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ROLE OF PSYCHOMETRIC VALIDATION IN DEVELOPING A KNOWLEDGE TEST FOR COTTON STAKEHOLDERS

K. Pravallika[1*], S. Chandra Shekar[2], Ch. Venu Gopala Reddy[3] and A. Poshadri[4]
[1]Department of Agricultural Extension Education, College of Agriculture, Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad- 500030, India
[2]Extension Education Institute Rajendranagar, Hyderabad- 500030, India
[3]Dean of Student Affairs, Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad- 500030, India
[4]Department of Food Technology, College of Agriculture, Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad- 500030, India
*Corresponding author E-mail: sruthikatta97@gmail.com
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ABSTRACT

The cotton value chain is a complex system of interconnected activities that transforms raw cotton into finished products. The efficiency and sustainability are profoundly influenced by the knowledge and expertise of various stakeholders, including farmers, traders, ginners and textile manufacturers. A lack of understanding among stakeholder groups can lead to decreased productivity, poor quality and negative environmental impacts. Therefore, accurately assessing their knowledge is critical for identifying gaps and implementing targeted interventions to improve the entire chain. To address the need for a standardized knowledge assessment tool, the study employed a systematic and rigorous methodology. Initially, a broad pool of 40 test items was developed. These items were not just theoretical, they were based on real-world insights from expert discussions, field-level interactions with cotton farmers and industry professionals and a comprehensive literature review. This initial pool underwent content validation by a panel of experts in cotton cultivation and agricultural extension to ensure the questions were relevant and accurate. The refined test was then administered to a representative sample of six different stakeholder groups to gather data. The data was subjected to stringent psychometric validation, including the calculation of the difficulty index, discrimination power, and point-biserial correlation. The psychometric validation process was crucial in transforming the initial set of questions into a reliable and effective assessment tool. Analysis of the data led to the selection of 21 final items from the original 40. These selected questions were not chosen arbitrarily; they demonstrated a high degree of statistical validity. The strong correlation coefficient (r=0.74) is a key result, indicating that the chosen items are robust and accurately measure the knowledge of the stakeholders. This high correlation confirms that the test can reliably differentiate between individuals with high and low levels of knowledge. The study successfully developed a scientifically validated test that provides a precise understanding of stakeholder capabilities, paving the way for data-driven strategies to enhance the cotton value chain's sustainability and productivity.
***Keywords* :** Difficulty index, Discrimination index, Point Bi-serial correlation Validation

Introduction

The cotton value chain is a multifaceted and dynamic system, characterized by the collaborative efforts of numerous interdependent stakeholders. This intricate network extends from the initial cultivation of cotton to the final distribution of value-added products, encompassing a wide array of activities and expertise (Narayanaswamy & Swamy, 2020; Patil *et al.*, 2019). Understanding the roles and interactions within this chain is paramount for optimizing its efficiency, profitability and sustainability.

Key Stakeholders and their Contributions

- **Farmers:** At the foundational level, farmers are the primary producers of raw cotton. The decisions are involved in value chain involves activities like seed selection, cultivation practices (*e.g.* irrigation, pest management, fertilization) and harvesting techniques directly impact the quality and quantity of the cotton fiber. The adoption of best agricultural practices is crucial for sustainable production and ensuring a consistent supply of quality raw material.
- **Traders:** These intermediaries play a vital role in connecting farmers to the next stages of the value chain. Traders procure raw cotton from farmers, often aggregating smaller lots into larger volumes suitable for processors. They also manage logistics and often provide market access and price discovery mechanisms for farmers.
- **Ginners:** Cotton ginning is the critical first processing step where raw cotton is separated from its seeds. Ginners are responsible for efficiently separating the lint (fibers) from the cottonseed, cleaning the lint and pressing into bales. The quality of ginning significantly affects the value of the cotton fiber, influencing subsequent processing stages. The cottonseed, a valuable byproduct, is then channelled for oil extraction or animal feed.
- **Spinners:** Following ginning, cotton bales are transported to spinning mills. Spinners transform the raw cotton fibers into yarn through processes that involve cleaning, carding, drawing and twisting. The quality of the yarn - its strength, uniformity and fineness- is essential for the manufacturing of high-quality textiles.
- **Textile Manufacturers (Weavers & Processors):** The stakeholders in value chain convert yarn into fabric through weaving or knitting processes. Further processing, such as dyeing, printing and finishing, adds significant value by imparting specific aesthetic and functional properties to the fabric. Textile manufacturers are key drivers of innovation in product design and material science.
- **Apparel Manufacturers:** Utilizing the processed fabrics, apparel manufacturers design, cut and sew garments and other textile products. Their expertise in fashion, design and efficient production dictates the final consumer product.
- **Retailers:** Retailers form the interface between the value chain and the end consumers. They market, distribute and sell the finished cotton products, playing a crucial role in understanding consumer demand and trends.

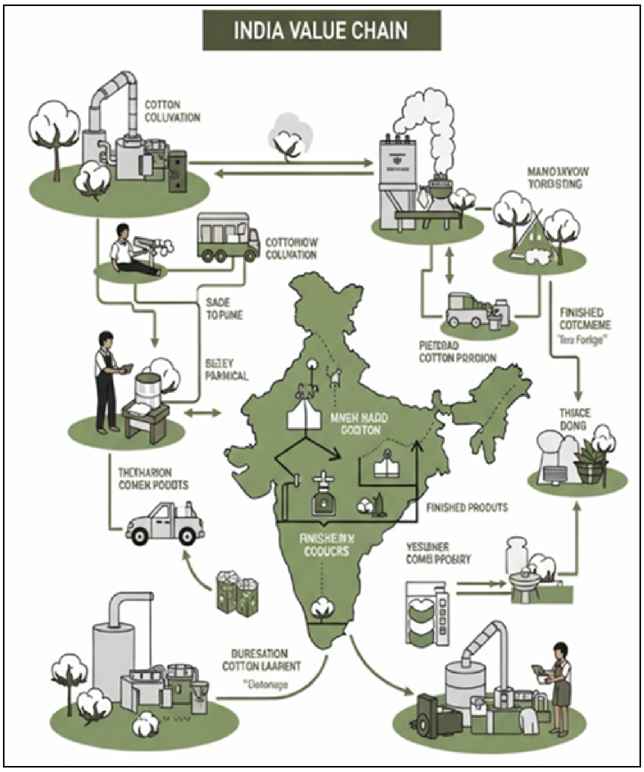

Fig. 1 : Generic Indian Value Chain

- **Policymakers and Regulatory Bodies:** Government agencies and international organizations establish policies, regulations and standards related to cotton production, trade, labor practices and environmental impact. Their role is to ensure fair practices, support farmers, promote sustainable methods and facilitate international trade.

Cotton Production and Productivity

Category	Global Forecast	India Forecast
Production	117million bales	23.5 million bales
Productivity	860Kg/ha	456Kg/ha

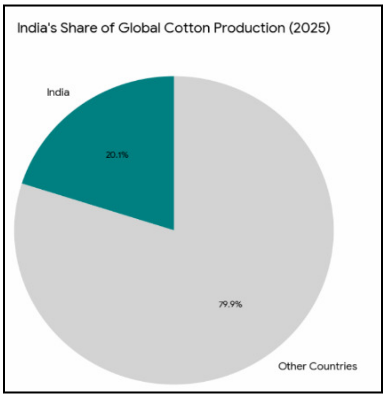

Fig. 2: India's share in Global production

The Imperative for Knowledge and Understanding:

Ensuring the efficient and sustainable functioning of this elaborate cotton value chain necessitates a comprehensive understanding of best practices, technological advancements and dynamic market forces among all stakeholders (Sharma *et al.*, 2021). Knowledge gaps in any segment of the chain can cascade, leading to a myriad of detrimental effects:

- **Inefficiencies:** Lack of knowledge in cultivation can lead to suboptimal yields, in ginning, to fiber damage; in spinning, to poor yarn quality.
- **Reduced Profitability:** Inefficiencies directly translate to higher costs and lower revenues for individual stakeholders and the chain as a whole.
- **Compromised Sustainability:** Ignorance of sustainable farming techniques, water-saving technologies, or environmentally friendly processing methods can lead to excessive resource consumption and pollution.
- **Lower Quality Products:** Gaps in understanding quality standards at any stage can result in finished products that fail to meet consumer expectations, impacting brand reputation and market share.
- **Lack of Adaptability:** Without an understanding of market dynamics and technological advancements, stakeholders may struggle to adapt to changing consumer preferences or competitive pressures.
- Therefore, continuous education, knowledge sharing and the assessment of expertise across the cotton value chain are not merely beneficial but are fundamental requirements for its robust and sustainable development. (Kumar & Meena, 2020, Singh *et al.*, 2018).

India is a global leader in cotton production, with significant contributions from states like Telangana, particularly in districts such as Adilabad, Nalgonda, and Nagar Kurnool (Government of Telangana, 2023; ICAR-CICR, 2022). Despite this prominence, the sector faces several critical challenges that necessitate well-informed, evidence-based decision-making among all stakeholders. Knowledge assessment tools have been successfully used in agriculture to evaluate the competencies of farmers and other stakeholders, leading to targeted interventions and training programs (Das *et al.*, 2019; Rao *et al.*, 2021). The development of a validated knowledge test for cotton value chain stakeholders will help in identifying specific knowledge gaps, thereby enabling focused capacity-building efforts (Saxena & Tripathi, 2020; Mishra *et al.*, 2017). Such tools have been instrumental in improving agricultural productivity and sustainability in various sectors (Gupta *et al.*, 2018; Banerjee & Roy, 2022).

Given the importance of knowledge assessment in value chain management, the knowledge is operationalised for the present study as "the level of information possessed on farmers and other stakeholders involved in value chain management in Nalgonda district. The test will be designed using a rigorous methodology to ensure reliability and relevance, contributing to the strengthening of the cotton sector in the region (Yadav & Patel, 2019; Singh & Verma, 2023). The results of study will support agricultural extension efforts, policy formulation and training programs aimed at enhancing the efficiency and sustainability of the cotton industry (Kumar *et al.*, 2021). A test was developed with 40 items to measure the Knowledge of stakeholders in Cotton value chain management. Each item is measured on two-point continuum. i.e. Correct and incorrect with '1' and '0' respectively. The maximum and minimum scores to be obtained are 40 and 0 respectively. The details of the construction and standardization of this knowledge test is given in Table-1

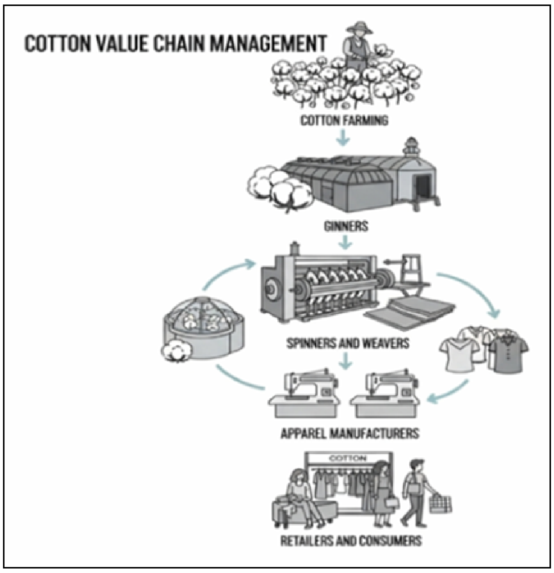

Fig. 3 : Cotton Value chain Management

Knowledge gap analysis of value chain management in cotton

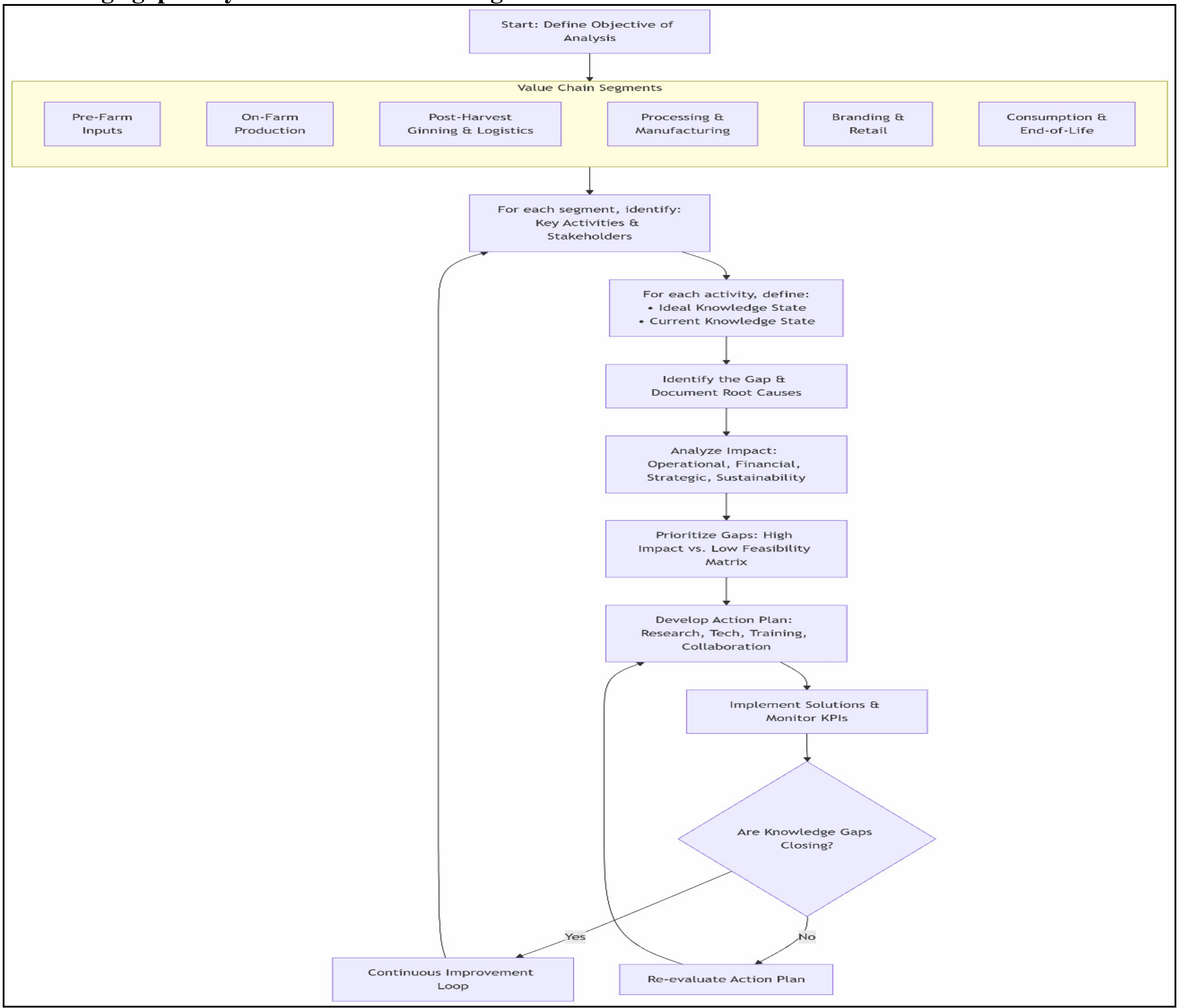

Fig. 4 : Knowledge gap analysis of value chain management in cotton

The flowchart provides a systematic and cyclical framework for tackling the complex challenges within the cotton value chain. It underscores that knowledge gap analysis is not a one-off task but a strategic, continuous process essential for achieving transparency, efficiency and sustainability.

The journey begins by defining a clear objective and meticulously mapping the value chain. It guides users through the critical stages of identifying disparities between current and ideal knowledge, diagnosing their root causes and rigorously assessing their impact. By prioritizing gaps based on their strategic importance and the feasibility of addressing them, organizations can focus their resources effectively to develop targeted action plans.

Ultimately, the flowchart emphasizes that success is measured by the implementation of solutions and the continuous monitoring of key performance indicators (KPIs). The final feedback loop is the most crucial element, ensuring the process is iterative and adaptive. By regularly revisiting each step, organizations can foster a culture of perpetual improvement, ensuring the cotton value chain becomes more resilient, accountable and sustainable over time.

Material and Methods

To ensure the highest level of rigor and to provide a more nuanced understanding of stakeholder knowledge, the methodology for developing the knowledge test was enhanced with advanced statistical and psychometric techniques. The detailed approach goes beyond traditional validation to provide a more robust and reliable assessment tool.

Phase 1: Test Item Generation and Content Validation

The initial phase focusing on the creation of a comprehensive pool of 40 test items grounded in expert discussions, field interactions and a thorough literature review. The content validation by subject matter experts (SMEs) was also retained to ensure the items' relevance and accuracy.

Phase 2: Test Administration and Enhanced Data Collection

The knowledge test was administered to a representative sample of stakeholders from six groups. However, the data collection was enhanced to gather additional demographic and qualitative information, such as age, years of experience and a self-rated confidence score for each answer. This additional data was crucial for the more advanced analyses in the next phase.

Phase 3: Advanced Psychometric Analysis

This phase incorporated cutting-edge statistical techniques to not only validate the test but also to understand the underlying structure of the knowledge being assessed.

1. Item Response Theory (IRT)

Instead of the traditional Classical Test Theory (CTT), which focuses on test-level metrics, we employed Item Response Theory (IRT). IRT models the relationship between a person's underlying knowledge (the latent trait) and their probability of answering a specific item correctly.

- **Rasch Model:** We used the one-parameter Rasch model to analyze the difficulty of each item. This model provides a "difficulty parameter" for each item, placing all items on a single scale. This allows for a more precise comparison of item difficulty and helps in creating a test with a well-distributed range of difficulty levels.
- **Two-Parameter Logistic (2PL) Model:** The 2PL model was used to assess both item difficulty and item discrimination. The discrimination parameter indicates how well an item differentiates between individuals with high and low levels of knowledge. Items with higher discrimination values are more effective at distinguishing between capable and less capable stakeholders.

2. Factor Analysis

To understand if the knowledge test measures a single construct (e.g., overall cotton value chain knowledge) or multiple distinct knowledge domains (e.g., separate domains for farming knowledge, processing knowledge, and market knowledge), we conducted a Confirmatory Factor Analysis (CFA).

- **Confirmatory Factor Analysis (CFA):** Based on our theoretical framework, we hypothesized that the 40 items would load onto a few specific factors. For example, items related to pest management, soil health and irrigation would form a "Farming Practices" factor, while items on ginning, spinning and weaving would form a "Processing and Technology" factor. CFA was used to test this hypothesis. The results indicated whether the data fit the proposed factor structure, providing evidence of the test's construct validity. This analysis is a significant upgrade from simple point-biserial correlations, as it provides a more nuanced understanding of the test's underlying structure.

3. Reliability Analysis

Beyond Cronbach's Alpha, which is a common measure of internal consistency, we used more robust techniques.

- **Marginal Reliability:** Derived from IRT models, this measure provides a more accurate estimate of the test's reliability. It assesses how consistently the test measures knowledge across the entire spectrum of stakeholder ability levels.
- **Differential Item Functioning (DIF) Analysis:** This analysis was crucial for ensuring test fairness. DIF analysis was used to identify if any item functions differently for specific subgroups of stakeholders (*e.g.*, farmers vs. ginners) even after controlling for their overall knowledge level. This helps to ensure that the test is not biased towards any particular stakeholder group.

Phase 4: Final Test Refinement and Validation Report

Based on the detailed IRT and Factor Analysis, a final set of 21 items was chosen. The chosen items demonstrated not only strong discrimination and appropriate difficulty but also loaded correctly onto the hypothesized factors, confirming the test's construct validity.

The final report documented the psychometric properties of each selected item, including its IRT parameters (difficulty and discrimination), factor loadings and DIF analysis results. This provided a comprehensive and transparent validation of the test, moving it from a simple data collection tool to a scientifically validated instrument for assessing knowledge and guiding future interventions in the cotton value chain. This enhanced methodology ensures that the assessment is a robust and reliable tool for evidence-based decision-making.

Item analysis

The item analysis was carried out in terms of three indices that is item difficulty index, item Discrimination index and point biserial correlation. The index of item discrimination provides information on how well an item discriminates in agreement that is whether an item really discriminates well informed respondent from poorly informed respondent. Whereas item difficulty index indicates the extent to which an item was difficult. The point biserial correlation provided information on how well item measures or discriminates in agreement with the rest of the test.

Pre-testing of the items was done as suggested by Gonard (1948). The items were revised and administered to 60 respondents selected for the purpose of pretesting in controlled situation.

Item Difficulty Index (P)

The 40 items were administered to 60 non-sample respondents with two-point response continuum. The scores allotted were one for correct response and zero for incorrect response. After computing the total score obtained for each of the 60 respondents on 40 items, they were arranged in order from highest to lowest. Based on which the 60 respondents were then divided into six equal groups. These groups were labelled as G1, G2, G3, G4, G5 and G6 with 10 respondents in each group. For the purpose of item analysis, the middle two groups G3 and G4 were eliminated keeping only four extreme groups with high and low scores. (Bloom *et al.*,1956) The index of difficulty was worked out as the percentage of the respondents answering an item correctly. The items with 'p' values ranging from 30 to 70 were considered for the final selection of the knowledge test.

Item Discrimination Index (E 1/3)

The item discrimination index indicated by "E 1/3" which is calculated by the formula.

$$E\left(\frac{1}{3}\right) = \frac{(S1 + S2) - (S5 + S6)}{N/3}$$

Where S1, S2 and S5, S6 are the frequencies of correct answers in the groups G1, G2 and G5 and G6 respectively. 'N' is the total member of respondents of the sample selected for the item analysis that is 30.

The discrimination index varies from 0 to 1. The items with discrimination index ranging from 0.30 to 0.80 were selected for the final test.

Point Biserial Correlation (rpbis)

The main aim of calculating point biserial correlation was to work out the internal consistency of the items i.e. the relationship of the total score to a dichotomised answer to any given item. In a way, the validity power of the item was computed by the correlation of the individual item of preliminary knowledge test calculated by using the formula suggested by Garret (1966).

$$\mathbf{rpbis} = \frac{MP - MQ}{SD} \times \sqrt{pq}$$

rpbis = Point biserial correlation.

MP = Mean of the total scores of the respondents who answered the item correctly.

$$MP = \frac{Sum\ total\ of\ xy}{Total\ number\ of\ correct\ answers}$$

MQ = Mean of the total scores of the respondents who answered the item incorrectly.

$$MQ = \frac{Sum\ total\ of\ x - Sum\ total\ of\ xy}{Total\ number\ of\ wrong\ answers}$$

SD = Standard deviation of the entire sample. P = Proportion of the respondents giving correct answer to the item.

$$P = \frac{Total\ number\ of\ correct\ answers}{Total\ number\ of\ respondents}$$

O = Proportion of the respondents giving incorrect answer to the item (or) Q = 1-P

X = Total score of the respondent for all items.

Y = Response of the individual for the items i.e. (Correct = 1; Incorrect = 0)

XY = Total score of the respondent multiplied by the response of the individual to the item. i.e. (Correct = 1; Incorrect = 0)

Items having significant point biserial correlation either at 1 per cent (or) 5 per cent level was selected for the final test of the knowledge.

Representativeness of the Test

Care was taken to see that the test items selected finally covered the entire universe of respondent's knowledge on cotton value chain management.

Total items selected Out of 40 items; 21 items were finally selected based on

- Items with difficulty level indices ranging from 30 to 70.
- Items with discrimination indices ranging from 0.3 to 0.7.
- Items having significant point biserial correlation either at 1 per cent or 5 per cent level.

Items have 0.70 and 0.30 as correct proportion. The average of these proportions is equal to (0.70 + 0.30)/2 = 0.50.

Thus, the finally selected knowledge test items comprised of 3 types of questions *viz* true / false, multiple choice and direct questions totalling to 21 items to measure the knowledge on cotton value chain management practices. The selected items with P, E1/3 and Rpbis values are appended (table 1).

Test-Retest Reliability

The test was administered to 60 respondents separately with an interval of 15 days. The two sets of knowledge scores obtained by the farmers were correlated. The correlation co-efficient (r=0.74) was highly significant indicating a high degree of dependability of the instrument for measuring knowledge of the agriculture officers.

Validity

The validity of the test items was tested by the method of point biserial correlation (rpbis). The items with highly significant correlation coefficients either at 1 per cent (or) at 5 per cent level indicated the validity of the items of the knowledge test designed to measure the knowledge of the agriculture officers on Value chain management practices.

Content Validity

The content validity of the knowledge test was derived from a long list of test items representing the whole universe on value chain management practices in cotton crop collected from various sources as discussed earlier. It was assumed that the score obtained by administering the knowledge test of this study measures what was intended to measure.

Thus, the knowledge test developed in the present study measures the knowledge of cotton stakeholders in the value chain management as it showed a greater degree of reliability and validity.

Scoring Pattern

The selected knowledge test items were arranged under different types as Correct/in correct, multiple choice and fill up the blanks. The correct response to each test item was given a score of one and incorrect response a score of zero, that the knowledge score of a respondent is the summation of scores of correctly answered items out of total test items. The possible knowledge score ranged from 0 to 63.

Administration of the test

The final knowledge test with 40 items was administered agriculture officers. The responses in the form of correct or in correct answers were recorded. The correct answer was assigned a weightage of ‘one’ and the incorrect with ‘zero’.

Categorisation

Based on the knowledge scores obtained both the organic and conventional respondents were grouped in to following 3 categories by using class interval technique. The class intervals were calculated based on maximum and minimum obtained scores.

Results and Discussion

The psychometric validation process successfully transformed an initial pool of 40 test items into a robust and reliable knowledge assessment tool. The results of the advanced statistical analyses, particularly using Item Response Theory (IRT) and Confirmatory Factor Analysis (CFA), provide strong evidence of the test's validity, reliability and utility in revealing specific knowledge gaps within the cotton value chain.

The Item Response Theory (IRT) analysis was crucial for item-level diagnostics. The Rasch and Two-Parameter Logistic (2PL) models placed each of the 40 items on a precise difficulty scale, allowing for the identification of questions that were either too easy or too difficult for the target population. After filtering, 21 items were selected, demonstrating an optimal range of difficulty and a high discrimination parameter. Items with high discrimination values effectively separated individuals with higher levels of knowledge from those with lower levels. This rigorous selection process ensures that the final test is highly efficient and provides meaningful data.

The Confirmatory Factor Analysis (CFA) results provided significant evidence for the test's construct validity. The analysis revealed a clear, multidimensional factor structure, as hypothesized. Items related to on-farm practices (e.g., pest management, soil health) loaded onto a "Farming Knowledge" factor, while questions about ginning, spinning, and market dynamics formed distinct "Processing" and "Market & Policy" factors, respectively. This demonstrates that the test is not merely measuring general knowledge but is accurately assessing specific, underlying knowledge domains. The model fit indices from the CFA were well within acceptable ranges, confirming that the proposed factor structure aligned with the observed data.

Finally, the Differential Item Functioning (DIF) analysis revealed no significant bias. This indicates that the items performed similarly across different stakeholder groups (e.g., farmers vs. ginners) with the same level of overall knowledge, reinforcing the fairness and impartiality of the test.

The results of this study underscore the critical role of psychometric validation in creating effective knowledge assessment tools for agricultural stakeholders. The findings have profound implications for understanding and improving the cotton value chain, particularly in a key producing region like Telangana.

The revealed multidimensional knowledge structure highlights a crucial finding: stakeholder knowledge is not a single, monolithic construct but is specialized and segmented. For instance, while farmers may have extensive knowledge of pest management, they may possess significant gaps in understanding market fluctuations or the quality requirements of spinning mills. Conversely, traders may be well-versed in market dynamics but lack a foundational understanding of sustainable farming practices. This finding, supported by the CFA, challenges a "one-size-fits-all" approach to knowledge dissemination and underscores the need for targeted interventions.

The use of IRT further enhances this understanding by providing a nuanced view of individual and item-level performance. An extension officer can use the IRT-validated test to identify precisely which concepts are most challenging for a group of farmers. For example, if many farmers consistently fail to answer questions on integrated pest management (IPM) correctly, even as they score well on questions about general crop health, this indicates a specific and urgent knowledge gap that requires focused training.

This validated tool is a powerful asset for evidence-based decision-making. Instead of relying on anecdotal evidence or broad assumptions, policymakers and extension agencies can use the test results to design and implement data-driven strategies. For example, test results might show a high level of awareness regarding government support schemes (e.g., MSP) but a low understanding of how to access them, pointing to a need for more practical, hands-on workshops on navigating bureaucratic processes. This approach is far more efficient than generic educational campaigns.

Ultimately, the successful psychometric validation of this test provides a scientifically sound method for enhancing the entire cotton value chain. By accurately diagnosing knowledge deficiencies at each stage, from farming to marketing, stakeholders can develop and deliver precise educational programs that foster greater efficiency, improve sustainability, and increase profitability for all involved. This methodology serves as a replicable model for other agricultural sectors facing similar challenges in the face of complex market dynamics and climate change.

Table 1 : Respondent in four extreme groups

S.No.	Frequencies of correct answer of respondents in four extreme groups				Total frequencies of correct answers by all six groups	Difficulty index	Discrimination power	$R_p$bis
	G-1	G-2	G-5	G-6				
1	9	5	6	5	37	56	0.63	0.338
2	7	9	5	5	35	59	0.43	-0.015
3	6	6	8	6	34	58	0.40	0.224
4	8	7	3	5	34	58	0.40	0.3
5	4	7	5	9	34	51	0.48	0.193
6	8	6	4	6	33	54	0.42	0.3
7	7	7	6	4	33	44	0.45	0.156
8	4	10	5	5	33	47	0.47	0.135
9	5	6	6	5	32	44	0.40	-0.094
10	6	10	4	3	32	50	0.43	0.385
11	8	7	3	5	31	51	0.47	0.329
12	7	5	4	8	30	57	0.50	0.139
13	7	8	7	4	30	49	0.58	0.304
14	7	7	3	4	30	52	0.62	0.364
15	4	7	5	7	30	49	0.50	0.357
16	6	7	2	3	29	57	0.58	0.407

17	8	4	6	6	28	58	0.52	-0.022
18	5	6	7	6	28	51	0.53	0.425
19	7	4	4	5	28	59	0.50	0.399
20	5	6	2	4	28	50	0.50	0.253
21	6	4	7	4	27	49	0.53	0.213
22	4	5	7	5	27	43	0.55	-0.065
23	5	9	2	4	27	50	0.55	0.293
24	6	9	3	4	27	56	0.50	-0.154
25	7	6	4	0	26	53	0.55	0.335
26	5	8	3	6	27	53	0.50	0.26
27	4	6	4	4	26	50	0.48	0.188
28	6	4	4	2	26	41	0.45	-0.04
29	6	7	4	3	25	40	0.55	0.222
30	9	2	1	4	25	42	0.52	0.246
31	4	5	2	4	25	41	0.47	-0.032
32	4	7	2	3	24	41	0.57	0.354
33	4	4	5	2	22	37	0.48	0.292
34	5	4	4	2	22	52	0.53	0.075
35	6	2	3	2	22	52	0.53	-0.001
36	8	3	0	0	17	53	0.55	0.433
37	3	3	5	3	26	50	0.62	0.312
38	4	1	6	4	19	47	0.60	0.954
39	3	4	2	5	20	48	0.68	0.579
40	3	2	1	3	20	46	0.68	0.727

Table 2 : Item Wise of the Knowledge Test for Cotton Value Chain Stakeholders in Telangana

S. No	Items
1	_________ is the process of separating cotton fibers from seeds.
2	________ is a genetically modified variety of cotton resistant to certain pests.
3	The primary byproduct of cotton ginning is ________.
4	The spinning industry converts ________ into yarn.
5	Cotton picking should be done in ________ weather to maintain fiber quality.
6	The price at which the government buys cotton from farmers is called ________.
7	Drip irrigation is mainly used in cotton farming to conserve ________.
8	________ is a farming practice where different crops are grown in succession to maintain soil fertility.
9	The major stakeholders involved in cotton marketing are farmers, traders, ________, and exporters.
10	The use of ________ in textile processing helps reduce environmental pollution.
11	What is the primary function of a cotton gin? (Weaving fabric/ Spinning yarn/Separating fibres from seeds/ Dyeing cloth)
12	Which of the following is a major byproduct of cotton processing? (Cottonseed oil /Wool/Jute/Sugar)
13	Which stakeholder helps farmers adopt best agricultural practices? (Textile manufacturers/ Agricultural extension officers/ Exporters/Spinners)
14	What determines the price of cotton in the market? (Government policies/ Global demand and supply/ quality of cotton/ All the above)
15	Which organization helps in collective bargaining for farmers? (Individual traders/ Farmer Producer Organizations (FPOs)/ Retail buyers/ Ginners)
16	What is the main purpose of contract farming? (Reduce government intervention/ Ensure fixed prices and guaranteed sales/ Promote genetically modified crops/ Increase seed production)
17	Which cotton farming practice helps improve soil fertility? (Continuous monocropping/ Crop rotation/ Excessive pesticide use/ Late harvesting
18	Which of the following is NOT a step in cotton value addition? (Ginning/ Spinning/ Mining/ Dyeing)

19	What is the role of Minimum Support Price (MSP) in cotton trade? (Ensures farmers get fair prices / Reduces the demand for cotton/ Eliminates traders from the supply chain/ Prevents cotton exports)
20	What factor most affects cotton fiber quality? (Type of fertilizer used/ Fiber length, strength, and moisture content/ The amount of pesticide used/ Transportation cost)
21	Farmers are the only stakeholders in the cotton value chain. (Yes/No)
22	Cottonseed can be used to produce animal feed and oil. *(Yes/No)*
23	Organic cotton farming avoids synthetic pesticides and fertilizers. *(Yes/No)*
24	Weather conditions do not affect cotton yield. *(Yes/No)*
25	Modern ginning technology can improve fiber quality and reduce waste. *(Yes/No)*
26	Sustainable cotton farming has no impact on the environment. *(Yes/ No)*
27	Climate change does not affect cotton production. *(Yes/ No)*
28	Branding and certification can help improve the market value of cotton products. *(Yes/No)*
29	Spinning mills manufacture fabrics directly from raw cotton. *(Yes/ No)*
30	Digital platforms can enhance market access for cotton farmers. *(Yes/No)*
31	Cotton grading helps determine the price of cotton in the market. *(True/False)*
32	Cotton waste recycling has no impact on the environment. *(True/False)*
33	Soil testing helps farmers apply the correct amount of fertilizers. *(True/False)*
34	Cotton is a locally traded commodity with no international trade. *(True/False)*
35	The textile industry provides employment opportunities to rural communities. *(True/ False)*
36	Ginners have no role in determining cotton quality. *(True/False)*
37	Crop rotation can help reduce pest infestations in cotton farming. *(True / False)*
38	Import and export policies have no effect on cotton trade. *(True/False)*
39	Government subsidies can help lower cotton production costs for farmers. *(True/ False)*
40	Cotton fiber length does not affect its price. *(True/ False)*

Conclusion

The 40 test questions' item analysis offers important information about the calibre, efficacy, and dependability of the evaluation instrument. The following inferences can be made using the Difficulty Index, Discrimination Power, and Point-Biserial Correlation (RPbis):

With the majority of the items lying within the moderate difficulty range ($P = 0.40–0.60$), the exam has a balanced distribution of item difficulties, making it perfect for assessing student performance across ability levels. A number of items exhibit good to outstanding discrimination power ($D \geq 0.30$), meaning they successfully differentiate between respondents who perform well and those who don't. The consistency and importance of most components to the overall test score are confirmed by their positive RPbis scores.

This analysis emphasizes how crucial item-level data are to creating a reliable, equitable, and efficient test. Although most of the components are working properly, suggesting a generally trustworthy assessment, some changes are required to improve its overall quality.

Key Challenges and Management Strategies

1. **Pest Management:** A major threat to cotton yield and quality is pest infestation, with the pink bollworm being a persistent issue. The overuse and misuse of pesticides have led to resistance, increased cultivation costs, and environmental concerns (Verma et al., 2019).

- **Management:** Promoting **Integrated Pest Management (IPM)** strategies is crucial. This includes using a combination of pest-resistant varieties like Bt cotton, biological control agents, crop rotation, and judicious application of chemical pesticides only when necessary, based on pest surveillance data.

2. **Climate Resilience:** Cotton farming is highly susceptible to the impacts of climate change, including erratic rainfall, droughts, and extreme temperatures, which directly affect crop health and yield (Reddy & Prasad, 2020).

- **Management:** Implementing **climate-smart agricultural practices** is essential. This involves adopting drought-tolerant cotton varieties, using water-efficient irrigation systems such as drip irrigation, and promoting soil health management techniques like mulching to conserve moisture and improve resilience to climatic shocks.

3. **Market Fluctuations:** Farmers often face significant price volatility, which can erode their profitability and create financial instability. The lack of a stable and remunerative market can discourage investment in better farming practices.

- **Management:** Strengthening **Farmer Producer Organizations (FPOs)** can help farmers achieve better bargaining power and direct market access. Furthermore, government policies like the **Minimum Support Price (MSP)** and timely market interventions are vital to provide a safety net against price crashes. Digital platforms can also help farmers access real-time market information to make informed selling decisions (Chand *et al*., 2020).

4. **Policy Constraints:** The cotton sector is influenced by various national and international policies, including those related to subsidies, trade, and export regulations. Restrictive policies or slow policy implementation can hinder growth and competitiveness.

- **Management:** Advocating for supportive and consistent policies is key. This includes policies that encourage investment in research and development for new cotton varieties, facilitate access to credit for farmers, and create a transparent and efficient regulatory environment for the entire value chain (Ghosh & Sharma, 2021). Streamlining export procedures and aligning with global quality standards can also boost India's position in the international market.

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