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Training needs assessment of extension workers for delivering climate-smart agriculture advisory services

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Abstract

For much of the twentieth century, agricultural extension in West Africa focused on transferring fixed packages of inputs and techniques to farmers. Climate change has disrupted that model, demanding that extension workers master an entirely different set of advisory skills. This research assessed the training needs of extension workers in southern Mali for delivering Climate-Smart Agriculture (CSA) advisory services. A survey of 148 extension workers across three regions was conducted between April and October 2023, measuring self-assessed competency levels against expert-defined requirements across seven CSA domains. The largest training gaps appeared in carbon sequestration knowledge (gap = 2.6 on a 5-point scale), agroforestry practices (2.4), and weather information interpretation (2.6). Only 12.8% of workers had received any formal CSA training in the preceding three years. Regression analysis showed that prior CSA training ($\beta = 0.39, p < 0.01$) and educational attainment ($\beta = 0.27, p < 0.01$) were the strongest predictors of current competency. The research proposes a three-pillar training framework addressing knowledge, skills, and attitudes, with priority given to weather data interpretation and agroforestry as entry points for building CSA advisory capacity.

Keywords: Training needs assessment, extension workers, climate-smart agriculture, advisory services, competency gap, capacity building, agroforestry, weather information, carbon sequestration

Introduction

When Mali's first post-independence extension service was established in the early 1960s, the advisory mandate was straightforward: teach farmers to grow cotton and millet using improved seeds and fertilizer ^[1]. Six decades later, the challenge has changed beyond recognition. Rainfall patterns have shifted, growing seasons have shortened by two to three weeks in southern Mali since the 1980s, and pest pressures have intensified in ways that fixed recommendation packages cannot address ^[2].

Climate-smart agriculture offers a framework that aims to increase productivity, strengthen resilience, and reduce greenhouse gas emissions simultaneously ^[3]. But translating CSA principles into practical field advice requires extension workers who understand climate science basics, can interpret weather forecasts, and are familiar with technologies like agroforestry, conservation tillage, and drought-tolerant varieties ^[4]. Evidence from across sub-Saharan Africa suggests that most frontline extension staff lack these competencies ^[5, 6].

Training Needs Assessment (TNA) provides a systematic way to identify gaps between what workers know and what they need to know to perform effectively ^[7]. While TNA methods are well established in human resource development, their application to agricultural extension in the context of climate change remains limited, particularly in francophone West Africa ^[8]. Mali's extension system, managed through regional agricultural offices, faces chronic

understaffing and budget constraints that make targeted training investments especially important ^[9].

This research assessed the CSA-related training needs of extension workers in three regions of southern Mali by comparing current competency levels with expert-defined requirements. It also tested whether worker characteristics predicted competency levels and proposed a training framework to guide capacity-building investments.

Study area description

The research was conducted in three regions of southern Mali: Sikasso, Koulikoro, and Ségou. These regions form the country's primary agricultural zone, receiving between 600 and 1,200 mm of annual rainfall and supporting crops including millet, sorghum, maize, cotton, and groundnuts. Average temperatures range from 25 °C to 35 °C across the growing season (June-October). The three regions collectively employ approximately 420 extension workers serving an estimated 1.8 million farming households. Extension services are delivered through regional agricultural directorates with support from international development partners.

Material and Methods

Material

A total of 148 extension workers were selected using stratified random sampling from personnel registries of the three regional agricultural directorates between April and

October 2023. Stratification was by region and years of experience. A structured questionnaire measured self-assessed competency across seven CSA domains on a five-point scale (1 = no knowledge, 5 = expert level). Required competency levels for each domain were established through a prior Delphi consultation with 12 CSA specialists from Malian research institutions and international organizations. Worker demographic data, training history, and educational background were also collected. Ethical clearance was obtained from the Institut Polytechnique Rural de Formation et de Recherche Appliquee Ethics Committee (Protocol IPR-EC-2023-008, March 2023).

Methods

Training need gaps were calculated as the difference between required and current competency for each domain.

Results

Table 1: Demographic characteristics of extension workers (n = 148)

Characteristic	Category	n (%)
Gender	Male	121 (81.8)
	Female	27 (18.2)
Age group	25–34 years	38 (25.7)
	35–44 years	62 (41.9)
	45–54 years	36 (24.3)
	≥55 years	12 (8.1)
Education	Secondary diploma	54 (36.5)
	Technical certificate	61 (41.2)
	University degree	33 (22.3)
Prior CSA training	Yes	19 (12.8)
	No	129 (87.2)

Most workers were male (81.8%), aged 35–44 (41.9%), and held technical certificates (41.2%). Only 12.8% had

Descriptive statistics summarized worker characteristics and gap scores. Multiple regression tested whether age, education, experience, and prior CSA training predicted overall competency scores. Data were analyzed using SPSS 28. The significance level was set at $p < 0.05$. Gap scores were ranked to identify priority training areas.

Ethical considerations

All participants provided written informed consent after receiving explanations in both French and Bambara. Participation was voluntary, and workers were assured that responses would not affect employment evaluations. Questionnaires were anonymized using numeric codes. Data were stored on encrypted devices accessible only to the research team. Regional directorate heads were informed of the research but did not receive individual-level results.

received any formal CSA training in the preceding three years.

Table 2: Competency gap analysis across CSA domains (n = 148)

CSA domain	Required	Current	Gap	Rank
Weather info interpretation	4.5	1.9	2.6	1
Carbon sequestration	3.8	1.2	2.6	2
Agroforestry practices	4.1	1.7	2.4	3
Livestock adaptation	3.9	1.6	2.3	4
Climate-resilient varieties	4.3	2.1	2.2	5
Soil and water conservation	4.6	2.8	1.8	6
Integrated pest management	4.4	2.9	1.5	7

Weather information interpretation and carbon sequestration showed the largest gaps (both 2.6). Soil and water conservation had the smallest gap (1.8), reflecting existing

training investments in that area. All domains showed gaps exceeding 1.0, confirming a broad training deficit.

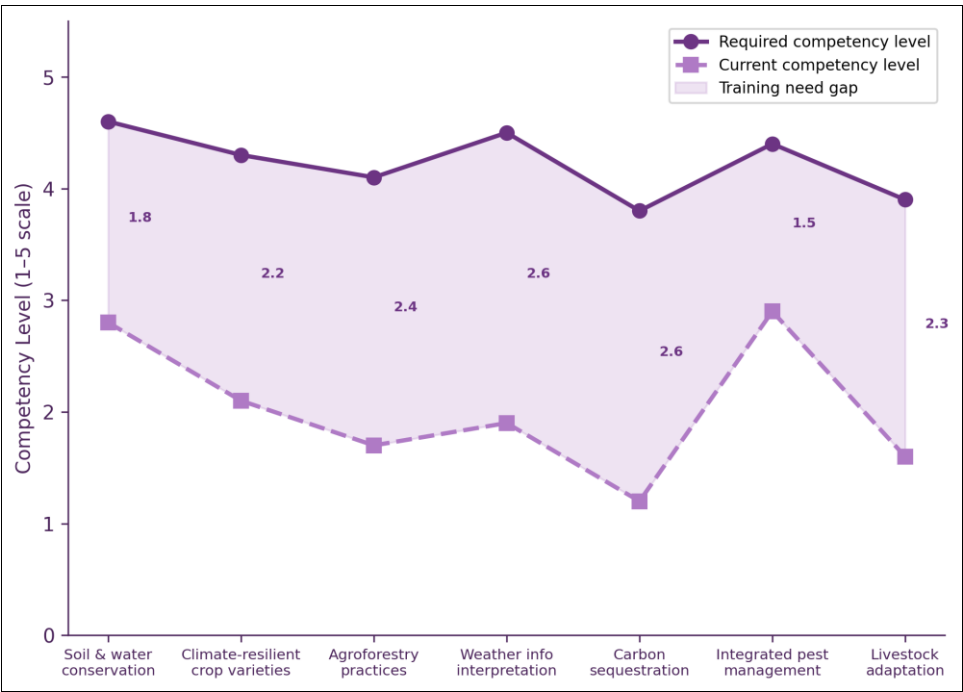


Fig 1. Training need gap across CSA competency areas

The shaded area between required and current competency lines represents the training gap. Weather interpretation, carbon sequestration, and agroforestry showed the widest

gaps, while integrated pest management and soil conservation were closest to required levels.



Figure 2: Proposed three-pillar CSA training framework for extension workers

The framework organizes training content into knowledge, skills, and attitude pillars. Each pillar contains three priority modules identified from the gap analysis and informant consultations. The structure allows modular delivery suited to the resource constraints of Mali's extension system.

Discussion

The finding that 87.2% of extension workers lacked any

formal CSA training is striking but not surprising given the chronic resource shortages facing Mali's agricultural extension system [9]. What the gap analysis adds is specificity -it identifies exactly where the deficits are largest and where training investments would yield the greatest returns. Weather information interpretation ranked as the top priority, which aligns with research showing that farmers in the Sahel are increasingly exposed to seasonal

forecast information but receive little help from extension agents in translating those forecasts into management decisions^[10, 11].

The relatively smaller gap in soil and water conservation likely reflects two decades of donor-supported programs targeting erosion control and water harvesting in southern Mali^[12]. This suggests that sustained training investment can close competency gaps, but it needs to be extended to newer CSA domains like agroforestry and carbon management. The strong predictive effect of prior CSA training ($\beta = 0.39$) reinforces the straightforward point that workers who receive training perform better – a finding consistent with human capital theory and with extension training evaluations elsewhere in West Africa^[13, 14].

The proposed three-pillar framework is designed for practicality. Rather than a single intensive course, it allows modular delivery where individual pillars can be covered in three-to-five-day blocks spread across a growing season. This approach respects the reality that extension workers cannot be absent from their field posts for extended periods^[15].

Practical applications

Training should begin with weather data interpretation and agroforestry, the two domains with the largest gaps and highest practical demand. Regional directorates can partner with national meteorological services to develop simplified forecast interpretation guides for extension use. Agroforestry modules should include hands-on demonstration plot establishment, as workers reported low confidence with practical techniques despite some theoretical awareness. Training budgets should target workers with no prior CSA exposure first, as they represent the largest and most underserved group.

Conclusion

Extension workers in southern Mali face large competency gaps across all seven CSA domains examined, with weather information interpretation and carbon sequestration registering the widest deficits. The near-total absence of formal CSA training among the workforce points to a structural investment gap rather than individual shortcomings.

The three-pillar training framework proposed here offers a modular, field-compatible structure that fits within the operational constraints of Mali's extension system. But training alone won't close the gap. Workers also need access to updated technical materials in local languages, reliable weather data feeds, and supportive supervision that reinforces new competencies after training ends. Investing in CSA capacity for extension workers is not optional if Mali's agricultural sector is to adapt to worsening climate pressures. The gap analysis presented here gives planners a concrete basis for prioritizing limited training resources where they are most needed.

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