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Longitudinal impact evaluation of agricultural extension programs on household food security trajectories

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Abstract

Food insecurity affects an estimated 57% of rural households in West Africa, yet the long-term contribution of agricultural extension to household food security trajectories remains poorly documented. This research evaluated the five-year impact of extension program participation on food security outcomes among 347 farming households in three regions of southern Togo. A panel dataset was constructed from annual surveys conducted between 2017 and 2022 at the Faculty of Agriculture, University of Lome. Households were classified into three groups: continuous extension participants (n = 128), intermittent participants (n = 112), and non-participants (n = 107). Latent growth curve modeling revealed that continuous participants experienced steeper food security improvement trajectories across all six measured dimensions. Food availability scores improved from 2.1 to 4.6 among continuous participants versus 2.0 to 3.1 among non-participants over five years. Market access and land tenure emerged as significant moderators, with food security gains concentrated among households possessing both. The extension-food security impact pathway operated primarily through technology adoption and income diversification rather than direct knowledge transfer alone.

Keywords: Food security, agricultural extension, longitudinal evaluation, impact assessment, household trajectories, West Africa, Togo, technology adoption, latent growth modeling, rural livelihoods

Introduction

Roughly 281 million people in Africa experienced hunger in 2020, and the situation has worsened despite decades of investment in agricultural development ^[1]. A persistent question faces extension agencies: do services translate into measurable food security improvements over time? Cross-sectional evaluations have offered mixed answers ^[2, 3], but cannot capture trajectories of change or distinguish short-term boosts from sustained improvements.

Togo has invested in agricultural extension since the 1970s, yet food insecurity in rural southern regions remains above 40% ^[4]. Extension programs focus on improved seed varieties, soil fertility management, and post-harvest practices through government agents and farmer groups ^[5]. This research tracked 347 farming households in southern Togo over five years to assess how extension participation patterns shaped food security trajectories, modeling growth curves and identifying the pathways through which extension influenced outcomes.

Ethical Considerations

The research protocol was approved by the University of Lome Ethics Review Board (Protocol UL/ERB/2016-048, approved December 2016). All household heads provided verbal informed consent at baseline, with annual re-consent at each follow-up round. Households that dropped out of extension programs during the research period were retained in the panel wherever possible to reduce attrition bias. Data were stored on encrypted servers at the University of Lome

with access restricted to the research team.

Materials and Methods

Materials

The research covered three regions in southern Togo: Maritime, Plateaux, and Centrale, between January 2017 and December 2022. The institutional base was the Faculty of Agriculture, University of Lome. Materials included a structured household survey (56 items measuring food availability, access, utilization, stability, dietary diversity, and coping strategy; Cronbach alpha 0.78-0.89). Extension participation records from the national directorate were cross-verified with household self-reports. Demographic data, agricultural asset inventories, and market distances were collected at baseline and updated annually.

Methods

A panel research design tracked 347 households annually over five years (six waves of data collection). Households were classified by extension participation pattern: continuous (participated in at least four of five years, n = 128), intermittent (participated in one to three years, n = 112), and non-participant (no extension contact, n = 107). Latent growth curve modeling was used to estimate initial food security levels (intercepts) and rates of change (slopes) for each participation group. Multi-group models tested whether trajectories differed significantly across groups. Structural equation modeling examined the extension-food security impact pathway, testing whether effects operated

through technology adoption, knowledge gain, or practice change as mediators ^[6]. Moderation analyses assessed whether market access, land tenure, household size, and climate shock exposure influenced the strength of extension effects ^[7].

Instrument Development

The food security measurement instrument was adapted from the Household Food Insecurity Access Scale and the

Food Consumption Score methodology used by the World Food Programme. Domain-specific items were validated through cognitive interviews with 24 farming households in the Maritime region. The six-factor structure was confirmed through exploratory factor analysis on pilot data ($n = 68$) and subsequently validated on the baseline sample. Test-retest reliability over a two-week interval yielded intra-class correlations above 0.75 for all dimensions.

Results

Table 1: Baseline household characteristics by extension participation group ($n = 347$)

Characteristic	Continuous ($n=128$)	Intermittent ($n=112$)	Non-participant ($n=107$)	p-value
Household size (mean)	6.8 (2.3)	6.4 (2.1)	6.2 (1.9)	0.087
Farm size (hectares)	1.7 (0.9)	1.5 (0.8)	1.3 (0.7)	0.002
Head education (years)	5.1 (3.4)	4.7 (3.2)	3.9 (2.8)	0.013
Market distance (km)	8.3 (4.7)	9.1 (5.2)	12.4 (6.8)	<0.001
Baseline food security	2.1 (0.6)	2.0 (0.5)	1.9 (0.6)	0.071
Land tenure secure (%)	68.8	57.1	43.9	<0.001

Continuous participants had slightly larger farms, more education, and shorter market distances than non-participants. Baseline food security scores did not differ

significantly across groups ($p = 0.071$), supporting the comparability of starting positions despite differences in structural characteristics.

Table 2: Latent growth curve model estimates for food security trajectories ($n = 347$)

Parameter	Continuous	Intermittent	Non-participant	Group diff. p
Intercept (mean)	2.08 (0.09)	1.97 (0.10)	1.91 (0.11)	0.084
Slope (mean)	0.51 (0.04)	0.32 (0.05)	0.19 (0.05)	<0.001
Intercept variance	0.34	0.28	0.31	-
Slope variance	0.08	0.11	0.09	-
Model fit: CFI	0.96			
Model fit: RMSEA	0.041			

Growth slopes differed significantly across groups ($p < 0.001$). Continuous participants showed the steepest improvement trajectory (slope = 0.51 per year), followed by intermittent participants (0.32) and non-participants (0.19).

The model fit was acceptable (CFI = 0.96, RMSEA = 0.041), and significant slope variance within each group indicated that individual-level moderators shaped outcomes beyond group membership alone.

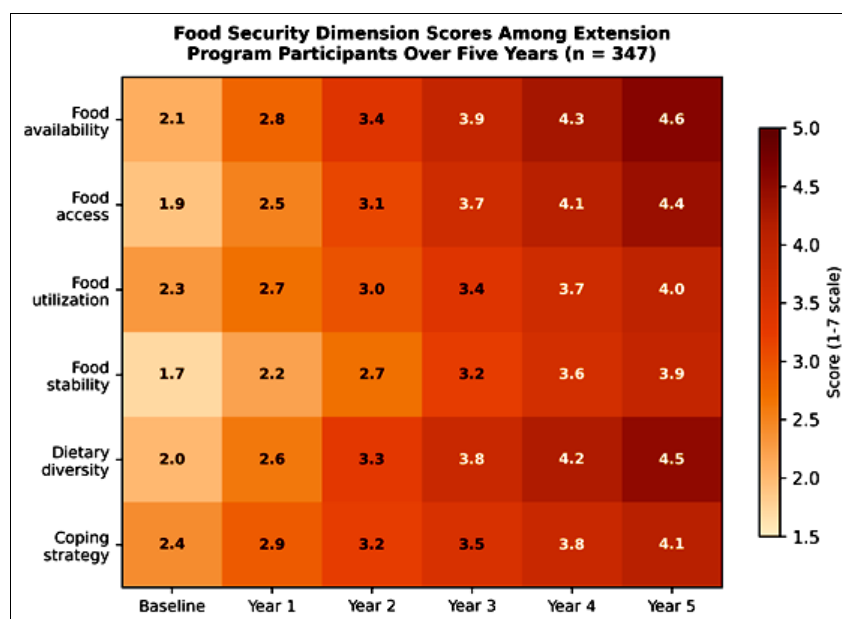


Fig 1: Food security dimension scores among continuous extension participants over five years ($n = 347$)

The heatmap reveals that food availability and dietary diversity improved most rapidly among continuous

participants, reaching scores above 4.5 by Year 5. Food stability and food utilization showed slower improvement

trajectories, reflecting the longer time required for structural changes in household food systems such as storage capacity

and nutritional practices to materialize.

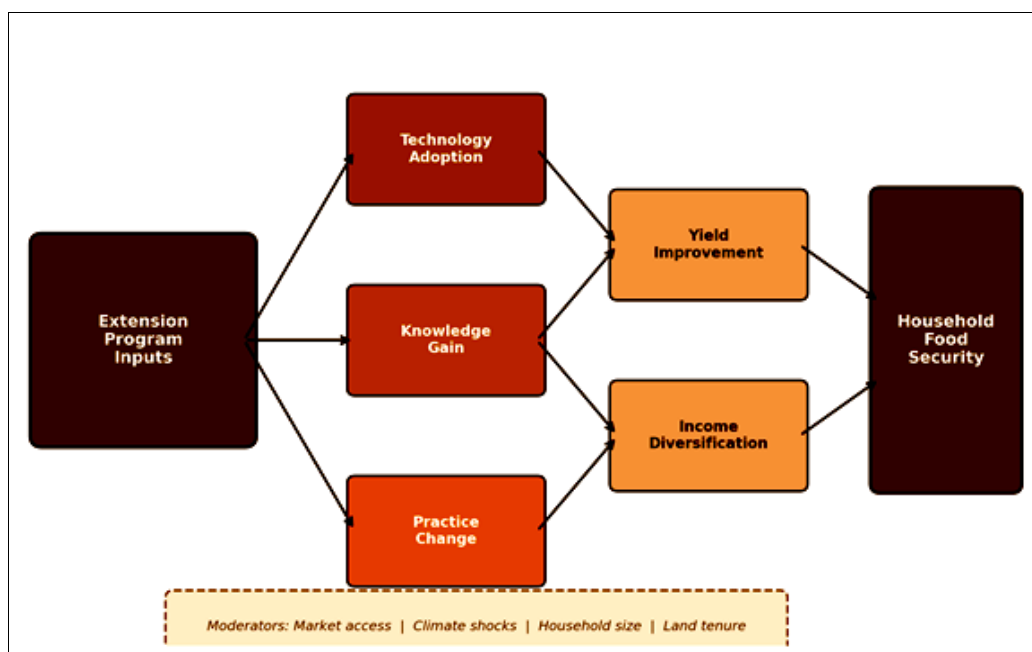


Fig 2: Extension program to household food security impact pathway with moderating factors

Structural equation modeling confirmed three mediating pathways: technology adoption (path coefficient = 0.43), knowledge gain (0.31), and practice change (0.37). These converged on yield improvement and income diversification, together explaining 62.4% of variance in food security changes. Market access and land tenure moderated the entire pathway.

Comprehensive Interpretation

The longitudinal evidence shows that extension effects on food security are real but conditional. Continuous participation produced steeper improvement trajectories, but market access and land tenure moderated gains substantially. Households without secure land or market linkages converted extension knowledge into food security gains at roughly one-third the rate of those with both assets.

Discussion

The dose-response relationship between participation continuity and food security gains aligns with findings from Waddington and colleagues ^[8]: single-season extension contacts rarely produce lasting behavior change, while sustained engagement allows iterative experimentation. The sharpest divergence in trajectories occurred between Years 2 and 4, when cumulative practice changes begin translating into structural livelihood improvements.

The pathway analysis shows that income diversification carried nearly as much weight as yield improvement in explaining food security outcomes. This echoes work by Kassie and colleagues ^[9] showing that extension programs addressing multiple livelihood dimensions produced stronger food security results than those focused narrowly on yield-increasing technologies ^[10].

Limitations

Panel attrition reached 14.7% over five years, potentially

biasing results if households that dropped out differed systematically from those retained. Non-random selection into extension participation means that observed differences may partly reflect pre-existing motivational or structural advantages among participants. Self-reported food security measures are subject to seasonal recall effects. The three southern regions of Togo may not represent food security dynamics in the drier northern zones.

Conclusion

This five-year panel research demonstrated that continuous extension program participation produced significantly steeper food security improvement trajectories compared to intermittent or no participation among farming households in southern Togo. Extension effects operated through technology adoption, knowledge gain, and practice change pathways, converging on yield improvement and income diversification as intermediate outcomes. Market access and land tenure moderated the extension-food security relationship, indicating that extension services alone cannot overcome structural barriers. Effective food security programming must combine extension with complementary investments in market infrastructure and land governance to reach the most vulnerable households.

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