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Agricultural Extension, Farmer Motivation, and Maize Food Security in Indonesia-Timor Leste Borderlands

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HIGHLIGHTS

- Agricultural extension was positively and significantly associated with maize-based household food security in semi-arid borderland households.
- Farmer motivation showed a stronger standardized association with food security than agricultural extension in the final structural model.
- Agricultural extension and farmer motivation jointly explained 55.0% of the variance in household food security.
- The CFA results supported convergent validity, construct reliability, and discriminant validity for all latent constructs.

ARTICLE INFO

Keywords: Extension services, Smallholder motivation, Household food security, Maize farming, Borderland agriculture, Semi-arid systems, Covariance-based SEMm East Nusa Tenggara.

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ABSTRACT

Household food security in semi-arid borderland areas remains vulnerable to drought, limited market access, and weak livelihood assets. Although agricultural extension and farmer motivation have been studied in smallholder contexts, their joint role in explaining maize-based household food security in semi-arid borderland agriculture remains under examined. Drawing on an ERG-based motivation framework, this study tested whether agricultural extension and farmer motivation are positively associated with household food security. A cross-sectional survey of 244 maize-farming households was conducted in the Indonesia–Timor Leste borderlands of East Nusa Tenggara from February to August 2025. Data were collected using a structured questionnaire administered through face-to-face interviews and analyzed using covariance-based structural equation modeling. The final model showed acceptable fit (GFI = 0.997; AGFI = 0.927; CFI = 0.999; TLI = 0.992; RMSEA = 0.050) and explained 55.0% of the variance in household food security. The findings show that agricultural extension and farmer motivation were both positively and significantly associated with household food security, indicating their complementary roles in strengthening maize-based household food security.

INTRODUCTION

Food security is commonly understood through four dimensions: availability, accessibility, utilization, and stability (FAO, 2008). In drylands, these dimensions remain vulnerable because household food systems are shaped by climate variability, land degradation, market instability, limited infrastructure, and restricted access to public services. The State of Food Security and Nutrition

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in the World 2025 emphasizes that high food-price inflation weakens purchasing power and limits access to healthy diets, especially among low-income populations (FAO et al., 2025). Indonesia is also classified as having a moderate level of hunger in the 2025 Global Hunger Index (Global Hunger Index, 2025). However, global and national indicators may conceal regional inequalities because semi-arid borderlands face constraints that differ from irrigated and commercially integrated zones. East Nusa Tenggara is one of Indonesia's vulnerable dryland regions, where maize is not only a crop but also a staple food, household reserve, and subsistence asset. Therefore, national maize production gains do not automatically ensure household-level food security in borderland communities (Silaen et al., 2023; BPS-Statistics Indonesia, 2025).

Agricultural extension provides an institutional mechanism for connecting scientific knowledge, experiential learning, and collective action. In this study, extension is understood not merely as technical information transfer but as a facilitative, motivational, and organizational process that helps farmers solve production problems, coordinate group action, access knowledge, and improve maize-based food-management practices. Evidence shows that extension and advisory services are associated with household welfare, food consumption, dietary diversity, and technology adoption when services are responsive to farmers' livelihood conditions (Aremu et al., 2025; Salam et al., 2024). Evidence from Indian Journal of Extension Education further supports this view, showing that extension contact was associated with food and nutrition security among farm households, while maize growers' marketing behavior was linked to planning, production, market information, extension contacts, and social participation (Gautam & Jha, 2022; Prasanna et al., 2024).

Farmer motivation is central because extension advice contributes to household outcomes only when farmers are willing and able to translate it into farming, storage, consumption, and livelihood decisions. Drawing on the ERG-based motivation framework described in contemporary organizational motivation literature, farmer motivation is conceptualized through existence, relatedness, and growth needs (Gibson et al., 2012). Existence needs reflect household food and income security, relatedness needs reflect social cooperation and farmer-group participation, and growth needs reflect learning, innovation, and improvement aspirations. These dimensions are relevant in semi-arid systems because farmers face livelihood risks, climate pressure, resource limitations, and food-security uncertainty (Swami et al., 2024; Touch et al., 2024). In addition, achievement motivation and management orientation have been shown to contribute significantly to occupational diversification among farmers, indicating that internal drive and managerial readiness are important behavioral resources for livelihood improvement (Jayasingh & Mishra, 2024). Therefore, motivation is treated in this study as a key internal condition that may strengthen farmers' capacity to use extension support for improving maize-based household food security.

Despite growing evidence on extension, farmer motivation, and smallholder food security, these components are often examined separately. Limited empirical attention has been given to how extension roles and ERG-based farmer motivation jointly explain maize-based household food security in semi-arid borderland farming systems. This is a conceptual gap because food security is shaped by external institutional support and farmers' internal readiness to secure food, cooperate socially, and improve food-management practices. This study examines two hypotheses: H1, the Role of Agricultural Extension is positively associated with maize-based household food security; and H2, farmer motivation is positively associated with maize-based household food security. By integrating extension roles, ERG-based motivation, and household food-security dimensions, the study contributes to a context-sensitive explanation of food security in semi-arid borderland agriculture.

METHODOLOGY

This study used a quantitative explanatory field design in Kupang, South Central Timor, and North Central Timor districts, East Nusa Tenggara Province, Indonesia, which represent semi-arid maize-farming areas along the Indonesia–Timor Leste border. The population comprised smallholder maize farmers whose livelihoods depended mainly on maize production. Systematic random sampling selected 300 respondents, and 244 valid cases were retained after excluding incomplete questionnaires and multivariate outliers. Data were collected from February to August 2025 using a structured questionnaire administered through face-to-face interviews. Participation was voluntary, informed consent was obtained, and respondent identities were anonymized. The final sample was adequate for CB-SEM, providing 24.4 cases per observed indicator.

The questionnaire was derived from a broader field instrument on maize farming, agricultural extension, farmer motivation, and household food security in Atoin Meto communities. This SEM analysis retained three latent constructs. The Role of Agricultural Extension was measured using 20 items grouped into facilitator-educator, technical-motivational, and organizer-linking roles, adapted from extension role frameworks (Wossen et al., 2017; Salam et al., 2024; Aremu et al., 2025). Farmer motivation was measured using 20 items grouped into existence, relatedness, and growth needs, based on Alderfer's ERG Theory studies (Gibson et al., 2012). Maize-based household food security was measured using 34 items grouped into availability, accessibility, stability, and utilization, adapted from FAO's food-security dimensions and household food-insecurity measurement (Coates et al., 2007; FAO, 2008). For SEM analysis, item scores were aggregated into 10 dimension-level composite indicators representing the three latent constructs. Agricultural extension and food-security items used a five-point frequency scale ranging from 1 = never to 5 = very frequent, while farmer-motivation items used a five-point willingness scale ranging from 1 = strongly unwilling to 5 = strongly willing.

Data were analyzed using IBM SPSS AMOS. CB-SEM with maximum-likelihood estimation was applied because the study tested a theoretically specified model and covariance relationships among latent constructs (Byrne, 2016; Kline, 2016). Data screening covered incomplete responses, multivariate outliers, and distributional assumptions. Confirmatory factor analysis assessed standardized loadings, squared multiple correlations, construct reliability, average variance extracted, discriminant validity, and model fit. Convergent validity was evaluated using loadings, construct reliability, and average variance extracted, while discriminant validity was assessed using the Fornell–Larcker

criterion, maximum shared variance, and average shared variance (Fornell & Larcker, 1981; Hair et al., 2021). The structural model estimated paths from agricultural extension and farmer motivation to household food security and the covariance between the exogenous constructs. Common method bias was reduced through anonymity, neutral wording, and construct separation, and was checked using Harman's single-factor test (Podsakoff et al., 2003).

RESULTS

Before evaluating the measurement and structural models, descriptive analysis was conducted to provide an initial overview of household food security, farmer motivation, and the Role of Agricultural Extension in the study area. This step was important to contextualize the empirical conditions of the main constructs before testing their statistical relationships in the SEM model.

As shown in Table 1, household food security was in the moderate/occasional category overall, with availability showing the highest score and stability showing the lowest score. This pattern indicates that maize availability after harvest was relatively strong, but year-round food stability, dietary utilization, and household purchasing capacity remained fragile. Farmer motivation was generally categorized as willing, although growth needs scored lower than existence and relatedness needs. This suggests that farmers' immediate concern for food and income security, as well as social cooperation, was stronger than their motivation for learning, innovation, and long-term improvement. The Role of Agricultural Extension was categorized as frequent, but the motivator role scored lower than the facilitator and organizer roles. These results indicate that extension services were present in the study area, yet they still need to strengthen motivational and organizational functions to support household food planning, maize stock management, post-harvest handling, and risk preparation.

These descriptive patterns support the need for structural analysis because the presence of extension services does not automatically translate into stronger food-security stability or growth-oriented motivation. Therefore, the SEM analysis examined how agricultural extension roles and farmer motivation were statistically associated with maize-based household food security, consistent with evidence that extension outcomes depend on farmers' livelihood conditions and their motivation to apply advisory support (Aremu et al., 2025; Swami et al., 2024).

Measurement model

Confirmatory factor analysis was conducted before structural interpretation to ensure that the latent constructs were measured adequately. Figure 1 presents the CFA measurement model, where rectangles represent observed indicators, ellipses represent latent constructs, and one-headed arrows represent standardized factor loadings. The figure shows that all observed indicators loaded strongly on their respective constructs, while the correlations among latent constructs indicate theoretically meaningful relationships without eliminating construct separation.

Figure 1 presents the CFA measurement model, showing that the Role of Agricultural Extension was represented by facilitator, motivator, and organizer roles; farmer motivation by existence, relatedness, and growth needs; and household food security by availability, accessibility, utilization, and stability. The CFA results showed strong standardized loadings for all indicators, ranging from 0.79 to 0.95 (Table 2). Extension indicators loaded between 0.93 and 0.95, farmer-motivation indicators between 0.90 and 0.94, and household food-security indicators between 0.79 and 0.87. These values exceeded commonly recommended thresholds and supported convergent validity (Kline, 2016; Hair et al., 2021).

The CFA results address the reviewer's concern about weak indicators. In the revised model, all indicators were retained because each loading was strong and theoretically consistent with its latent construct. This means that the extension construct no longer required cautious interpretation due to marginal measurement quality, and the measurement model provided a stronger basis for structural testing.

Table 3 confirms that all constructs met the recommended reliability and convergent-validity criteria. Construct reliability values were above 0.90, and AVE values exceeded 0.50 for all constructs. Therefore, the revised measurement model resolved the

Table 1. Descriptive statistics of research variables

Construct	Indicator	Mean	Score (%)	Category
Food security	Availability	4.31	86.24	Very frequent
Food security	Accessibility	3.66	73.16	Frequent
Food security	Utilization	3.00	60.08	Occasional
Food security	Stability	2.77	55.48	Occasional
Farmer motivation	Existence needs	3.94	78.73	Willing
Farmer motivation	Relatedness needs	3.66	73.17	Willing
Farmer motivation	Growth needs	2.97	59.49	Hesitant
Role of Agricultural Extension	Facilitator	3.57	71.40	Frequent
Role of Agricultural Extension	Motivator	3.37	67.40	Occasional
Role of Agricultural Extension	Organizer	3.50	70.00	Frequent
Total index	Household food security	3.22	64.36	Occasional
Total index	Farmer motivation	3.43	68.50	Willing
Total index	Role of Agricultural Extension	3.46	69.20	Frequent

Source: Authors' calculation from field survey data, 2025

Note: Score (%) = mean/5 x 100. Categories were based on equal intervals of the five-point scale: 20.00-36.00 = very low/very rare/strongly unwilling; 36.01-52.00 = low/rare/unwilling; 52.01-68.00 = moderate/occasional/hesitant; 68.01-84.00 = high/frequent/willing; and 84.01-100.00 = very high/very frequent/strongly willing. Category labels were adjusted to the construct being interpreted.

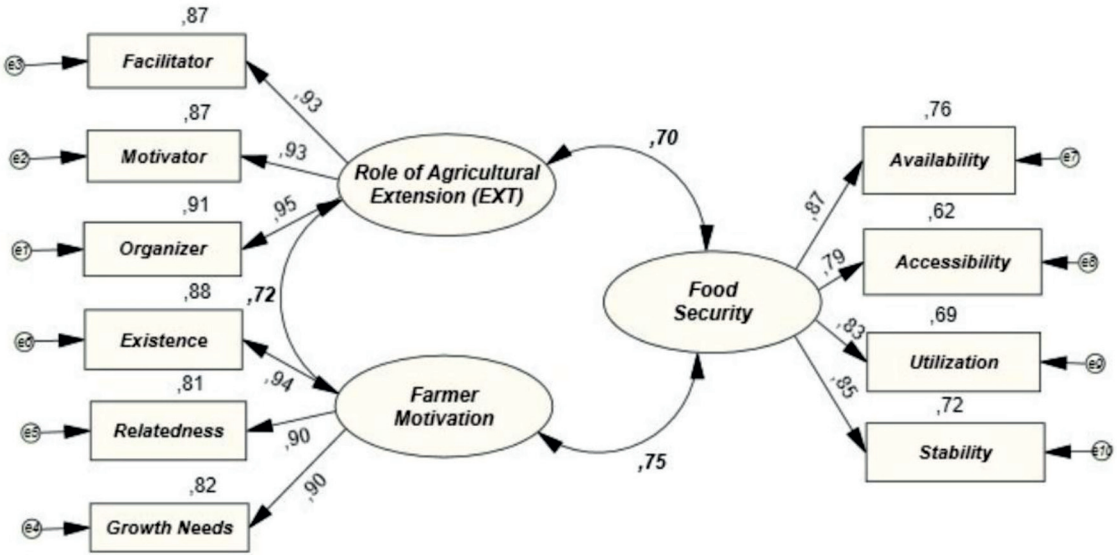

Figure 1. Confirmatory factor analysis measurement model.
Source: AMOS CFA output based on field survey data, 2025.; *Note:* Rectangles denote observed indicators, ellipses denote latent constructs, one-headed arrows denote standardized factor loadings, and curved two-headed arrows denote correlations among latent constructs.

Table 2. CFA standardized loadings and squared multiple correlations

Construct	Indicator	Loading	SMC	Decision
Role of Agricultural Extension	Facilitator	0.93	0.87	Accepted
Role of Agricultural Extension	Motivator	0.93	0.87	Accepted
Role of Agricultural Extension	Organizer	0.95	0.91	Accepted
Farmer motivation	Existence needs	0.94	0.88	Accepted
Farmer motivation	Relatedness needs	0.90	0.81	Accepted
Farmer motivation	Growth needs	0.90	0.82	Accepted
Household food security	Availability	0.87	0.76	Accepted
Household food security	Accessibility	0.79	0.62	Accepted
Household food security	Utilization	0.83	0.69	Accepted
Household food security	Stability	0.85	0.72	Accepted

Source: AMOS CFA output based on field survey data, 2025.
Note: One indicator for each latent construct was fixed to set the measurement scale; therefore, its standard error and critical ratio are not estimated in AMOS.

Table 3. Construct reliability and average variance extracted

Construct	Indicators	CR	AVE	Square root of AVE	Interpretation
Role of Agricultural Extension	3	0.956	0.877	0.937	Reliable and valid
Farmer motivation	3	0.938	0.835	0.914	Reliable and valid
Household food security	4	0.902	0.698	0.836	Reliable and valid

Source: AMOS CFA output and authors' calculation, 2025.
Note: CR = construct reliability; AVE = average variance extracted. CR >= 0.70 and AVE >= 0.50 indicate adequate reliability and convergent validity (Hair et al., 2021).

earlier concern about the extension construct and provided empirical support that facilitator, motivator, and organizer roles represent the Role of Agricultural Extension in this study.

Tables 4 and 5 show that the three constructs were empirically distinguishable. The square roots of AVE were higher than the inter-construct correlations, and AVE values exceeded both MSV and ASV. Although the correlations among EXT, farmer motivation, and food security were relatively high, the discriminant-validity results indicate that the constructs were related but not redundant. This supports the substantive argument that extension roles and farmer

Table 4. Fornell-Larcker discriminant-validity matrix

Construct	EXT	Farmer motivation	Food security
EXT	0.937		
Farmer motivation	0.72	0.914	
Food security	0.70	0.75	0.836

Source: AMOS CFA output and authors' calculation, 2025.
Note: Diagonal values are the square roots of AVE. Discriminant validity is supported when each diagonal value is greater than the relevant inter-construct correlations (Fornell & Larcker, 1981).

Table 5. AVE, MSV, and ASV for discriminant validity

Construct	AVE	MSV	ASV	Interpretation
Role of Agricultural Extension	0.877	0.518	0.504	Satisfied
Farmer motivation	0.835	0.562	0.540	Satisfied
Household food security	0.698	0.562	0.526	Satisfied

Source: AMOS CFA output and authors' calculation, 2025.
Note: MSV = maximum shared variance; ASV = average shared variance. Discriminant validity is supported when AVE exceeds MSV and ASV for each construct (Hair et al., 2021).

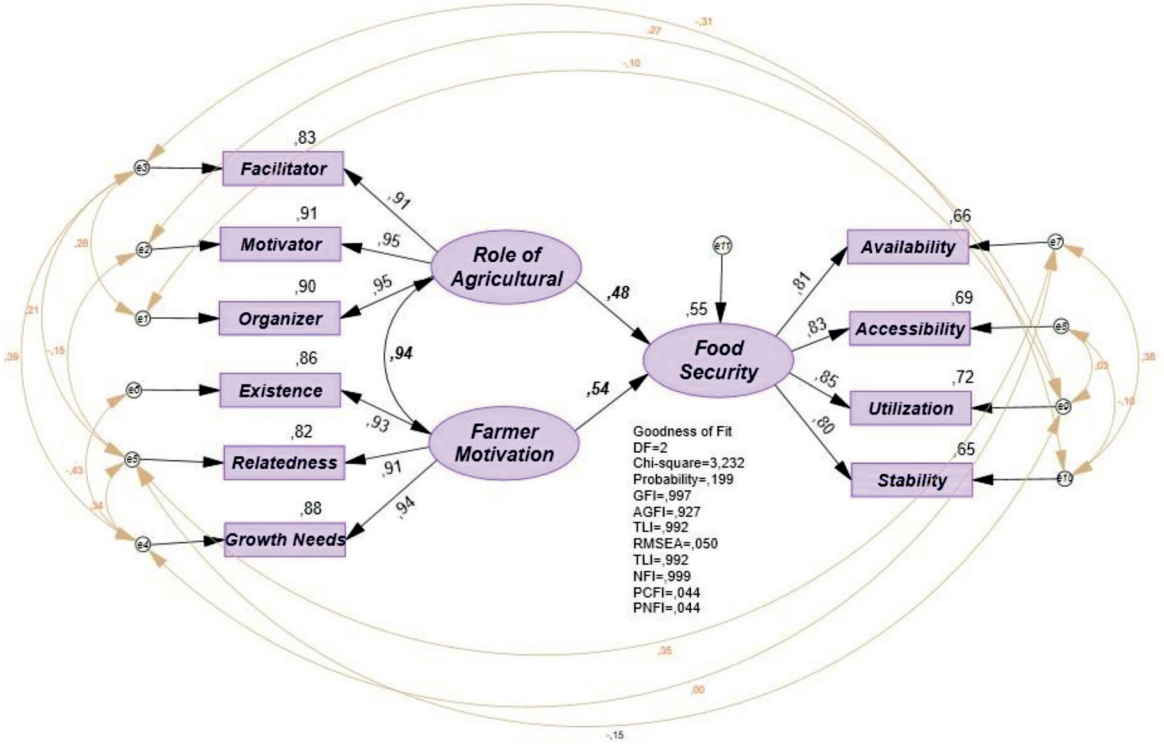

Figure 2. Final structural model after re-specification
Source: AMOS structural-model output based on field survey data, 2025.; *Note:* The diagram reports standardized estimates from the final model. Curved arrows represent covariance or residual-covariance adjustments among conceptually related indicators. Because the data are cross-sectional, the structural paths are interpreted as statistical associations rather than causal effects.

motivation are complementary but conceptually distinct components in explaining household food security.

Structural model and hypothesis testing

After theoretically defensible residual-covariance adjustments supported by model diagnostics and measurement logic, the final structural model was retained for hypothesis testing. The model specifies two direct paths to maize-based household food security: the path from the Role of Agricultural Extension and the path from farmer motivation. As shown in Figure 2, both paths were positive, and the model explained 55.0% of the variance in household food security, indicating moderate explanatory power for a household-level outcome shaped by ecological, economic, institutional, and behavioral factors.

The final model showed acceptable fit across absolute, incremental, and residual-based indices. However, because the model had only two degrees of freedom after respecification, the fit indices were interpreted cautiously and were not treated as evidence of a perfect model. Therefore, model adequacy was assessed using the combined evidence from several fit indices rather than relying on a single statistic. The detailed goodness-of-fit results are reported in Table 6.

The final model explained 55.0% of the variance in household food security and showed acceptable fit across absolute, incremental, and residual-based indices. Because the respecified model had only two degrees of freedom, fit indices and parsimony values were interpreted cautiously. The model was retained because the respecification was theoretically defensible, the measurement model was reliable and valid, and the structural paths were consistent with the hypotheses. Given the cross-sectional design, the paths were interpreted as statistical associations rather than causal effects. Hypothesis testing based on AMOS estimates showed that both hypothesized paths were positive and statistically significant at the 5% level (Table 7).

H1 was supported because the Role of Agricultural Extension was positively and significantly associated with household food

Table 6. Goodness-of-fit indices for the initial and final structural models

Index	Initial model	Final model	Criterion	Interpretation
df	32	2	Information	Degrees of freedom changed after respecification
Chi-square	327.130	3.232	p > 0.05	Substantial improvement
χ^2/df	10.223	1.616	d" 3.00	Fit in the final model
Probability	0.000	0.199	p > 0.05	Fit in the final model
GFI	0.759	0.997	>= 0.90	Fit in the final model
AGFI	0.586	0.927	>= 0.90	Fit in the final model
TLI	0.876	0.992	>= 0.90/0.95	Fit in the final model
RMSEA	0.195	0.050	<= 0.08	Fit in the final model
CFI	0.911	0.999	>= 0.90/0.95	Fit in the final model
NFI	0.904	0.994	>= 0.90	Fit in the final model
PCFI	0.648	0.044	Parsimony index	Low because df = 2
PNFI	0.642	0.044	Parsimony index	Low because df = 2
R2 food security	0.44	0.55	Higher value indicates greater explained variance	Explanatory power increased

Source: AMOS structural-model output based on field survey data, 2025.
Note: Fit indices were obtained from AMOS. The initial model was a benchmark, and the final model was used for hypothesis testing. Fit indices were interpreted cautiously because df = 2.

Table 7. Structural path estimates and hypothesis testing

Hypothesis	Structural path	Estimate	S.E.	C.R.	p-value	Standardized beta	Decision
H1	EXT -> food security	0.317	0.132	2.405	0.016	0.485	Accepted
H2	Farmer motivation -> food security	1.413	0.507	2.789	0.005	0.541	Accepted

Source: AMOS structural-model output based on field survey data, 2025.
Note: S.E. = standard error; C.R. = critical ratio. A p-value below 0.05 indicates a statistically significant association. The standardized beta values were used to compare the relative strength of the two paths.

security (standardized beta = 0.485; C.R. = 2.405; p = 0.016). This indicates that stronger extension roles as facilitator, motivator, and organizer were associated with higher maize-based household food security after accounting for farmer motivation. Substantively, extension contributes to food security by supporting problem solving, farmer-group coordination, access to relevant knowledge, and improved maize-farming and food-management practices. This finding is consistent with evidence that agricultural extension and advisory services are linked to household welfare, food consumption, dietary diversity, and technology adoption when services are responsive to farmers' livelihood conditions (Wossen et al., 2017; Rejula et al., 2017; Aremu et al., 2025; Salam et al., 2024).

H2 was also supported because farmer motivation was positively and significantly associated with household food security (standardized beta = 0.541; C.R. = 2.789; p = 0.005). The higher standardized coefficient indicates that motivation had a slightly stronger direct association with food security than extension. This suggests that household food security is shaped not only by external advisory support but also by farmers' internal readiness to secure food, cooperate socially, and improve farming and food-management practices. Existence needs may strengthen food and income security, relatedness needs may support cooperation through farmer groups, and growth needs may encourage learning, innovation, post-harvest improvement, and better household food management. This interpretation aligns with evidence that intrinsic motivation, perceived usefulness, institutional support, and knowledge capability influence farmers' willingness to adopt sustainable and adaptive agricultural practices (Gibson et al., 2012; Swami et al., 2024).

DISCUSSION

Overall, the findings show that maize-based household food security in the Indonesia–Timor Leste borderlands was associated with both agricultural extension and farmer motivation. Although extension services were perceived as relatively active, lower scores for food-security stability and growth motivation indicate that extension support has not been fully translated into year-round food stability and growth-oriented food-management behavior. Therefore, extension in semi-arid borderland systems should move beyond general technical advice and become more closely linked to maize stock management, post-harvest handling, household food planning, savings behavior, and dietary diversification. This interpretation is consistent with evidence that agricultural extension and advisory services improve household welfare, food consumption, dietary diversity, and farm outcomes when they are responsive to farmers' livelihood conditions and supported by farmer engagement, family resources, input use, and crop-management capacity (Salam et al., 2024; Aremu et al., 2025). It is also supported by evidence that household food and nutrition security is associated with resource-related and informational factors, including extension contact, and that maize growers require practical education, training, market information, and improved market access to strengthen production and marketing decisions (Gautam & Jha, 2022; Prasanna et al., 2024).

The stronger standardized association of farmer motivation with household food security provides the main conceptual contribution of this study. It suggests that advisory services are more meaningful when farmers have internal readiness to secure staple food, cooperate socially, and improve farming and household food-management practices. Existence needs strengthen concern for food and income security, relatedness needs support cooperation and mutual assistance, and growth needs encourage learning, innovation, post-harvest improvement, and dietary diversification. This finding supports studies showing that intrinsic motivation, perceived usefulness, institutional support, and knowledge capability influence farmers' adoption of sustainable and adaptive practices (Nain et al., 2007; Swami et al., 2024). It also aligns with evidence that achievement motivation and management orientation significantly contribute to farmers' occupational diversification, indicating that internal drive and managerial capacity are relevant for strengthening livelihood strategies (Jayasingh & Mishra, 2024). In semi-arid borderland households, food-security programs should therefore combine extension services with motivation-oriented strategies, particularly farmer-group learning, household food planning, maize storage improvement, cooperative support, and practical post-harvest management. Given the cross-sectional design, these implications should be interpreted as evidence-based associations rather than causal effects.

This study has several limitations. First, the cross-sectional design limits causal interpretation; therefore, the reported paths should be understood as statistical associations rather than definitive causal effects. Second, the use of self-reported questionnaire data may introduce recall bias and social desirability bias. Third, although model respecification improved the fit of the retained model, the modified structure requires further validation using independent samples, longitudinal data, or mixed-method designs. Finally, HTMT was not reported; however, discriminant validity was assessed using the Fornell–Larcker criterion and the AVE–MSV–ASV comparison, and future studies may complement these procedures with HTMT using item-level correlation matrices.

CONCLUSION

Agricultural extension and farmer motivation were positively and significantly associated with maize-based household food security among smallholder maize farmers in the semi-arid Indonesia–Timor Leste borderlands. Extension contributed through its facilitative, motivational, and organizational roles in supporting problem solving, farmer-group coordination, access to knowledge, and household food-management practices. Farmer motivation showed a slightly stronger direct association, indicating that food security is strengthened not only by external institutional support but also by farmers' internal readiness to secure staple food, cooperate socially, and pursue learning-oriented improvement. The study advances an integrated extension–motivation–food security model and extends the relevance of existence, relatedness, and growth needs to smallholder food-security research in vulnerable agrarian settings. Practically, food-security strategies in semi-arid borderlands should combine extension services with motivation-oriented approaches, especially farmer-group facilitation, post-harvest management, household food planning, and cooperative learning. Given the cross-sectional design, the findings indicate statistical associations rather than causal effects.

DECLARATIONS

Research ethics statement: The study protocol was reviewed and approved by the Research Ethics Committee of the Academic Hospital of Universitas Gadjah Mada (RSA UGM), Yogyakarta, Indonesia, under Ethical Clearance Number 032/RSA/KEP/EC/2026. The ethical review covered the research proposal, participant information sheet, and research questionnaire. The study was authorized in accordance with relevant national research ethics principles and the Guidelines and Standards for Research Ethics and National Health Development issued by the Ministry of Health of the Republic of Indonesia in 2021. Participation was voluntary, informed consent was obtained from all respondents before the interviews, and respondent identities were anonymized throughout data processing and reporting.

Conflict of interest: The authors declare that they have no conflict of interest. The research was conducted without any commercial, financial, or personal relationships that could be interpreted as influencing the design, implementation, analysis, interpretation, or reporting of the study.

Author contributions: Musa Frengkianus Banunaek contributed to conceptual development, field investigation, data collection, data curation, formal analysis, and preparation of the initial manuscript draft. Siti Andarwati contributed to methodology, validation, supervision, manuscript review, and editing. Sunarru Samsi Hariadi contributed to conceptualization, methodological guidance, validation, supervision, manuscript review, and editing. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for the accuracy and integrity of the work.

Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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