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Evaluating Agricultural Extension Agent's Sustainable Cotton Land Production Competencies: Subject Matter Discrepancies Restricting Farmers' Information Adoption

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Abstract: Cotton is more chemically intensive than many other commodities, which negatively impacts rural livelihoods at higher rates. Improvement in environmental stewardship of cotton would substantially impact the long-term sustainability of agriculture in cotton producing regions globally. Extension personnel provide producer education to improve these issues that ultimately impact economic growth and quality of life in rural areas, but their proficiency to foster innovation and diffusion of crop-specific content is unknown. A 48-item survey was administered to agricultural extension personnel in five U.S. states to develop an understanding of extension professionals' current knowledge in sustainable cotton production and sustainability, identify pertinent training needs to address in future professional development curricula, and to discern the value of crop-specific competency evaluation in organizational needs assessment. A ranked discrepancy model and an exploratory factor analysis of survey results indicated a glaring need for training in all evaluated competency areas to improve sustainability in cotton producing regions. Synchronous or asynchronous trainings could be developed for change agents to better serve the needs of rural cotton producers. Knowledge transfer or adoption diffusion of rural land sustainability recommendations to farmers will be challenging to achieve in the study's region until change agent's proficiency of sustainable cotton production practices improves.

Keywords: competencies instrument development; exploratory factor analysis; ranked discrepancy model; professional development; knowledge transfer; technology adoption; organizational needs assessment

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1. Introduction

A 21st century rural challenge of food security is elevating agricultural productivity while simultaneously prioritizing rural land sustainability [1]. The Gestalt of understanding agricultural land sustainability solutions exists given the global demands of climate, population, food security, Industry 4.0 technologies, and environmental degradation [2]. Sustainability in agriculture can be defined as management decisions that protect natural resources while improving the viability of social systems [3].

Goal 2 of the United Nations Sustainable Development Goals seeks to improve and promote sustainable agriculture practices worldwide [4]. Cotton production requires intensive chemical inputs compared to other commodities. As concerns of impacts from polyester-produced microplastics on food security and water quality continue to mount [5], natural fiber industries are under increasing pressure to become more socially and environmentally sustainable. Greater implementation of sustainable production practices in cotton has been shown to significantly reduce water and fertilizer inputs and associated costs and lead to more efficient use of resources [6].

Agricultural extension agents play a key role in disseminating new research and technology regarding sustainability to community members [7–9]. Training and professional development are important in agent preparation to fulfill rigorous job duties. Professional competencies and needs assessment for skills such as program development, personnel management, and organizational knowledge are common in extension [10–12]. Technical and subject matter expertise is listed as one of 19 core competencies for new agents [11], but few studies have evaluated training needs within technical contexts. Brodeur et al. [13] states that extension professional development models assume incoming agents already have technical and subject matter expertise, but in reality, new hires are lacking. This study further indicates subject competency is not a focus until 18 months post-hire, at which point it is ranked as the second most important and second most in need of improvement for competency mastery in the first three years of employment [13]. County level agents rely on state specialists as the most important source for subject matter expertise, but relationships with specialists were ranked lowest priority among agents [10]. In recent years, needs have been assessed in integrated pest management [14], nematology [15], and aquaculture [16], but there is a gap in knowledge of agent competencies within different commodity cropping systems. Agriculture producers utilized extension agents as a resource for precision farming [17] and climate change [18–20], but some producers felt extension was outdated and did not provide the most current information and recommendations [19]. Professional development opportunities to build new skills remains vital to ensure agents can meet agriculture producers' needs [21].

The purpose of this study was to develop an understanding of extension professionals' competencies in sustainable cotton production practices, identify negative competencies to develop future professional development trainings, and to determine the professional development merit of evaluating crop-specific competencies in a sustainable land production Ranked Discrepancy Model. The objectives were to describe the current competency levels and factor loadings of extension personnel and identify and rank discrepancies in agents' competencies of cotton production practices; (a) integrated pest management (IPM), (b) soil and nutrient management, (c) water management and conservation, (d) other chemical applications, (e) organic cotton production, (f) fiber quality and post-harvest, and (g) applied research.

2. Materials and Methods

McClelland [22] defined competency as one's ability to complete a certain task. Within organizations, competency is defined as a set of behaviors that determine effectiveness and performance of an employee, and result in increased organizational effectiveness or competitiveness [23]. In extension, competencies are often evaluated using a Borich [24] needs assessment model to identify specific employee training needs [14,25–27]. The Borich needs assessment model has been a widely used and accepted tool to identify training needs in extension for forty years [28]. The model identifies discrepancies between a participant's perceived ability to perform a competency and perceived importance of that competency [24]. Results from the differences in scores are utilized to identify knowledge gaps in areas of importance among the group of individuals surveyed. Presently and as identified by Lybaert et al. [29], an exact list of competencies to assist change agents promote rural land sustainability innovations does not exist.

Narine and Harder [28] proposed the Ranked Discrepancy Model (RDM) versus the Borich model [24] to assess training needs of a sample. RDMs are appropriate when: "(a) the census of a target population is being evaluated at one point in time, (b) data for each variable or item is paired on two ordinal scales with an equivalent number of response anchors, and (c) the objective is to assess discrepancies between two clearly identified states or conditions for each item" [28]. Beyond Borich, an RDM produces standardized scores symbolizing discrepancies in competencies juxtaposed to identified conditions of equilibrium.

Narine and Harder's RDM is central to the sustainable cotton production competency assessments investigated in our study. The research area encompassed over 50% of cotton acreage in the United States. Texas served as the anchor of the study due to its diverse and well-supported cotton industry. Surrounding states of Kansas, Louisiana, New Mexico, and Oklahoma were included in the survey area due to the shared geographical production areas Texas has with each state. Cotton is produced in higher rainfall coastal plains and river deltas, temperate prairie, and high desert regions. Cotton production is limited in surrounding states and multi-state networks provide a leveraging point for extension to develop shared trainings for states with fewer resources. The study population included county and parish extension agents, district extension administrators, and state agronomy and IPM specialists in cotton production areas of these states. Researchers cross referenced United States Department of Agriculture census data with county contacts from each state to create an email list of participants. Counties reporting planted cotton acreage within the last three years (2019–2021) were qualified for this study.

A 48-item instrument was developed to determine extension agents' sustainable cotton production competencies. Utilizing a modified RDM, Part 1 of the instrument asked participants to identify perceived proficiency and importance of 43 specific competencies using the following 4-point ordinal scale: 1 = no proficiency or importance, 2 = low proficiency or importance, 3 = average proficiency or importance, and 4 = high proficiency or importance. Instrument items included competencies in integrated pest management, soil and nutrient management, water management and conservation, chemical applications, organic cotton production, fiber quality and post-harvest, and applied research. Section 2 contained one open response question that provided an opportunity for participants to elaborate on specific training needs representative of participants' own experiences. Section 3 asked four personal characteristics questions identifying the participants' role within extension, state, tenure, and presence of cotton production within the service area. The instrument was reviewed by a four-member panel to ensure content validity and internal validity.

An online census was administered through Qualtrics (Provo, UT) to all 275 personnel who fit the criteria. The instrument was distributed following the Tailored Design Method from Dillman et al. [30]. To reduce non-response error, non-responders received three follow-up email reminders 2–3 days apart containing the link to the online assessment [30,31]. Surveys were distributed in June 2022 and could be accessed via email link for ten days, resulting in a response rate of 16% (n = 44).

All data were analyzed using the SPSS 27. Cronbach's alpha was calculated to determine instrument reliability [32]. Each construct included in the study was statistically reliable, according to Cronbach [32], with reliability coefficients of 0.80 or higher: (a) IPM proficiencies 0.96 and importance 0.91, (b) soil and nutrient management proficiencies 0.89 and importance 0.86, (c) water management and conservation proficiencies 0.91 and importance 0.88, (d) other chemical applications proficiencies 0.93 and importance 0.88, (e) organic cotton production proficiencies 0.95 and importance 0.98, (f) fiber quality and post-harvest proficiencies 0.90 and importance 0.88, and (g) applied research proficiencies 0.95 and importance 0.87.

Descriptive statistics were used to elucidate trends within the different categories of competencies [33]. A Ranked Discrepancy Score (RDS) was calculated for each competency statement following the methodology from Narine and Harder [28]. An exploratory factor analysis was utilized to analyze the data. Understanding multifaceted data structure patterns is accomplished through an exploratory factor analysis [34].

The RDM utilizes an intuitive standardized score that represents the discrepancy or gap in ability compared to a known state of equilibrium juxtaposed to Borich's [24] model that uses means with ordinal scales. Negative Rank (NR), Positive Rank (PR), and Tied Rank (TR) scores were calculated for each competency item [28]. An RDM has three steps. Narine and Harder [28] recommended the researcher should first calculate the number of occurrences in the sample when participants' ability ratings are: (a) less than participants' importance ratings (Negative Ranks = NR), (b) more than participants' importance ratings (Positive Ranks = PR), or (c) equal to participants' importance ratings

(Tied Ranks = TR). Next, the number of occurrences should be converted for NR, PR, and TR into percentages [28].

Relative weights are then assigned (W) to NR% (WNR= −1), PR (WPR= 1), and TR (WTR= 0), according to Narine and Harder [28]. The subsequent Ranked Discrepancy Score (RDS) is a standardized score that varies between −100 to 100. Narine and Harder [28] reported further the RDS has a symmetry of 0, with negative scores signifying an urgent need or discrepancy in aptitude or capacity, and positive scores representing the nonexistence of a disparity or need. This research was reviewed and approved by the Texas A&M University Internal Review Board (IRB2022-0162M).

Principal axis factoring using oblimin normalization as the rotation method including the Kaiser criterion were implemented to examine unidimensionality of the instrument. Field [34] indicated principal axis factoring discerns data patterns that delineates similar and dissimilar features in datasets to better assist researchers interpret the dataset. Examining sampling adequacy was achieved through Kaiser–Meyer–Olkin. Then, to test sphericity, Bartlett's was employed to assess interrelationships between factors [34]. Authors used SPSS 27 software to analyze exploratory factor analysis to measure data fittingness, to extract correct factors, choosing the rotational method, and data interpretation. Authors identified 0.30 or higher as the cutoff value to assess factors [34]. Scree plots determined the quantity of extracted factors in each construct (see Figures 1–4 in the Section 3).

3. Results

The following tables reveal results of the survey responses for each of the competency areas and individual items.

Table 1 provides the unweighted rank response means for each competency area surveyed. Weights were then applied as NR (−1), PR (1), and TR (0), and summed to determine the Ranked Discrepancy Score (RDS). Scores indicated performance gaps in all seven competency areas with the highest priority area being fiber quality and post-harvest (RDS = −61).

Table 1. Mean Ranked Discrepancy Scores for competency areas in sustainable cotton production.

Competency Domains	Ranks (%)			RDS
	NR	PR	TR	
Fiber quality and post-harvest	69	8	24	−61
Other chemical applications	63	9	28	−54
Integrated pest management	59	8	33	−50
Organic cotton production	57	13	30	−44
Applied research	46	7	47	−39
Water management	47	15	39	−32
Soil and nutrient management	46	15	39	−30

Table 2 lists the unweighted rank responses for individual items in the soil and nutrient management competency area. Weights were then applied as NR (−1), PR (1), and TR (0), and summed to determine the RDS. Scores indicated a performance gap in all but one competency item. The top three priority competency items in soil and nutrient management are (a) types of fertilizers to optimize return on investment (RDS = −53), (b) calculating fertilizer rates (RDS = −46), and (c) recognizing nutrient deficiencies in cotton plants (RDS = −38). Respondents demonstrated adequate proficiency in proper collection of soil samples (RDS = 3).

The unweighted rank responses and RDS for each competency item in the water management domain are presented in Table 3. Scores indicated a performance gap in all competency items. The highest priority competency items were (a) water needs of cotton at each growth stage (RDS = −48) and (b) strategies to improve water movement in soils (RDS = −48).

Table 2. Ranked Discrepancy Scores for individual competencies in soil and nutrient management.

Competencies	Ranks (%)			RDS
	NR	PR	TR	
Types of fertilizers to optimize return on investment	60	8	33	−53
Calculating fertilizer rates	62	15	23	−46
Recognizing nutrient deficiencies in cotton plants	48	10	43	−38
Implications for overapplication of fertilizers	50	15	35	−35
Soil types in your service area	40	10	50	−30
Interpreting soil test results to optimize fertility	40	18	43	−23
Conservation tillage practices	43	20	38	−23
Proper collection of soil samples	23	25	53	3

Table 3. Ranked Discrepancy Scores for individual competencies in water management.

Competencies	Ranks (%)			RDS
	NR	PR	TR	
Water needs of cotton at each growth stage	55	8	38	−48
Strategies to improve water movement in soils	55	8	38	−48
Irrigation scheduling	54	15	31	−38
Irrigation equipment options	41	23	36	−18
Importance of water conservation	28	21	51	−8

Table 4 provides the unweighted rank responses and RDS for each competency item in integrated pest management. Scores indicated a performance gap in all competency items. The top three priority competency items were (a) scouting for disease (RD*S* = −68), (b) making treatment decisions based on disease control return on investment (RDS = −63), and (c) making treatment decisions based on weed control return on investment (RDS = −60).

Table 4. Ranked Discrepancy Scores for Individual Competencies in Integrated Pest Management.

Competencies	Ranks (%)			RDS
	NR	PR	TR	
Scouting for disease (bacteria, fungi, viruses)	73	5	23	−68
Making treatment decisions based on disease control return on investment	68	5	28	−63
Making treatment decisions based on weed control return on investment	65	5	30	−60
Identifying common diseases in cotton	65	5	30	−60
Scouting for insects	63	8	30	−55
Making treatment decisions based on insect control return on investment	63	10	28	−53
Field management practices to decrease insect damage to crop	62	13	26	−49
Identifying common insects	58	10	33	−48
Field management practices to decrease weed pressure	55	13	33	−43
Field management practices to decrease insect damage to crop	51	10	38	−41
Identifying common weeds	45	8	48	−38
Scouting for weeds	40	10	50	−30

Table 5 lists the unweighted rank responses and RDS for each competency item in other chemical applications. Scores indicated a performance gap in all competency items. The top priority competency item was economic impacts of plant growth regulator (PGR) applications (RDS = −65).

Table 5. Ranked Discrepancy Scores for individual competencies in other chemical applications, which include plant growth regulators (PGR) and defoliants.

Competencies	Ranks (%)			RDS
	NR	PR	TR	
Economic impacts of PGR applications	70	5	25	−65
Timing of PGR applications	67	8	26	−59
Defoliation product usage	64	8	28	−56
Environmental impacts of PGR applications	60	10	30	−50
Importance of plant growth regulators	54	13	33	−41

Unweighted rank responses and RDS for each competency item in fiber quality and post-harvest are presented in Table 6. Scores indicated a performance gap in all competency items. The top priority item was ginning to optimize fiber quality (RDS = −73).

Table 6. Ranked Discrepancy Scores for individual competencies in fiber quality and post-harvest.

Competencies	Ranks (%)			RDS
	NR	PR	TR	
Ginning to optimize fiber quality	78	5	18	−73
Textile industry needs	73	5	23	−68
Impacts of crop management on fiber quality	68	10	23	−58
Cotton quality measures	64	8	28	−56
Harvesting to optimize fiber quality	63	10	28	−53

Table 7 provides the unweighted rank responses and RDS for each competency item in organic cotton production. Scores indicated a performance gap in all competency items. The top priority competency item was marketing organic cotton fiber and seed (RDS = −55).

Table 7. Ranked Discrepancy Scores for individual competencies in organic cotton production.

Competency	Ranks (%)			RDS
	NR	PR	TR	
Marketing organic cotton fiber and seed	65	10	25	−55
Ginning for organic cotton	58	10	33	−48
Transitioning from conventional to organic acreage	54	18	28	−36
Regulations for organic cotton production	51	15	33	−36

Table 8 lists the unweighted rank responses and RDS for each competency item in applied research. Scores indicated a performance gap in all competency items. The top priority competency item was statistical analysis of field trials (RDS = −45).

Table 8. Ranked Discrepancy Scores for individual competencies in applied research.

Competency	Ranks (%)			RDS
	NR	PR	TR	
Statistical analysis of field trial data	53	8	40	−45
Interpreting statistical data	57	14	30	−43
Selecting appropriate cotton varieties for your service area	50	8	43	−43
Reporting findings to stakeholders	35	0	65	−35
Designing replicated field trials	35	5	60	−30

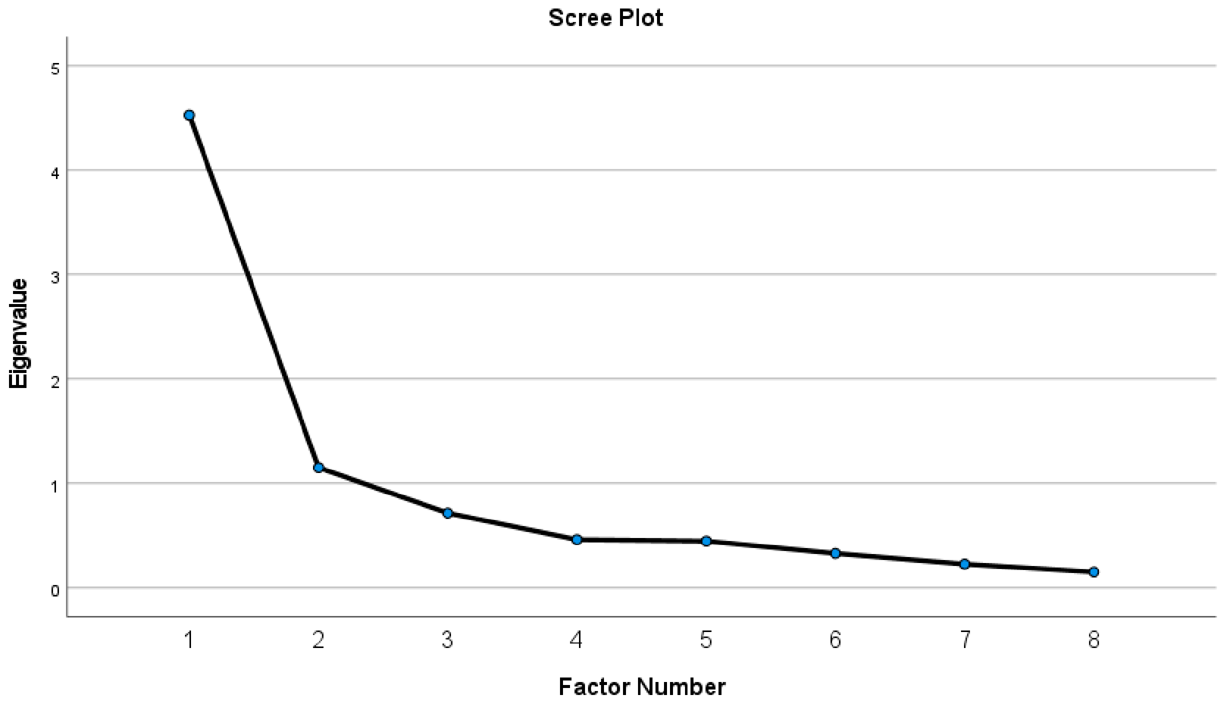

Figure 1. Scree Plot for Exploratory Factor Analysis.

Proficiencies of soil and nutrient management competencies were analyzed using a factor matrix. Factor one consisted of eight items with factor loadings ranging from 0.54 to 0.88 and explained 52.03% of the variance. Factor two consisted of five items with factor loadings ranging from −0.44 to 0.35. and explained 61.39% of the variance (see Table 9).

Table 9. Factor loadings and proficiency items of soil and nutrient management competencies.

	Factor	
	1	**2**
Interpreting soil test results to optimize fertility	0.88	
Recognizing nutrient deficiencies in cotton	0.77	
Calculating fertilizer rates	0.73	−0.44
Types of fertilizers to optimize return on investment	0.72	−0.34
Soil types in your area	0.71	−0.32
Conservation tillage practices	0.71	0.32
Implications for overlapping of fertilizers	0.67	0.35
Proper collection of soil samples	0.54	

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The importance of proficiencies of soil and nutrient management competencies were analyzed using a factor matrix. Factor one consisted of eight items with factor loadings ranging from 0.56 to 0.89 and explained 50.66% of the variance. Factor two consisted of three items with factor loadings ranging from −0.40 to 0.67. and explained 64.50% of the variance (see Table 10).

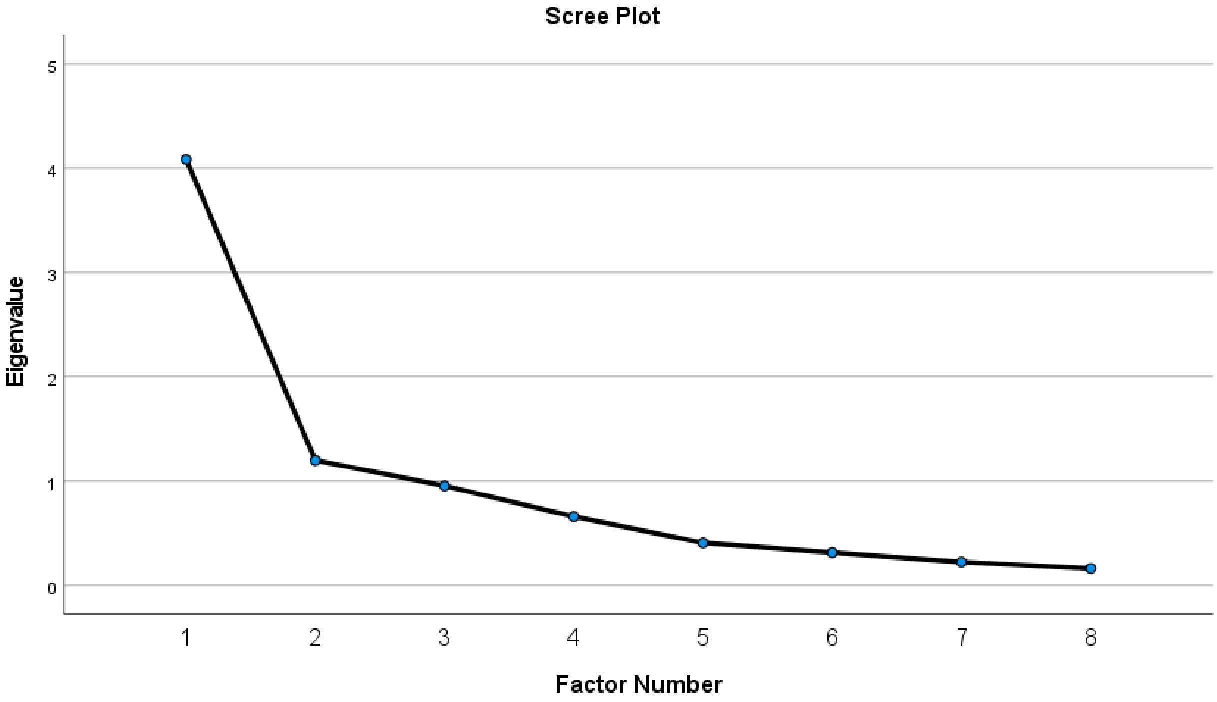

Figure 2. Scree Plot for Exploratory Factor Analysis.

Table 10. Factor loadings and importance items of soil and nutrient management competencies.

	Factor	
	1	**2**
Types of fertilizers to optimize return on investment	0.89	
Implications for overlapping of fertilizers	0.79	−0.40
Recognizing nutrient deficiencies in cotton plants	0.71	
Types of fertilizers to optimize return on investment Proper collection of soil samples	0.69	0.44
Interpreting soil test results to optimize fertility	0.66	0.67
Calculating fertilizer rates	0.63	
Conservation tillage practices	0.60	
Soil types in your area	0.56	

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Proficiencies of water management and conservation competencies were analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.76 to 0.88 and explained 66.86% of the variance (see Table 11).

Table 11. Factor loading and proficiency items of water management and conservation competencies.

	Factor
	1
Irrigation scheduling	0.88
Irrigation equipment options	0.86
Water needs of cotton at each growth stage	0.83
Strategies to improve water movement in soils	0.76
Importance of water conservation	0.76

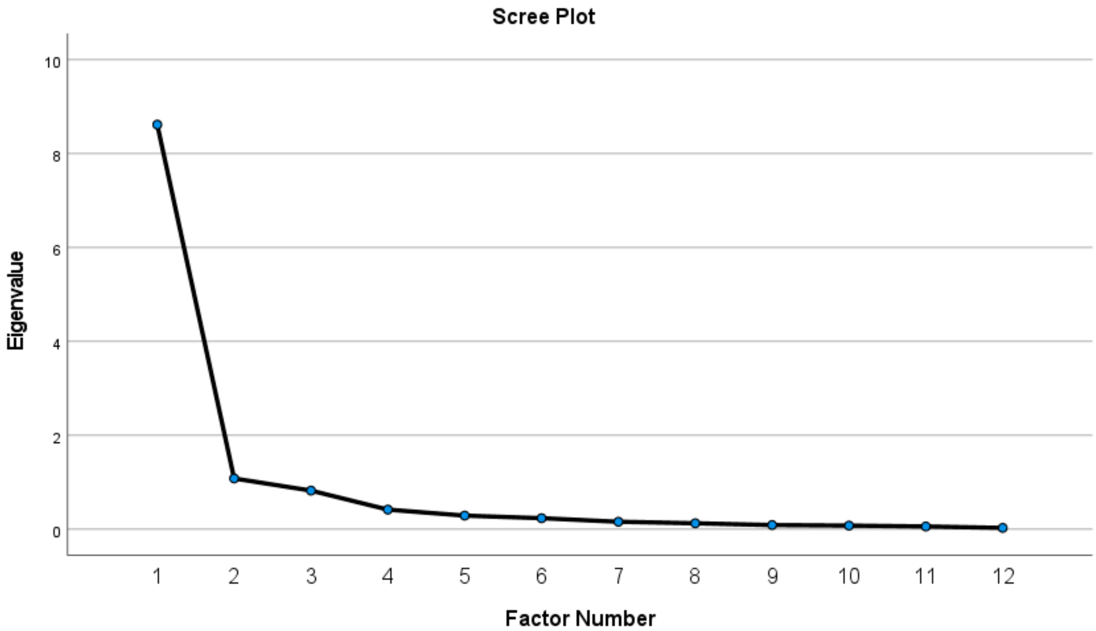

Figure 3. Scree Plot for Exploratory Factor Analysis.

The importance of water management and conservation competencies were analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.62 to 0.88 and explained 61.23% of the variance (see Table 12).

Table 12. Factor loading and importance items of water management and conservation competencies.

	Factor
	1
Irrigation scheduling	0.88
Irrigation equipment options	0.86
Water needs of cotton at each growth stage	0.83
Strategies to improve water movement in soils	0.76
Importance of water conservation	0.76

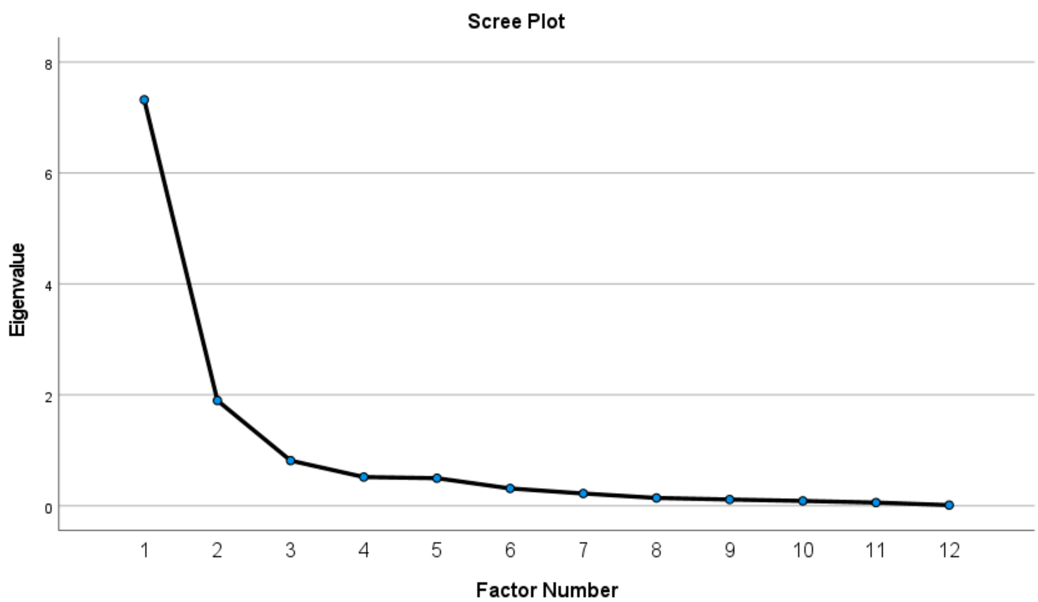

Figure 4. Scree Plot for Exploratory Factor Analysis.

Proficiencies of integrated pest management competencies were analyzed using a factor matrix. Factor one consisted of twelve items with factor loadings ranging from 0.75 to 0.91 and explained 70.01% of the variance. Factor two consisted of five items with factor loadings ranging from −0.33 to 0.43 and explained 77.52% of the variance (see Table 13).

Table 13. Factor loadings and proficiency items of Integrated Pest Management competencies.

	Factor	
	1	**2**
Making treatment decisions based on insect control return on investment	0.91	
Field management practices to decrease insect damage to crop	0.90	
Scouting for insects	0.89	
Identifying common diseases in cotton	0.87	0.37
Field management practices to decrease weed pressure	0.85	
Making treatment decisions based on disease control return on investment	0.85	0.43
Identifying common insects	0.84	−0.33
Field management practices to decrease disease damage to crop	0.82	0.37
Scouting for weeds	0.80	0.32
Scouting for diseases	0.80	
Making treatment decisions based on weed control return on investment	0.75	
Identifying common weeds	0.75	

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The importance of integrated pest management competencies was analyzed using a factor matrix. Factor one consisted of twelve items with factor loadings ranging from 0.71 to 0.81 and explained 58.75% of the variance. Factor two consisted of six items with factor loadings ranging from −0.56 to 0.54 and explained 72.90% of the variance (see Table 14).

Table 14. Factor loadings and importance items of Integrated Pest Management competencies.

	Factor	
	1	**2**
Identifying common diseases in cotton	0.81	−0.47
Scouting for diseases	0.80	−0.45
Identifying common weeds	0.80	
Field management practices to decrease weed pressure	0.79	
Field management practices to decrease insect damage to crop	0.78	
Identifying common insects	0.78	
Field management practices to decrease disease damage to crop	0.78	−0.56
Making treatment decisions based on insect control return on investment	0.75	
Scouting for insects	0.74	0.51
Making treatment decisions based on disease control return on investment	0.74	−0.43
Scouting for weeds	0.72	
Making treatment decisions based on weed control return on investment	0.71	0.54

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Proficiencies of other chemical application competencies were analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.75 to 0.92 and explained 74.09% of the variance (see Table 15).

The importance of other chemical application competencies was analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.69 to 0.91 and explained 64.64% of the variance (see Table 16).

Table 15. Factor loading and proficiency items of other chemical application competencies.

	Factor
	1
Importance of plant growth regulators	0.92
Timing of plant growth regulators applications	0.88
Economic impacts of strategic chemical application	0.87
Defoliation product usage	0.86
Environmental impacts of plant growth regulators applications	0.75

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Table 16. Factor loading and importance items of other chemical application competencies.

	Factor
	1
Economic impacts of strategic chemical application	0.91
Timing of plant growth regulators applications	0.86
Importance of plant growth regulators	0.85
Environmental impacts of plant growth regulators applications	0.69
Defoliation product usage	0.69

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Proficiencies of organic cotton production competencies were analyzed using a factor matrix. Factor one consisted of four items with factor loadings ranging from 0.87 to 0.96 and explained 84.1% of the variance (see Table 17).

Table 17. Factor loading and proficiencies of organic cotton production competencies.

	Factor
	1
Transitioning from conventional to certified organic acreage	0.96
Marketing organic cotton fiber and seed	0.92
Ginning for organic cotton	0.91
Regulations for organic cotton production	0.87

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The importance of organic cotton production competencies was analyzed using a factor matrix. Factor one consisted of four items with factor loadings ranging from 0.92 to 0.99 and explained 91% of the variance (see Table 18).

Table 18. Factors and importance items of organic cotton production competencies.

	Factor
	1
Transitioning from conventional to certified organic acreage	0.99
Marketing organic cotton fiber and seed	0.97
Ginning for organic cotton	0.93
Regulations for organic cotton production	0.92

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The proficiency of applied research competencies was analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.87 to 0.90. 77.86%, and explained of the variance (see Table 19).

Table 19. Factor loading and items of proficiency in applied research after factor rotation.

	Factor Loading
Interpreting statistical data	0.90
Designing replicated field trials	0.89
Selecting appropriate varieties for your service area	0.88
Reporting findings to stakeholders	0.87
Statistical analysis of field trial data	0.87

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The importance of applied research competencies was analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.44 to 0.96 and explained 60.19% of the variance (see Table 20).

Table 20. Factor loading and items of importance in applied research after factor rotation.

	Factor Loading
Statistical analysis of field trial data	0.96
Designing replicated field trials	0.94
Interpreting statistical data	0.86
Selecting appropriate varieties for your service area	0.54
Reporting findings to stakeholders	0.44

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

The proficiency of fiber quality and post-harvest competencies were analyzed using a factor matrix. Factor one consisted of five items with factor loadings ranging from 0.62 to 0.86 and explained 65.22% of the variance (see Table 21).

Table 21. Factor loading and proficiencies items of fiber quality and post-harvest after factor rotation.

	Factor Loading
Harvesting to optimize fiber quality	0.86
Impacts of crop management on fiber quality	0.85
Cotton grading and quality measures	0.85
Textile industry needs-present and future	0.83
Ginning to optimize fiber quality	0.62

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

Importance of fiber quality and post-harvest competencies were analyzed using a factor matrix. The factor loading consisted of five items with factor loadings ranging from 0.62 to 0.86 and explained 66.42% of the variance (see Table 22).

Table 22. Factor loading and importance items of fiber quality and post-harvest after factor rotation.

	Factor Loading
Harvesting to optimize fiber quality	0.85
Cotton grading and quality measures	0.85
Ginning to optimize fiber quality	0.85
Impacts of crop management on fiber quality	0.75
Textile industry needs-present and future	0.63

Note. Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.

4. Discussion

The RDS results and scree plot illustrations from the exploratory factor analysis provided glaring discrepancies and needed professional development for extension professional's capacity to teach farmers sustainable cotton practices and promote adoption for potential behavior change. The revelation that all sustainable cotton production practices competency statements were negative, but one illuminates the need for rapid and effective professional development training for extension professionals in cotton producing regions. Each factor matrix illustrated in the Findings inform future scholars and current practitioners the coalescence of statements used to measure each respective competency as a grouping. The results from the exploratory factor analysis provide a Ranked Discrepancy Model for global researchers and extension specialists via itemized measurements to assess sustainable cotton production competencies of extension professionals or any form of change agent from Ministries of Agriculture, agricultural institutions, non-governmental organizations, Peace Corps, Ministries of Defense, Global Forum for Rural Advisory Services, agricultural commodity groups, International Food Policy Research Institute, farmer associations, Food and Agriculture Organization, agricultural cooperatives, European Union, United States Agency for International Development, China National Agricultural Development Group, etc.

Agents need long term in-service training on climate-related subjects that include strategies to engage with climate change skeptics [35]. Literature indicated producers in Texas are generally uninterested in organic practices [36] and county agriculture agents are not as concerned about climate change issues as specialists and directors [35]. In this study which included Texas and surrounding states, agents expressed a need for training in organic cotton competencies. When examining literature in specific competency areas, agents expressed a need and interest for in-service training in integrated pest management [14,36], water conservation, soil loss, and nutrient management [25]. Agents needing training in organic agriculture were interested in sustainability practices such as soil fertility but did not have an interest in marketing, transitioning, and certification of organic agriculture programs [36]. Soil improvement strategies are integral to climate conscious practices and also appeal to producers because of their economic impacts. A need exists for trainings that equip agents with actionable steps for producers and provide foundational and current science on climate issues, as well as specific content tailored to individual commodities and topics such as irrigation and integrated pest management [18]. Equipping agents to further develop competencies in technical and subject matter expertise [11] is essential to facilitating the diffusion and adoption of sustainable practices among agricultural producers [7].

This research followed a survey design, and the response rate was low despite continued communication with recipients throughout the survey window. We recommend implementing randomized controlled trials [2,37] that evaluate how asynchronous online trainings in sustainable production practices of specific commodity crops impact the number and quality of dissemination events from county agents and adoption rates of those practices by agriculture producers. The advantage of investigating the impact of asynchronous trainings is the any time, any place, at their convenience for producers and change agents' participation coupled with time and resource savings juxtaposed to face to face trainings.

The use of RDS allows one to see the severity of a need and allows for direct comparison and priority ranking between competencies. Results from the differences in scores can be utilized to identify and prioritize knowledge gaps in areas of importance within a group of extension professionals. The data indicated agents need professional development respective to fiber quality and post-harvest, other chemical applications, IPM, organic cotton production, applied research, water management, and soil and nutrient management. Several identified needs including the two highest priority items were unique to cotton, demonstrating value in assessing training needs for specific commodity crops. Improving extension personnel competencies are an annual professional development necessity [21]. Discrepancies were identified and can now be used to develop training opportunities for agents to increase dissemination and adoption of sustainable practices among cotton producers [28]. Field days, demonstration plots, farmer-field schools [38], and virtual or online asynchronous trainings [7,8] would assist agents to improve proficiencies in all competency areas to enhance agriculture producers' cotton sustainability adoption practices. Competency in sustainable agriculture practices has been shown to be a significant predictor of ability to promote practices to producers [39]. Professional development in sustainable cotton production will assist agents to improve program impact [14] for cotton stakeholders and to decrease negative impacts on agriculture producers' income and natural resources [6].

Data indicated a glaring need for specific professional development training in respective cotton production competencies. Authors recommend additional study of agent competencies for edible crops such as corn, peanuts, wheat, etc. due to sustainability demands and continued priority USDA focus and communities producing edible crops. Only when agents are proficient in sustainable agricultural production competencies will they be best prepared to serve as a change agent in designated communities [14] and be able to influence the adoption and diffusion of sustainable agricultural practices [40,41].

5. Conclusions and Future Plans

Our study developed an understanding of extension professionals' current knowledge in sustainable cotton production and sustainability, identified pertinent training needs to address in future professional development curricula, and discerned the value of crop-specific competency evaluation in organizational needs assessment, by surveying extension professionals in cotton producing regions within five U.S. states. The results indicated a glaring need for training in all evaluated competency areas to improve sustainability in cotton-producing regions. Future inquiries are needed for extension professionals' precision agriculture, nutrition, edible crops, farmer's mental health [42], animal science, climate change [43], communications with opinion leaders, Industry 4.0 and Agriculture 4.0 tools, and agricultural innovation competencies. The Gestalt of more content-focused competency professional development beyond program planning, development, and evaluation is crucial to elevate extension professionals for maximum stakeholder impact resulting from the adoption of sustainable agricultural systems locally and globally. Our developed valid and reliable instrument should be used by others studying or preparing agricultural extension professionals or change agents serving in agricultural and natural resource contexts.

The RDS provided a more robust analysis by scoring competencies based on a known equilibrium instead of utilizing weighted means. RDMs offer extensive benefits that solidify data interpretation of discrepancies making the analyses easier to communicate how research can inform practice and improve target extension personnel training. When NR is higher, the score indicates a gap in ability to perform the sustainable cotton production practice. Our study was limited to the largest cotton production region in the United States. Replication in other rural cotton production regions across the globe are needed, as well as edible and nonedible crops from diverse agricultural producers including marginalized farmers. Recommendations for future work include the transfer of findings here to develop an RDM for edible crop growers including extension personnel and examine the longitudinal impacts of extension competencies on farmer impact of sustainability innovations for rural land production.

Authors plan to develop and evaluate online asynchronous trainings based on the findings presented here to meet the professional development needs of change agents working in cotton producing areas. The curricula will be openly accessible for all farmers, industry representatives, agricultural leaders, extension workers, Ministries of Agriculture, and agricultural institutions to assist improving rural land sustainability and communities' food security. What makes this research novel is the investigations of the degree extension agents are prepared to transfer knowledge of sustainable agricultural practices to producers using an RDM. Creation of online learning modules may improve agent competencies and preparedness. Online asynchronous modules need future examination to determine if the digital professional development opportunities are an effective approach to improve extension agents' sustainable agricultural production competencies. The limitation of our work is the survey-design methodology. Future inquiry should focus on the effects of the intervention, asynchronous learning modules, on the treatment group (producers or extension agents) versus the control groups who were not provided or did not participate in the intervention.

Traditional extension professionals' competency inquiries centered on program planning, implementation, and evaluation. Our findings are novel in the discovery of competency discrepancies for a group of professionals hired to produce behavior change in famers producing cotton. As the data indicated, farmers are not gaining sustainable cotton production knowledge from this group of extension professionals according to the reported competency discrepancies, and therefore, sustainable cotton production practices are not being disseminated from the agricultural institutions to the change agent to the stakeholders. More RDM assessments are needed with global extension professionals assigned to farmers producing other agricultural commodities. The data is critical for the advancement of extension professionals around the world working to improve rural land sustainability. The recognition of extension professionals' sustainable cotton production competency discrepancies are impactful for industry, academia, and government respective to extension's role as change agents in local communities disseminating information to improve the lives of individuals, community vitality, and positive impacts on the environment.

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