concordance (Kendall's 'W') is used as it measures the agreement among the experts who have given a rank to a set of items or subjects ordinally. The following formula of Kendall's W (16–18) determines the total score.

$$w = \frac{12S}{m2n(n^2\text{-}1)} \quad \text{(Eqn. 1)}$$

n = the total number of components being ranked

m = the total number of experts

S = the sum of the squares of the deviations of the row sums of ranks from their mean

Kendall's W is commonly used to measure agreement or consistency among experts on the taken components, ranging from 0 to 1.

$0 \leq W \leq 1$

Where zero denotes non-existence of agreement among the experts and 1 denotes perfect agreement.

Steps followed for the construction of the perception scale

Collection of relevant statements: Exhaustive lists of statements were collected on the concept of various consequences of flood on society to represent the universe of the construct. In the primary stage, total 93 statements reflecting perception were gathered from various sources like the researcher's thought, published research papers, review articles, newspaper articles, books, consultation with guide, experts and experienced farmers after a pilot study.

Selection and editing of the statements: The collected items were edited following the criteria of Edwards and Kilpatrick (19). After scrutiny of all the items, 66 items were retained. Utmost care was given to select non-factual and non-ambiguous items.

Judge's rating of perception statements: Recognising that the collected items may vary in their validity for accurately assessing perceptions, the items were subjected to expert evaluation to determine their content appropriateness and relevance. The 66 items were administered to the 100 experts having knowledge on climatology research, rural studies and policy formulation, drawn from different universities, research institutes and Krishi Vigyan Kendra. The items were categorised into 5 broad groups and sent to the experts to analyse the relevancy of the items in a seven-point psychological continuum from 1 to 7 (20). Here 2 extremes of the intervals (1 and 7) represent the most unfavourable and most favourable feelings, respectively, while the middle one (4) represents neutral.

Determining the criteria for the elimination of judges: Out of 100 experts, only 73 responses were collected within a time frame. Some judges responded carelessly with little or no interest, while others misunderstood the directions and the instructions. Therefore, considering Thurston's criteria for elimination, 13 judges were eliminated during the final selection. Hence, responses from the 60 experts were finalised for the scale construction.

Calculation of scale value: A 7-point equal-appearing interval continuum was employed to evaluate each statement based on its degree of unfavourableness to favourableness. For every statement, the frequency, proportion and cumulative proportion were computed. The scale (S) value or median value of each statement was then determined using the following formula.

$$S = l + \left(\frac{0.5 - \Sigma pb}{pw}\right) * i \quad \text{(Eqn. 2)}$$

Where, S = Median or Scale value of the statement

l = Lower limit of the interval in which the median falls

$\sum pb$ = Sum of proportion below the interval in which the median falls

Pw = Proportion within the interval in which the median falls

i = Width of the interval and is assumed to be 1

Computation of Q values: Obtaining the scale values by computing the median alone is not sufficient. It is also necessary to identify the ambiguity, uncertainty, or disagreement among the judges in classifying each statement into a particular category. This was accomplished by calculating the interquartile range (Q), which serves as an index of the dispersion of statements (21). To determine the Q value, the 75th percentile (Q75) and 25th percentile (Q25) were computed using the following formula.

$$C_{25} = l + \left(\frac{0.25 - \Sigma pb}{pw}\right) * i \quad \text{(Eqn. 3)}$$

C_{25} = the 25th centile

l = Lower limit of the interval in which the 25th centile falls

$\sum pb$ = Sum of the proportion below the interval in which the 25th centile

pw = Proportion within the interval in which the 25th centile

i = Width of the interval and is assumed to be 1

$$C_{75} = l + \left(\frac{0.75 - \Sigma pb}{pw}\right) * i \quad \text{(Eqn. 4)}$$

C_{75} = the 75th centile

l = Lower limit of the interval in which the 75th centile falls

$\sum pb$ = Sum of the proportion below the interval in which the 75th centile

pw = Proportion within the interval in which the 75th centile

i = Width of the interval and is assumed to be 1

The interquartile range Q was found by taking the difference between C_{75} and C_{25}.

$$Q = (C75 - C25) \quad \text{(Eqn.5)}$$

For example, for the first statement frequency of responses collected in a seven-point continuum scale was presented in Table 1 and the calculation of S-value and Q-value was in Table 2.

Final selection of statements: Statements exhibiting higher Q-values were excluded from the final perception scale, as a large Q-value denotes ambiguity or inconsistency in respondents' judgments. Based on this criterion, the 48 statements retained for the final scale had scale values ranging from 2.50 to 6.50, while their corresponding Q-values ranged from 1.04 to 1.92.

Reliability of the scale: The scale is said to be reliable when it produces consistent results on repeated assignment to the same sample. The scale was administered to 30 respondents from a non-sample area who experienced floods every year. The split-half method given by Spearman and Brown (22) was employed to measure internal consistency. However, to further strengthen reliability assessment, triangulation of reliability statistics was done for improving the credibility of the scale with all 3 methods, viz. Split-half method (22), Cronbach's alpha method (23) and Guttmann split-half coefficients.

$$r_{xx'} = \frac{2r_{12}}{1+r_{12}} \quad \text{(Eqn. 6)}$$

r_{xx}'= Estimated reliability of the full test

r_{12}= Correlation between the two halves of the test (e.g., odd vs. even items)

$$\alpha = \frac{k}{k-1}\left(1-\frac{\Sigma\sigma^2_i}{\sigma^2_i}\right) \quad \text{(Eqn. 7)}$$

α= Cronbach's alpha coefficient

k= Number of items in the scale

$\sum\sigma_i^2$ = sum of variances for each item

σ_t^2 = variance of the total scores across all items

Validity of the scale: Validity is a crucial attribute of any research instrument, as it reflects the accuracy and truthfulness with which the instrument measures the intended construct. During the development of a new instrument, establishing content validity is strongly recommended (24). Content validity involves a systematic evaluation of the instrument to ensure that it adequately represents all relevant dimensions of the construct domain by including essential items and excluding irrelevant or inappropriate ones (25). The content validity ratio (CVR) for each item was computed using the method proposed by Lawshe (26).

$$CVR = \frac{n_e - (\frac{N}{2})}{(\frac{N}{2})} \quad \text{(Eqn. 8)}$$

n_e= the number of panel members indicating the items 'essential.'

N=Total number of panel members

A panel of 9 experts, following the guidelines of Lawshe, Lynn and Polit et al. (26–28), evaluated each item by categorising it as either "essential" or "not essential" for the instrument. For a panel consisting of nine experts, the statements with a CVR value of 0.78 or higher were considered as valid (29, 30).

Results and Discussion

Social, agricultural, economic, psychological and environmental dimensions were ranked using Kendall's W. The analysis presented in Table 3 yielded a Kendall's W value of 0.762, signifying strong inter-rater concordance in ranking the assessed dimensions. Since the value of W ranges between 0 and 1, a coefficient of 0.762 suggests that the judges exhibited a strong level of consensus. The associated chi-square value was 182.932 with 4 degrees of freedom and the test was statistically significant at the 1 % level (Asymp. Sig. = 0.000, p<0.01). Furthermore, the Monte Carlo estimation provides a non-parametric p-value by simulating the null distribution through random permutations of the rankings which confirmed the result's significance at the 99 % confidence interval, thereby validating the robustness of the agreement observed. These findings indicate that there was a significant difference among the dimensions considered for scale construction. This result shows a degree of congruence with the findings reported previously (31, 32). A careful examination of Fig. 1 illustrates the ranking of 5 dimensions based on Kendall's coefficient of concordance approach to determine the degree of agreement among judges. The analysis revealed that the

Table 1. Frequency of responses in a seven-point continuum for the first statement

	Sorting category							Total
	1	2	3	4	5	6	7	
Frequency of judges scored to the 1st statement	II	IIII	IIII III	IIII IIII	IIII IIII II	IIII IIII IIII II	IIII IIII IIII III	60
	2	4	7	8	10	14	15	

Table 2. Calculation procedure of the S-value and Q-value of the first statement

1st statement	Sorting category							S	Q
	1	2	3	4	5	6	7		
Frequency (f)	2	4	7	8	10	14	15		
Proportion (P)	.03	.07	.12	.13	.17	.23	.25	5.65	1.86
Cumulative proportion (cp)	.03	.10	.22	.35	.52	.75	1.0		

Table 3. Results of Kendall's coefficient of concordance test for selected dimensions

	N			60
	Kendall's W			.762***
	Chi-Square			182.932
	df			4
	Asymp. Sig.			.000
Monte Carlo Sig.		Sig.		.000
	99 % Confidence Interval		Lower Bound	.000
			Upper Bound	.000

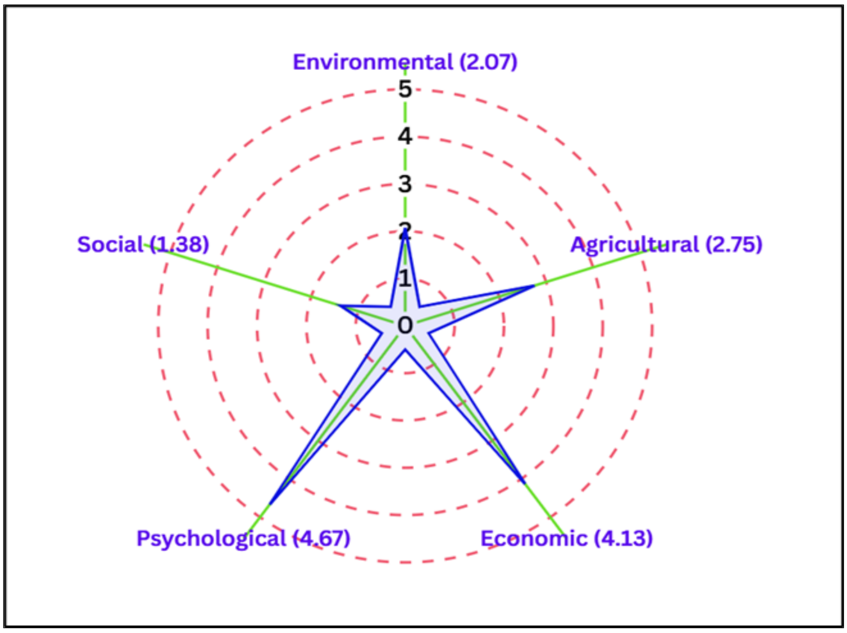

Fig. 1. Comparative ranking of dimensions based on Kendall's W mean scores.

psychological consequences dimension obtained the highest mean score of 4.67, implying that judges perceived this dimension as the most critical aspect influencing the construct under study. This may reflect the significant emotional and mental stress experienced by individuals when confronted with adverse situations. The economic consequences followed with a mean value of 4.13, suggesting that financial losses and livelihood disruptions were also perceived as major concerns. The agricultural consequences dimension ranked third, with a mean score of 2.75, highlighting the substantial but comparatively lesser emphasis placed on direct impacts on agricultural productivity and practices. The environmental consequences secured the fourth rank (mean = 2.07), indicating that ecological disruptions, though acknowledged, were not prioritised as strongly as psychological or economic impacts. Lastly, the social consequences dimension ranked fifth with a mean score of 1.38, signifying that social aspects such as community displacement or relationship dynamics were considered perceived as comparatively less influential among the evaluated dimensions. Table 4 presents that statements having S value ranging between 2.50 and 6.50 and Q value between 1.04 and 1.92 were retained from each dimension for the final scale construction, while the remaining 18 statements lying outside these ranges were eliminated.

Reliability of the scale

The reliability analysis presented in the Table 5 demonstrates a high level of internal consistency among the items of the scale. The Cronbach's Alpha was found to be 0.874, significant at the 1 % level, which suggests a strong positive relationship between the 2 halves of the scale. Moreover, the Spearman-Brown Coefficient for both equal and unequal length adjustments was 0.933 and the Guttman Split-Half Coefficient was also 0.933, confirming excellent internal reliability.

Administration and scoring of the statements

The selected statements of the scale were then randomly arranged and incorporated into the final format of the interview schedule for the farmers. Through the scale-product method, the weights of Likert and the scale values of Thurstone were combined to produce higher reliability of the scale (33). So, each of the statements was provided with four-point response categories (like a Likert Scale). The 4 points in the continuum were 'strongly agree', 'agree', 'disagree' and 'strongly disagree' with scores (weights) 4, 3, 2 and 1, respectively, for the statements. The respondents from both Bihar and Odisha were asked to respond to each statement in terms of their agreement or disagreement. The summation of the scores indicated the perception score of each respondent.

Conclusion

The study successfully developed a reliable and valid scale to measure farmers' perceptions of flood consequences. Using Kendall's W value of 0.762, the scale demonstrated strong agreement among judges and by using the scale product method, the instrument is ready with 48 items to effectively capture multidimensional perceptions, a robust tool for assessing farmers' perception towards flood consequences in both Bihar and Odisha. Also, the scale can be extended to other flood-prone Indian states or to similar agrarian contexts.

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Authors' contributions

BM led the writing of the manuscript and contributed to data analysis and interpretation. SD and MPN conceptualised the research framework and provided overall supervision of the study. SKM contributed to the research methodology design, data validation and manuscript refinement. AD assisted with statistical analysis, interpretation of results and development of data visualisations. KKS coordinated the drafting process and ensured clarity of presentation. All authors read and approved the final version of the manuscript.

Table 4. Details of the perception statements with their corresponding S and Q values

Sl. No.	Perception statements	S value	Q value	Decision (Select/Reject)
A.	**Social consequences**			
1.	Floods increase vulnerability among marginalised populations, such as the elderly and disabled	4.44	1.30	Selected
2.	Floods disrupt sanitation systems, contaminate water sources, which leads to health risks	5.65	1.86	Selected
3.	Floods lead to prolonged power outages, disrupting daily life and essential services	5.28	1.75	Selected
4.	Floods increase the risk of waterborne diseases	9.00	1.47	Rejected
5.	Floods severely affect transportation and communication networks	5.50	1.24	Selected
6.	Flood causes extensive damage to infrastructure, rendering essential services non-functional	5.28	1.47	Selected
7.*	Flood is not a serious problem for the people having pucca houses	4.50	1.08	Selected
8.	Floods increase social conflicts over scarce resources	4.63	1.25	Selected
9	Displacement due to flooding leads to loss of community bonds	8.00	-5.92	Rejected
10.*	Community-based disaster response programs help minimise flood impacts	4.70	1.55	Selected
11.	Flood causes human mortality each year	6.70	2.52	Rejected
12.*	Floods promote solidarity and cooperation among affected communities	5.28	1.67	Selected
13.	Women and children are more vulnerable to exploitation and abuse during floods	4.86	1.04	Selected
14.	Temporary displacement disrupts children’s education	11.50	3.55	Rejected
15.	Evacuation centres often lack adequate facilities to support affected families	3.25	1.91	Selected
16.*	Media coverage of floods increases awareness and preparedness in society	4.95	1.71	Selected
B.	**Agricultural consequences**			
1.	Floods cause significant losses in livestock and crops	5.14	1.23	Selected
2.	Crop loss leads to food insecurity among the farming communities	22.50	-1.56	Rejected
3.*	Floodwaters bring nutrient-rich silt, improving soil fertility	5.79	1.62	Selected
4.	Agricultural lands become unusable due to prolonged waterlogging	5.93	1.71	Selected
5.	Coastal flooding brings saltwater intrusion, permanently damaging agricultural land	9.50	2.46	Rejected
6.	Floods destroy standing crops, leading to huge financial losses	5.83	1.82	Selected
7.	Excess water causes soil erosion, washing away the fertile topsoil needed for cultivation	5.30	1.58	Selected
8.*	Floods recharge groundwater levels	3.88	1.60	Selected
9	Flooding increases the spread of crop diseases and pest infestations, reducing yields	5.50	1.20	Selected
10.	Floods destroy irrigation systems, making post-flood cultivation difficult and expensive	7.50	-3.91	Rejected
11	Floods delay the planting and harvesting of crops, affecting overall agricultural productivity	5.60	1.68	Selected
12	Stored grains, seeds and fertilisers get damaged, making it harder to restart farming after floods	5.38	1.92	Selected
13	Damaged roads and transport networks prevent farmers from selling their produce, leading to economic losses	12.50	1.14	Rejected
14	Frequent floods discourage farmers from long-term investments in agriculture	11.50	3.63	Rejected
15*	Flooding is a natural phenomenon that has both risks and benefits for agriculture	5.30	1.80	Selected
16*	Floods encourage farmers to adopt improved agricultural practices	5.88	1.08	Selected
C.	**Economic consequences**			
1.	Flood causes seasonal or permanent migration due to unemployment	5.17	1.92	Selected
2.	Flood reduces purchasing power of the people	7.70	1.18	Rejected
3.*	Flood increases livelihood options in the affected areas	4.79	1.44	Selected
4.	Floods damage local businesses, leading to long-term economic decline	6.13	1.82	Selected
5.	Government flood relief programs are often insufficient for complete recovery	2.70	2.32	Rejected
6.	Repeated flooding discourages investments in affected areas	4.90	1.60	Selected
7.*	Reconstruction and recovery after floods create temporary employment opportunities	6.36	-5.35	Rejected
8.	Floods increase debt burdens as people take loans for recovery	5.61	1.84	Selected
9.	Small businesses and informal workers suffer the most economically from floods	4.77	2.45	Rejected
10.*	The construction sector benefits from post-flood rebuilding activities	5.06	1.28	Selected
11.*	Government compensation and relief packages help mitigate economic losses	4.88	1.70	Selected

D.	**Psychological consequences**			
1.	I feel anxious during the rainy season	5.39	1.48	Selected
2.	I feel helpless or hopeless after uncertainty about living arrangements due to the severity of floods	6.21	1.69	Selected
3.	I feel demotivated towards agriculture after the flood	5.75	1.88	Selected
4.	Post-traumatic stress disorder increases due to flood	10.50	2.45	Rejected
5.*	I found more opportunities after the flood	5.75	1.83	Selected
6.	Repeated exposure to floods lowers resilience and coping mechanisms	5.50	1.91	Selected
7.*	Flood survivors develop a greater sense of preparedness and resilience	5.25	2.12	Rejected
8.	Social media spreads both awareness and panic about floods	5.67	1.67	Selected
9.*	People who experience flooding tend to have increased emergency preparedness	4.95	1.66	Selected
10.	Flood-related displacement causes emotional distress among families	5.63	1.90	Selected
E.	**Environmental consequences**			
1.	Flooding causes erosion of riverbanks	6.36	1.42	Selected
2.	Forest cover is declining due to stagnant of water	5.63	1.87	Selected
3.	Groundwater pollution due to sustaining of flood for several days	5.50	1.75	Selected
4.	Floods increase the spread of invasive plant and animal species	5.50	-7.12	Rejected
5.	Loss of biodiversity due to prolonged submersion of ecosystems	4.90	1.90	Selected
6.	Floods contribute to deforestation due to uprooted trees	10.17	2.71	Rejected
7.*	Wetlands and floodplains benefit from periodic flooding by maintaining ecological balance	6.33	1.40	Selected
8.	Floods cause excessive waste accumulation, leading to long-term pollution	4.73	1.83	Selected
9.	Increased moisture from floods accelerates infrastructure deterioration	5.75	1.71	Selected
10.	Heavy flooding alters the course of rivers, affecting nearby ecosystems	4.59	1.91	Selected
11.	Floods disrupt natural predator-prey relationships in aquatic ecosystems	11.00	2.83	Rejected
12.*	Natural floodplains help mitigate flood impacts by absorbing excess water	5.61	1.75	Selected
13.*	Wetlands act as natural buffers against flooding, reducing long-term damage	4.86	1.50	Selected

Table 5. Triangulation of the reliability of the scale

Cronbach's Alpha	Part 1	Value	.753
		N of Items	24
	Part 2	Value	.725
		N of Items	24
		Total N of Items	48
Correlation Between Forms			.874**
Spearman-Brown Coefficient		Equal Length	.933
		Unequal Length	.933
Guttman Split-Half Coefficient			.933

Compliance with ethical standards

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

Ethical issues: None

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