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Scale development for assessing farmers perception regarding climate smart interventions under technology demonstration component of NICRA project

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ABSTRACT

Farmers in rain-fed areas are highly vulnerable to the impact of climate change due to their dependence on agriculture, therefore adoption of climate-smart interventions is important in these areas. The technology demonstration component (TDC) of the National Innovations in Climate Resilient Agriculture (NICRA) project deals with demonstrating proven interventions for adaptation of crop and livestock production systems to climate variability. It is therefore important to measure the perception of farmers towards climate-smart interventions as it may affect the implementation of the climate-smart interventions of technology demonstration component of the NICRA project. The present study made an attempt to develop the scale to measure the farmers perception on climate-smart agricultural interventions. The scale construction consisted of construct validity, content validity and internal consistency reliability. To maximize the theoretical meaningfulness and practical utility of the scale, the aspects of construct validity was considered at all stages of the scale construction process. Relevancy weightage (RW) and mean relevancy score (MRS) was measured to assess the relevancy of items on the scale. Factor analysis was done for psychometric evaluation. Exploratory factor analysis (EFA) grouped the items into three key factors. In Confirmatory Factor Analysis (CFA), factor structure of the model was used to confirm to relationship between items and factors. Further, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Standardized Root Mean Square Residual (SRMR) were used to assess the model fit. Cronbach alpha was used to assess the reliability of the scale. A total of 26 items were retained. The scale developed was found to be reliable and valid.

Keywords: *Comparative Fit Index, Confirmatory Factor Analysis, Construct, Cronbach alpha, Exploratory Factor Analysis, Perception, Relevancy, Reliability, Scale, Tucker-Lewis Index, Validity*

INTRODUCTION

The term "climate change" refers to statistically significant changes in the climate that have occurred for decades [1]. Climate-exposed sectors like agriculture, forestry, and fisheries have shown signs of economic loss from climate change. Individual livelihoods have been impacted by factors including food security and income [2]. Given the challenges posed by climate change in the agriculture sector, it is crucial for farmers to implement effective adaptation strategies to navigate these issues [3].

Climate-smart agriculture has the ability to boost long-term productivity, strengthen farming systems' resilience to climate impacts, and mitigate climate change [4]. Climate-smart agriculture can have different meanings depending on the scale at which it is implemented. Smallholder farmers in developing nations will choose higher food security and income, as well as greater resilience, when embracing climate-smart agriculture over mitigation opportunities [5].

Location and context are key factors in adaptation. There is no single best approach for reducing risks across all settings [6]. In order to achieve this, the Indian Council of Agricultural Research, in partnership with ICAR research institutes, SAUs, and KVKs, launched the National Innovation for Climate Resilient Agriculture (NICRA) nationwide. Under the Technology Demonstration Component (TDC), a number of modules are deployed, including agricultural productivity, livestock management, natural resource management, and institutional interventions that address how crop and livestock production systems may adapt to climatic variability. NICRA project demonstrated a wide range of technologies and improved practices for mitigating climate change to improve the livelihood of the farmers [7], [8]. Appropriate extension interventions can reduce the impact of climate change significantly, which can also assist farmers in sustaining their output amid extreme climate variations [9].

Farmers must first recognize that the climate has changed, then identify and implement practical adaptations. In order to determine whether to adopt a particular measure, farmers must first perceive that climate change has truly occurred. Perception is therefore a precondition for adaptation [10]. Therefore, how farmers perceive climate change has a significant impact on how they handle risks and uncertainties induced by climate change and use particular coping mechanisms to lessen its negative effects on agriculture [11].

Scale construction refers to the development of empirical measures for theoretical constructs. There was no scale available to measure the farmers' perception regarding climate smart interventions under the technology demonstration component of NICRA. Hence, the goal of the current study was to create and standardize a scale for measuring farmers' perception of climate-smart interventions.

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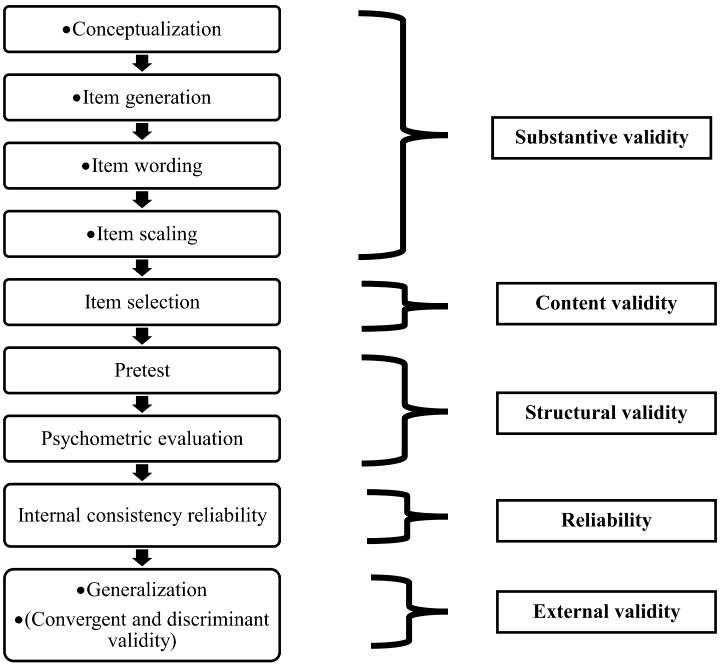
METHODOLOGY

Perception is the process by which people interpret and assign meaning to information they receive from their sensory experiences. It includes the way an individual identifies, understands, and arranges information from their experiences or surroundings. It also influences how a person perceives the world, other people as well as themselves [12]. In the study, SKUAST- Jammu, India the perception was operationalized as the farmers unique way of viewing the climate-smart interventions, involving the processing of stimuli and incorporating memories and experiences in the process of understanding.

The scale construction consisted of construct validity, content validity and internal consistency reliability. To maximize the theoretical relevance and practical applicability of the scale, the aspects of construct validity were considered at every step of the scale construction process [13]. The three aspects of construct validity that were used for the study are structural validity, substantive validity, and external validity [14].

The steps of the scale development (shown in Figure 1) were based on scale construction models given by (Hinkin, 1997), (Simms, 2008), (Hinkin, 2005), (Clark and Watson, 2016) [15], [16], [17], [18].

Figure 1: Flowchart depicting the scale development process



1. Conceptualization

Climate change is a worldwide issue that need comprehensive, cross-sectoral action, especially in agrifood systems. Such action must be made with full regard to international goals and agreements. It must also be established in the economic, social, and environmental aspects of sustainable development [19]. Climate change alters the agriculture production conditions, increasing the frequency and depth of risk to agricultural production [20]. Farmers' perception of climate change has a significant influence on how they handle risks and uncertainties and implement certain coping mechanisms to lessen the negative effects of climate change on agriculture. In order to mitigate the adverse effects of climate change on agriculture. Targeted interventions need to be implemented to increase the farming community's and other stakeholders' readiness to deal with the negative impact of climate change [21]. A comprehensive understanding of farmers' perspective on climate change and adaptation strategies is essential to improving policy to address the challenges that farmers face [22], [5]. There is however, limited research about farmers perception on climate smart interventions and adaption methods. Therefore, the goal of the current study is to construct a scale to evaluate farmers' perceptions of climate-smart interventions.

2. Item generation

Expert consultation and literature review were used to create a pool of items. The items were collected concerning the climate-smart interventions under technology demonstration component (TDC) of the NICRA project. The items were developed to be (i) representative of all the important aspects of the target construct and (ii) relevant to the construct to be measured.

3. Item wording

The following guidelines were followed in writing items. Statements were simplified and kept short. Items were kept consistent in terms of perspective. Items addressed just one topic, and double-barrelled items were avoided. Leading questions were avoided due to potential bias in responses. Items that are likely to elicit similar responses from all respondents were excluded since they are unlikely to produce significant variation.

4. Item scaling

It is recommended that five- or seven-point scales be used to measure the new items [23]. Therefore, five-point psychological continuum scale was used (strongly agree, agree, neutral, disagree, strongly disagree) to produce enough variation among respondents for further statistical evaluations.

The choice of a neutral middle point in the scale has been the subject of extensive discussion. It is unclear whether the respondent is actually neutral or is answering in this way for other reasons. However, respondents must be given the option of declining to answer a question if it is irrelevant to their position. This can be done using a neutral midpoint, which will be a data point used in the subsequent analysis [17].

5. Item selection

For this, experts were selected based on their expertise and experience in the area of agricultural extension and climate change adaptation. Thirty-five items (on climate smart interventions under the technology demonstration component of the NICRA project) were sent to 60 judges with the necessary instructions to critically evaluate the scale for content validity. The judges were requested to evaluate the scale to determine if it covered all aspects of the study and to check if the items were relevant to the topic. The judges gave their response on a five-point continuum viz., most relevant, relevant, somewhat relevant, less relevant, and not relevant with scores 5, 4, 3, 2, and 1 respectively. In all, 10 judges could respond in a time of two months. In addition, the relevancy score of each item was found by Relevancy weightage (RW) and mean relevancy score (MRS). Items having relevancy weightage > 0.70 and mean relevancy score > 3.5 [24] were considered for final selection. A total of 26 items were retained on the basis of relevancy weightage and mean relevancy score (Table 1).

The formula of relevancy weightage and mean relevancy score is given below:

- RW = (MRx5+ Rx4+SWRx3+LRx2+NRx1/maximum possible score)
- MRS= (MRx5+ Rx4+SWRx3+LRx2+NRx1/number of judges responded)

Where, MR is most relevant, R is relevant, SWR is somewhat relevant, LR is less relevant, and NR is not relevant.

Table 1: Relevancy weightage and mean relevancy score of items that were selected

Indicator	Items	Relevancy weightage	Mean relevancy score
S1.	Technology Demonstration Component (TDC) provides help to farmers in climate vulnerable situations	0.9	4.5
S2.	TDC reduces uncertainty caused by climate change	0.9	4.5
S3.	TDC is suited to farmers need	0.88	4.4
S4.	Crop loss has reduced due to TDC	0.9	4.5
S5.	TDC enables the farmers to produce food during dry spell	0.96	4.8
S6.	TDC helps to provide supplemental irrigation	0.86	4.3
S7.	TDC raises awareness about mulching practices to conserve soil and rain water in dryland areas	0.84	4.2
S8.	TDC assist farmers in transitioning to summer deep ploughing to decrease the incidence of insects/pests and diseases in plants	0.92	4.6
S9.	TDC encourages integrated farming	0.9	4.5
S10.	TDC helps to maintain the current resources and preserves for the future	0.9	4.5
S11.	TDC facilitates the establishment of nutritional vegetable garden	0.86	4.3
S12.	The technology demonstrated under TDC has practical utility	0.94	4.7
S13.	TDC promotes green manuring that reduces the fertilizer requirements in different crops	0.92	4.6
S14.	It promotes IPM practices like pheromone traps and sticky traps	0.94	4.7
S15.	TDC provides input for crop production	0.9	4.5
S16.	TDC provides custom hiring centers that are helpful for timely planting of different crops	0.86	4.3
S17.	The demonstration facility is provided to the farmers on time	0.9	4.5
S18.	The trainings under the TDC are appropriate and related to current climate related challenges.	0.86	4.3
S19.	It promotes vermicompost to enhance soil fertility	0.88	4.4
S20.	Technology demonstrated sites are monitored by the staff regularly	0.88	4.4
S21.	TDC drives the adoption of crop varieties that are resistant to climate change	0.9	4.5
S22.	TDC promotes different crop species and varieties for crop diversification	0.88	4.4
S23.	Under TDC, animal health camps are organized.	0.94	4.7
S24.	Under TDC, methods of fodder storage are demonstrated	0.84	4.2
S25.	TDC demonstrates improved silage and mineral mix methods for livestock.	0.86	4.3
S26.	TDC fosters development of better shelters for reducing heat stress of livestock	0.9	4.5

6. Pretest
The study was conducted in Kathua district of Jammu and Kashmir, India. The list of farmers under NICRA project was provided by KVK Kathua and farmers were randomly selected to measure the perception of farmers regarding climate-smart interventions. For the development and standardization of the perception scale, 50 farmers were selected from the non-sampled part of the population. The data was collected in November 2023.

7. Psychometric evaluation
7.1 Factor analysis
Factor analysis is a comprehensive term for a number of different but related mathematical and statistical techniques designed to examine the nature of relationships between variables in a particular setting, as distinct from other techniques. The basic problem is to determine whether the 'n' variables in a set exhibit pattern of a relationship with each other, such that the set can be broken down into, say, 'm' sub sets, each of which consists of a group of variables tending to be more related to each other in the sub set than to other variables in other sub sets [25]. In the study, factor analysis was used to determine the nature and number of latent variables (factors) underlying a set of items.

7.1.1 Exploratory factor analysis
The EFA is used to determine the factor and factor loading of measured variables. In this study, EFA was performed on 26 items to extract key factors affecting perception. The EFA was done by following the steps: Kaisyer-Meisyer-Olkin (KMO), Barlett Test of Sphericity, total variance explained, component matrix, commonalities values, a scree plot, and matrix rotation. The principal component analysis (PCA) method and the varimax rotation method were used. The results, as shown in table 2, grouped the 26 items into 03 key factors. After observing the loadings, names or labels were assigned to the factors based on which variables have high loadings on them and how they conceptually relate. Each factor represented an underlying concept that linked the observed variables. By examining the loadings, it was determined which variables were most influential with respect to each factor. Factor 1 is associated with service provision (SP) under the Technology Demonstration component of the NICRA project. The SP factor consisted of 08 items with factor loadings from 0.868 to 0.929. Factor 2 represented sustainable practices (StP) and consisted of 10 items having factor loading from 0.894 to 0.939. Factor 3 touched the climate resilience (CR) attribute and consisted of 08 items with factor loadings that ranged from 0.914 to 0.976.

Table 2: Factor loadings of the items

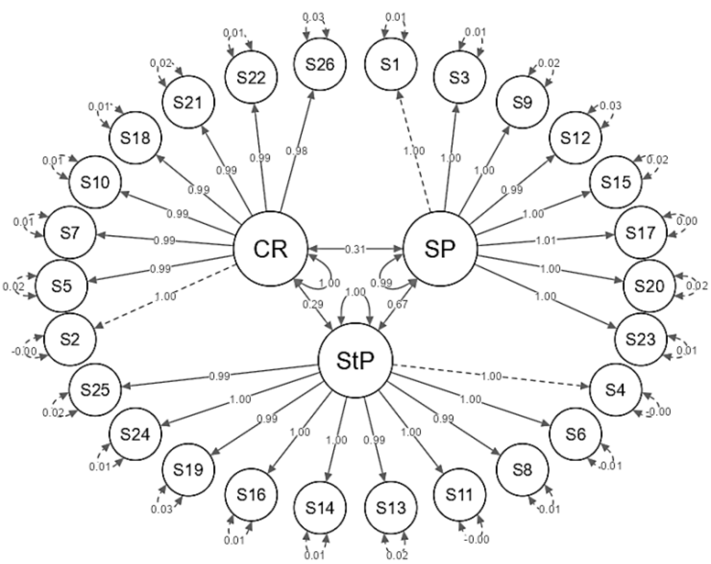
	Item No.	Items	Factors		
			SP	StP	CR
Service Provision (SP)	S1	Technology Demonstration Component (TDC) provides help to farmers in climate vulnerable situations	0.868		
	S3	TDC is suited to farmers need	0.871		
	S9	TDC encourages integrated farming	0.887		
	S12	The technology demonstrated under TDC has practical utility	0.868		
	S15	TDC provides input for crop production	0.870		
	S17	The demonstration facility is provided to the farmers on time	0.884		
	S20	Technology demonstrated sites are monitored by the staff regularly	0.881		
	S23	Under TDC, animal health camps are organized	0.929		
Sustainable Practices (StP)	S4	Crop loss has reduced due to TDC		0.936	
	S6	TDC helps to provide supplemental irrigation		0.923	
	S8	TDC assist farmers in transitioning to summer deep ploughing to decrease the incidence of insects/pests and diseases in plants		0.901	
	S11	TDC facilitates the establishment of nutritional vegetable garden		0.939	
	S13	TDC promotes green manuring that reduces the fertilizer requirements in different crops		0.899	
	S14	It promotes IPM practices like pheromone traps and sticky traps		0.894	
	S16	TDC provides custom hiring centers that are helpful for timely planting of different crops		0.922	
	S19	It promotes vermicompost to enhance soil fertility		0.909	
	S24	Under TDC, methods of fodder storage are demonstrated		0.912	
	S25	TDC demonstrates improved silage and mineral mix methods for livestock.		0.902	
Climate Resilience (CR)	S2	TDC reduces uncertainty caused by climate change			0.976
	S5	TDC enables the farmers to produce food during dry spell			0.961
	S7	TDC raises awareness about mulching practices to conserve soil and rain water in dryland areas			0.948
	S10	TDC helps to maintain the current resources and preserves for the future			0.959
	S18	The trainings under the TDC are appropriate and related to current climate related challenges.			0.960
	S21	TDC drives the adoption of crop varieties that are resistant to climate change			0.938
	S22	TDC promotes different crop species and varieties for crop diversification			0.944
	S26	TDC fosters development of better shelters for reducing heat stress of livestock			0.914

7.1.2 Confirmatory factor analysis

Confirmatory factor analysis (CFA) is a type of structural equation modelling that focuses on measurement models; that is, the relationships between observed variables or indicators and latent variables or factors [26]. CFA verified the number of underlying factors as well as the pattern of item-factor relationships as shown in Figure 1 where, SP, StP and CR stands for service provision, sustainable practices and climate resilience respectively. S1 to S26 indicate the items of the scale. The lines represent the relationship between items and the factor. The line thickness/continuity indicates the magnitude of the loading factors.

In this study, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Standardized Root Mean Square Residual (SRMR) measures were used to assess the model fit. Values greater than 0.90 is considered acceptable for incremental fit indexes (CFI and TLI) and a value below 0.08 is typically considered a good fit for SRMR [27], [28]. In the study, CFI was found to be 0.944, the value of TLI was 0.939 and the SRMR value was 0.0376, indicating a very good fit.

Figure 1: Factor structure of the three-factor model of the perception scale



8. Internal consistency Reliability

The reliability of the scale was assessed by using the Cronbach Alpha coefficient. The retained items were administered to 50 respondents on a five-point continuum scale viz., strongly agree, agree, neutral, disagree, strongly disagree to assess the reliability of the scale.

The formula for Cronbach's alpha is:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_y^2}{\sigma_x^2}\right)$$

Where, α = Cronbach's Alpha, k = Number of items in your scale, $\Sigma\alpha^2y$ = Summated variance of each item, and α^2x = Variance of total scores.

Acceptable range of Cronbach's alpha is a value of 0.70 and above [29]. In the study, the reliability was found to be 0.97 indicating that the perception scale is reliable.

9. Convergent and discriminant validity

The external validity step is the last stage of scale development that assesses whether the measure aligns with one's theoretical comprehension of the target construct and its relative position to other similar and dissimilar constructs. External validity involves the assessment of convergent and discriminant validity. Convergent validity refers to how well a measure correlates with other indicators of the same construct, whereas discriminant validity refers to how poorly a measure corresponds with indicators of theoretically separate conceptions.

Evidence of convergent validity [30] was each factor's average factor loading being more than 0.7, indicating strong loading (Table 3). The variance extracted was also greater than 0.5 as shown in Table 3 indicating good convergence. To assess discriminant validity, the correlation squares of all items were compared to the average variance extracted for each construct. The variance extracted percentages were more than the correlation square, indicating discriminant validity for each construct.

Table 3: Variance extracted from factor loadings

Factors	Av loadings	Variance
Service Provision (SP)	0.914	0.835
Sustainable Practices (StP)	0.950	0.903
Climate Resilience (CR)	0.882	0.778

CONCLUSION

The purpose of this study was to construct a reliable and valid scale assessing farmers perception regarding climate smart interventions under the technology demonstration component of NICRA project. The scale construction consisted of construct validity, content validity and internal consistency reliability. To optimize the scale's theoretical significance and practical usefulness, the aspects of construct validity were considered at all stages of the scale construction process. The three aspects of construct validity that were used for the study are substantive validity, structural validity, and external validity. The structural validity was kept in check by conceptualization, item generation, item wording, and item scaling and a total of thirty-five items were finalized. For content validity thirty-five items were administered to judges and twenty-six items were selected on the basis of relevancy weightage and mean relevancy score. Pretesting and psychometric evaluation were used to assess the structural validity. After pretesting, psychometric evaluation was done by using factor analysis and internal consistency reliability. Exploratory factor analysis grouped the twenty-six items into three key factors i.e., service provision, sustainable practices and climate resilience. Further, in confirmatory factor analysis, factor structure of the three-factor model was used to confirm the pattern of the relationship between items as well as factors. Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Standardized Root Mean Square Residual (SRMR) showed that the model is a very good fit. Cronbach Alpha coefficient was used to assess the reliability and it was found to be highly reliable. The external validity of the scale was evaluated by convergent and discriminant validity and the scale was found to be valid. The analysis resulted in a twenty-six item scale.

Future scope of the study: The different perception scale construction methods should be compared or a new method to assess the validity and reliability of the scale could be developed.

Conflict of Interest: None

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