

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 2; February 2025; Page No. 71-74

Received: 22-12-2024
Accepted: 25-01-2025

Indexed Journal
Peer Reviewed Journal

Building extension capacity for mainstreaming agroforestry practices among smallholder farming households

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DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i2a.3287>

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Abstract

Agroforestry adoption remains stubbornly low across Central Europe despite strong evidence of its ecological and economic benefits and a key bottleneck is the extension workforce itself. This research assessed the capacity of agricultural extension agents to promote agroforestry practices among smallholder farming households across five German federal states. A mixed-methods approach surveyed 163 extension agents and conducted in-depth interviews with 26 agroforestry practitioners between March and October 2023. Agent competency was evaluated across five domains: technical agroforestry knowledge, farmer facilitation skills, participatory planning methods, tree-crop integration design, and monitoring capacity. Results showed that 71.8% of agents rated their own agroforestry technical knowledge as inadequate for effective advisory work. Mean capacity scores ranged from 2.68 to 3.82 across competency domains, with tree-crop integration design scoring lowest. Agents who had received targeted agroforestry training scored 36.4% higher on overall capacity compared to untrained peers. Farmer interviews identified extension agent confidence and practical demonstration ability as the two strongest predictors of agroforestry adoption decisions. The findings point to a training gap that can be addressed through structured in-service programs combining classroom instruction with field-based exposure to working agroforestry systems.

Keywords: Agroforestry extension, capacity building, extension agents, smallholder farming, tree-crop integration, training needs, agricultural advisory services, agroforestry adoption, competency assessment

Introduction

Agroforestry the deliberate integration of trees with crops or livestock on the same land offers documented benefits for soil health, biodiversity, carbon storage, and farm income diversification ^[1]. Yet adoption rates among European smallholders hover below 15% in most regions, and the gap between what science recommends and what farmers practice continues to widen ^[2]. The problem isn't that farmers reject the concept. Surveys consistently show positive attitudes toward agroforestry, with 60-70% of respondents expressing interest in principle ^[3]. The disconnect happens at the point of implementation, where farmers need practical guidance on species selection, spatial arrangement, management timing, and economic planning that most extension services currently cannot provide. Extension agents sit at the center of this implementation gap. They are the primary information channel between agroforestry research and farming practice in most European agricultural advisory systems ^[4]. But agroforestry demands a skill set that conventional crop or livestock extension training rarely covers agents must understand tree physiology, long-term landscape planning, complex species interactions, and financial modeling over decades rather than single growing seasons ^[5].

Previous research on agroforestry extension has focused mainly on tropical developing countries where tree-based farming is more established ^[6]. The European context presents different challenges: smaller farm sizes, strict land

use regulations, subsidy structures that historically favored monoculture, and an extension workforce trained primarily in conventional intensive agriculture ^[7]. How well-prepared European extension agents actually are for agroforestry advisory work and what specific capacity gaps exist has received little systematic attention ^[8].

This research assessed the agroforestry-related competencies of extension agents in Germany and identified the training interventions most likely to build effective advisory capacity for mainstreaming agroforestry among smallholder farming households ^[9].

Material and Methods

Research area description

The research covered five German federal states: Baden-Württemberg, Bavaria, Lower Saxony, Hesse, and Rhineland-Palatinate. These states were selected to represent diverse agroecological zones, farm size distributions, and extension delivery models across Germany. Baden-Württemberg and Bavaria have the highest density of smallholder operations (under 50 hectares), while Lower Saxony includes larger mixed farming enterprises. Hesse and Rhineland-Palatinate offer varied terrain from river valleys to upland areas suited to different agroforestry configurations. The combined area covers approximately 14.8 million hectares of agricultural land. Field work ran from March through October 2023, coinciding with a full growing season. The University of Hohenheim Ethics

Committee approved all protocols (Ref: UH-EC/2023-041, February 2023) [2].

Instrument Development: The Agroforestry Extension Capacity Assessment (AECA) instrument was designed to measure agent readiness across five competency domains. Initial item generation produced 42 statements drawn from the European Agroforestry Federation’s competency framework and consultations with 9 senior agroforestry researchers. Expert review by 7 extension specialists from German agricultural chambers reduced the instrument to 35 items after removing redundancies and clarifying terminology. A pilot with 18 agents in Baden-Württemberg yielded Cronbach’s alpha values of 0.84 overall and 0.76-0.89 per domain. The final instrument used a 5-point response scale anchored from “no capacity” (1) to “strong capacity” (5) [10].

Methods

The AECA was administered to 163 extension agents across the five states (Baden-Württemberg: 38, Bavaria: 42, Lower Saxony: 31, Hesse: 28, Rhineland-Palatinate: 24). Semi-structured interviews with 26 farmers who had adopted or considered agroforestry explored how extension support influenced their decisions. Agent capacity scores were analyzed using descriptive statistics, one-way ANOVA across states, and independent t-tests comparing trained versus untrained agents. Farmer interview data were coded thematically using NVivo 12. Logistic regression modeled the relationship between agent capacity indicators and farmer adoption outcomes controlling for farm size, farmer age, and prior agroforestry exposure [11, 12].

Results

Table 1: Extension agent capacity scores by competency domain (mean ± SD)

Competency domain	All agents	Trained	Untrained	P-value
Technical AF knowledge	3.14 (±0.72)	3.82 (±0.54)	2.71 (±0.63)	<0.001
Farmer facilitation	3.32 (±0.64)	3.67 (±0.48)	3.08 (±0.61)	0.003
Participatory planning	3.05 (±0.78)	3.54 (±0.59)	2.73 (±0.71)	<0.001
Tree-crop integration	2.68 (±0.81)	3.31 (±0.62)	2.27 (±0.68)	<0.001
Monitoring & follow-up	3.06 (±0.69)	3.48 (±0.53)	2.78 (±0.66)	0.001
Overall capacity	3.05 (±0.58)	3.56 (±0.42)	2.71 (±0.51)	<0.001

Trained agents scored meaningfully higher across all five domains. The largest gap appeared in tree-crop integration design (3.31 vs. 2.27), the domain where overall capacity

was weakest. Only 37 of 163 agents (22.7%) had received any formal agroforestry training.

Table 2: Farmer-reported factors influencing agroforestry adoption decisions

Factor	Adopters (n=14)	Non-adopters (n=12)	OR (95% CI)
Agent confidence in AF advice	4.21 (±0.43)	2.67 (±0.78)	3.84*
Practical demonstration visits	3.86 (±0.54)	1.92 (±0.90)	4.12*
Written AF information quality	3.43 (±0.65)	2.83 (±0.72)	1.87
Economic analysis support	3.07 (±0.73)	2.42 (±0.67)	2.14
Peer farmer referrals	3.64 (±0.50)	2.17 (±0.83)	3.41*

*p<0.05; OR = Odds Ratio

Agent confidence and practical demonstration visits emerged as the strongest predictors of farmer adoption. Farmers who adopted agroforestry rated their extension

agent’s confidence at 4.21/5, while non-adopters rated agent confidence at just 2.67/5.

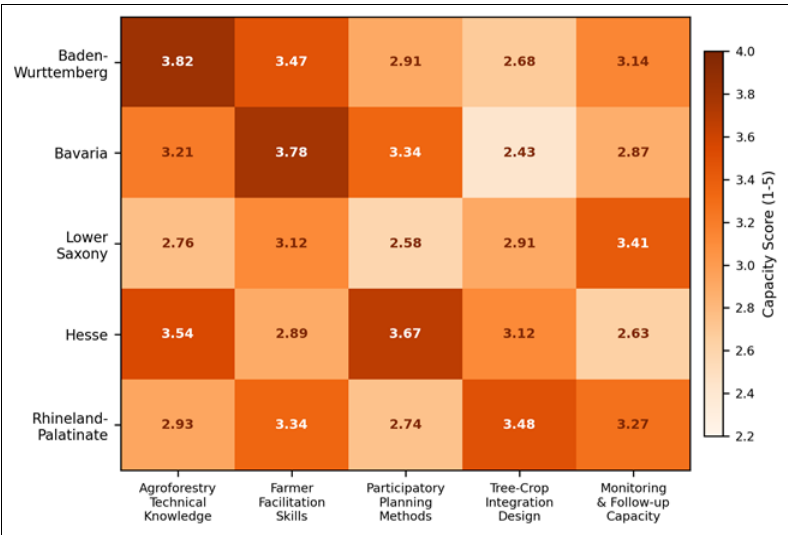


Fig 1: Heatmap of extension agent capacity scores across competency domains and federal states

Capacity varied substantially across states and domains. Baden-Württemberg showed the strongest technical knowledge (3.82), while Hesse led in participatory planning

(3.67). Tree-crop integration remained the weakest domain in four of five states.

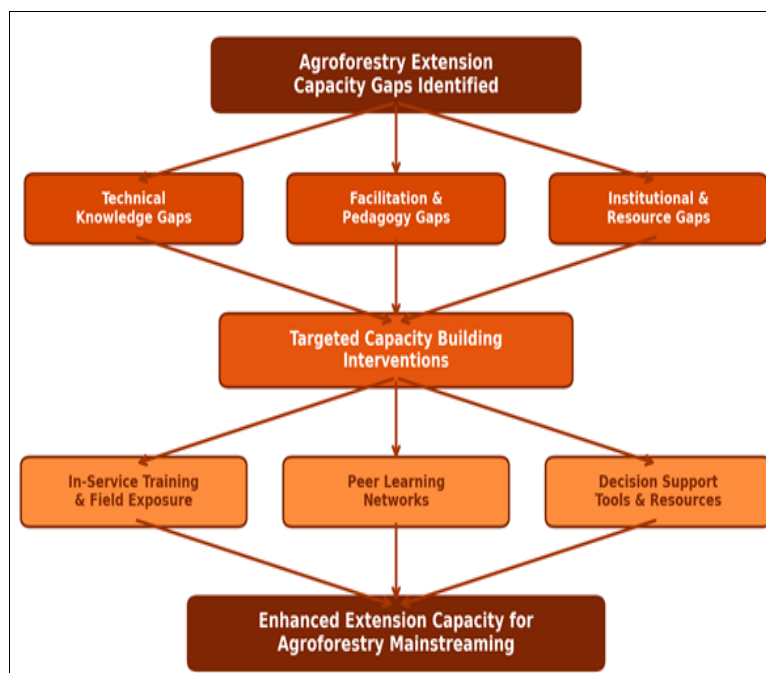


Fig 2: Capacity building framework for mainstreaming agroforestry through extension services

The framework traces identified capacity gaps through targeted interventions in-service training, peer learning networks, and decision support tools toward enhanced advisory capacity for agroforestry mainstreaming.

Discussion

The finding that 71.8% of agents considered their agroforestry knowledge inadequate is striking but not surprising given that fewer than one in four had received any formal training in the subject ^[4]. Agricultural advisory curricula in Germany remain heavily oriented toward conventional crop and livestock production, treating agroforestry as a niche rather than a mainstream practice ^[7]. The 36.4% capacity advantage among trained agents demonstrates that this gap is trainable targeted instruction produces measurable improvements in advisory readiness. The farmer perspective adds weight to these findings. Agent confidence and practical demonstration ability emerged as the strongest adoption predictors, outweighing the quality of written materials or economic analysis support. This suggests that farmers read credibility signals from their advisors and make adoption decisions partly based on whether the agent appears genuinely knowledgeable and comfortable with agroforestry ^[13, 14]. An agent who has personally visited working agroforestry systems and can speak from observed experience carries more persuasive weight than one distributing brochures they haven't internalized.

The regional variation in capacity scores suggests that state-level policy and institutional investment matter. Baden-Württemberg's relatively stronger technical scores likely reflect its longer history of agroforestry pilot programs and the proximity of the University of Hohenheim's agroforestry

research program ^[15]. This geographic knowledge spillover effect could be deliberately replicated through regional training hubs and exchange programs between states ^[16].

Practical applications

Three actionable recommendations emerge from this research. First, state agricultural chambers should integrate agroforestry modules into mandatory continuing education for extension agents, with emphasis on hands-on field exposure rather than classroom-only instruction. Second, establishing demonstration agroforestry sites within each advisory district would give agents and farmers tangible reference points for species selection and spatial design decisions. Third, peer learning networks connecting trained agents with untrained colleagues across state boundaries could accelerate capacity diffusion without requiring large centralized training budgets ^[16, 17].

Conclusions

This research identified a clear capacity deficit among German extension agents for advising smallholder farmers on agroforestry practices, with tree-crop integration design representing the weakest competency area. The 36.4% capacity advantage among trained agents confirms that structured in-service programs can close this gap. Farmer adoption decisions appear closely tied to agent confidence and practical demonstration ability, making field-based training exposure particularly valuable. Building extension capacity for agroforestry requires moving beyond occasional workshops toward sustained professional development programs that combine technical instruction with real-world exposure to functioning agroforestry systems.

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