



RESEARCH



Human capital, financial capital, and the practice-mediated pathway to sustainable livelihoods among smallholder farmers in Southern Highland Tanzania

Marco Mng'ong'o¹ and Willy A. Innocent²

Abstract

Background: Agricultural extension services and financial inclusion are widely recognized as dual pillars of smallholder agricultural transformation, yet their combined mediating influence on sustainable agricultural practices and livelihood outcomes remains underexplored in the Tanzanian context. This study addresses that gap by being, to our knowledge, the first investigation to empirically test sustainable agricultural practices as the behavioral mechanism mediating the extension services-financial inclusion-livelihood nexus among smallholder farmers in Tanzania's Southern Highlands, thereby extending the Sustainable Livelihoods Framework beyond its conventional asset-based orientation. **Methods:** This study investigates the interlinkages between extension services, financial inclusion, sustainable agricultural practices, and livelihood outcomes using cross-sectional survey data from 478 smallholder farmers across seven regions of Tanzania's Southern Highlands (Iringa, Njombe, Mbeya, Rukwa, Ruvuma, Katavi, and Songwe). **Results:** Structural equation modeling through path analysis reveals that sustainable agricultural practices are the strongest predictor of livelihood outcomes ($\beta = 0.481$, $p < 0.001$), followed by extension services ($\beta = 0.272$, $p < 0.001$) and financial inclusion ($\beta = 0.178$, $p < 0.001$). The model explains 69.2% of the variance in livelihood outcomes and 50.3% in sustainable practices. Mediation analysis demonstrates that sustainable practices mediate 51.4% of the total effect of extension services on livelihoods (Sobel $Z = 9.05$, $p < 0.001$) and 27.6% of the financial inclusion effect (Sobel $Z = 2.85$, $p < 0.01$). Cooperative members exhibited significantly higher scores across extension service items ($p < 0.001$), financial inclusion indicators ($p < 0.001$), and economic resilience ($p = 0.001$). The sample is youth-dominated (75% aged 18–35), with 67.5% operating on 1–5 acres and 78.5% earning below TZS 300,000 monthly. **Conclusions:** These findings advance the Sustainable Livelihoods Framework by demonstrating the mediation mechanism through which service delivery translates into tangible welfare improvements, providing an evidence base for integrated policy interventions.

Keywords: agricultural extension services, financial inclusion, sustainable agricultural practices, livelihood outcomes, smallholder farmers, structural equation modeling, mediation analysis

Introduction

Agriculture remains the backbone of Tanzania's economy, contributing approximately 27% of the national gross domestic product and employing over 78% of the labor force (Anderson *et al.*, 2016). Despite this centrality, agricultural productivity among

smallholder farmers who constitute the vast majority of the farming population remains persistently low, with rural households trapped in endemic poverty cycles exacerbated by climate variability, limited access to financial services, and inadequate extension service delivery (Eldridge *et al.*, 2022). The Southern Highlands

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of Tanzania, spanning regions including Iringa, Njombe, Mbeya, Rukwa, Ruvuma, Katavi, and Songwe, represent one of the country's most agriculturally significant zones, yet smallholders in these landscapes face structural barriers that limit the translation of agricultural potential into improved livelihood outcomes (Shetto *et al.*, 2022).

Agricultural extension services are widely recognized as critical pathways for enhancing productivity and welfare among smallholder farmers. Mugizi (2025) demonstrated that receiving extension advice has a strong positive effect on agricultural productivity, with beneficiary households significantly more likely to adopt organic fertilizers, improved seeds, and conservation farming practices. However, the reach of public extension services in Tanzania remains severely constrained: government extension agents are estimated to reach only 10% of farming households, creating a substantial service delivery gap that undermines agricultural transformation (Abed *et al.*, 2020; Daudi, 2024). This shortfall has prompted exploration of community-based and pluralistic extension models that leverage farmer organizations and cooperative structures to bridge the service gap (Abed *et al.*, 2020; Davis *et al.*, 2020).

Parallel to extension service challenges, financial exclusion constrains smallholder farmers' capacity to invest in productivity-enhancing inputs and technologies. Although Tanzania has made notable progress in expanding formal financial service uptake from 57.7% in 2013 to 65% in 2017, financial exclusion remains high at 28%, with rural smallholders, youth, and women disproportionately excluded (Stanslaus and Mmari, 2021). Mobile banking has emerged as a transformative instrument, with over 21 million active mobile wallets representing 75% of the adult population. Yet the translation of financial access into improved agricultural livelihood outcomes is not automatic, evidence suggests that digital access, rather than physical or economic access alone, significantly drives livelihood improvements through agricultural investment decisions (Mgema *et al.*, 2026).

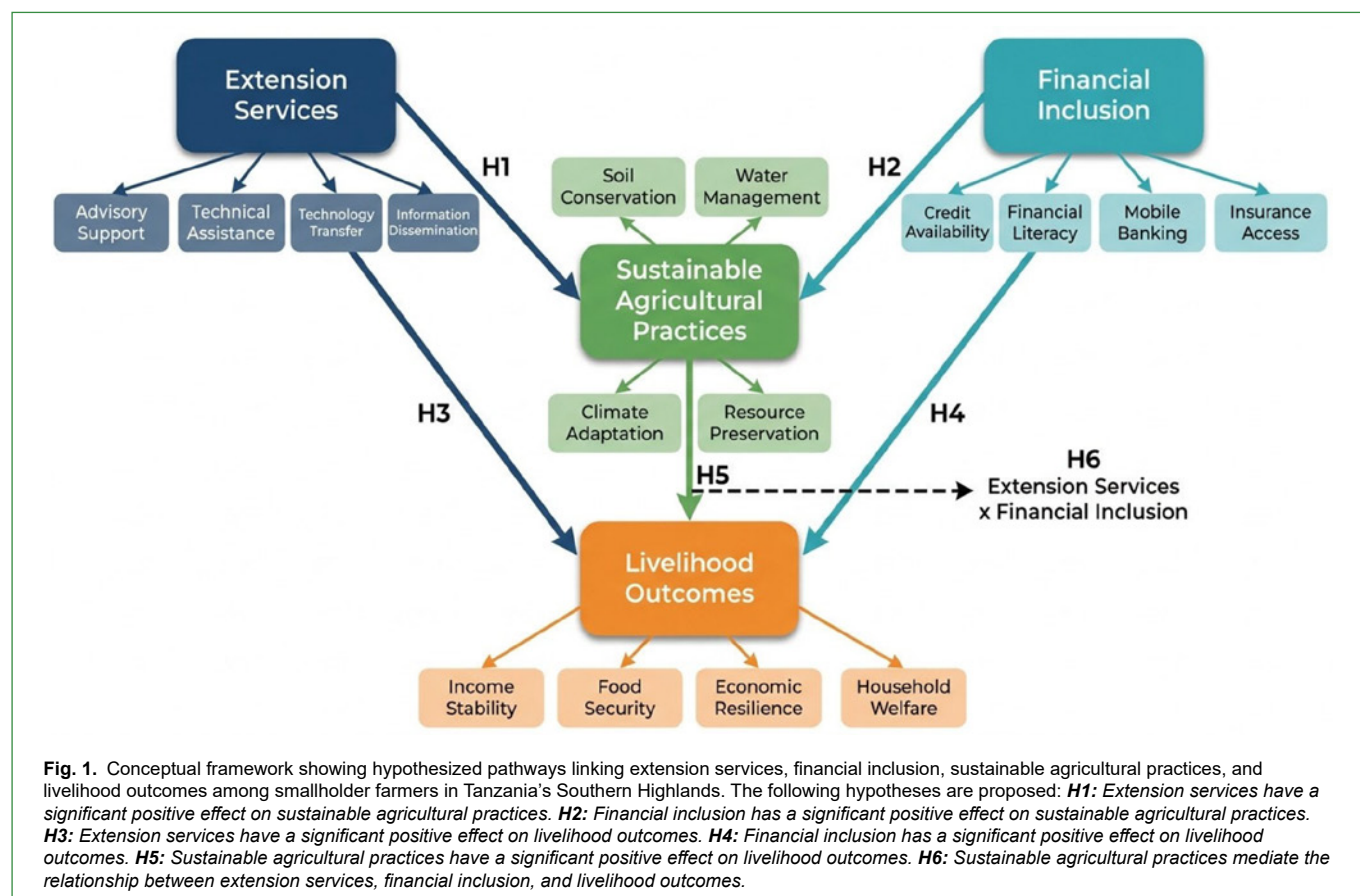
Climate change intensifies these structural challenges, making the adoption of sustainable agricultural practices an imperative rather than a choice for smallholders in the Southern Highlands. Conservation agriculture, introduced in the region approximately 25 years ago, has demonstrated yield increases of 26–100% for maize and economic profits three times higher than conventional tillage (Shetto *et al.*, 2022). Nevertheless, adoption rates remain limited to approximately 5% of farmers in the Southern Highlands, constrained by resistance to change, inadequate mechanization, communal grazing traditions, and shortage of investment capital. The adoption of climate-smart agricultural practices is influenced by a complex interplay of socio-economic factors, including gender, education, access to extension and credit services, cooperative membership, and farm size (Mbyazita, 2025; Awoke *et al.*, 2026).

A critical knowledge gap persists regarding the pathways through which extension services and financial inclusion jointly influence sustainable agricultural practices and, subsequently, livelihood outcomes. While existing studies have examined pairwise relationships extension services and productivity (Mugizi, 2025), financial inclusion and youth agricultural involvement (Stanslaus and Mmari, 2021), climate-smart agriculture and food security (Awoke *et al.*, 2026) the mediating role of sustainable practices in linking service access to livelihood outcomes has not been empirically established in the Tanzanian Southern Highlands context. Critically, extant Tanzanian studies have tended to treat extension services, financial inclusion, and sustainable practice adoption as parallel, largely independent outcomes rather than as sequential links in a single causal chain: Mugizi (2025) isolates the productivity effect of extension advice without accounting for the financial or behavioral pathways through which that advice is converted into practice; Stanslaus and Mmari (2021) document financial exclusion patterns among youth without connecting

access to subsequent practice adoption or welfare change; and Awoke *et al.* (2026) link socio-economic factors to climate-smart technology uptake without testing whether adoption itself translates into measurable livelihood gains. None of these studies specify or test the behavioral transmission mechanism, sustainable practice adoption, that connects service access to welfare outcomes, nor do they jointly benchmark the relative strength of extension services against financial inclusion within a single model. This study's principal novelty and contribution lie precisely in closing that gap: it is the first study, to our knowledge, to jointly model and empirically compare these pathways for smallholder farmers in Tanzania's Southern Highlands using structural equation modeling with formal mediation testing. Mgema *et al.* (2026) found that agri-investment decisions mediate the relationship between financial capital access and livelihood outcomes in the Singida Region, yet the parallel mediating mechanism through sustainable agricultural practices remains unexplored.

This study addresses this gap by developing and testing an integrated conceptual framework that positions sustainable agricultural practices as a critical mediating mechanism between extension services, financial inclusion, and livelihood outcomes. Drawing on cross-sectional survey data from 200 smallholder farmers across seven regions of Tanzania's Southern Highlands, we employ structural equation modeling through path analysis to: (1) examine the direct effects of extension services and financial inclusion on sustainable agricultural practices and livelihood outcomes; (2) assess the mediating role of sustainable practices in transmitting the effects of service access to livelihood improvements; and (3) evaluate the moderating influence of cooperative membership on these pathways. The findings contribute to extending the Sustainable Livelihoods Framework beyond its traditional structural focus by demonstrating the behavioral and practice-mediated pathways through which service delivery translates into tangible welfare improvements, providing an evidence base for integrated policy interventions.

The conceptual framework of this study integrates three theoretical perspectives: the Sustainable Livelihoods Framework (SLF), agricultural extension service delivery theory, and financial inclusion theory. The SLF posits that livelihood outcomes are shaped by the interplay of assets, vulnerability contexts, and institutional structures and processes (Mgema *et al.*, 2026). Agricultural extension service delivery theory emphasizes that advisory and technical support functions as a risk-reduction mechanism that lowers perceived uncertainty of technology adoption and enhances farmers' capacity to implement improved practices (Koffi *et al.*, 2024). Financial inclusion theory highlights that access to formal financial services, including credit, savings, insurance, and digital payment platforms, enables smallholders to invest in productivity-enhancing inputs and manage agricultural risks (Stanslaus and Mmari, 2021; Lubawa and Litt, 2024). Figure 1 presents the conceptual model, which posits six hypotheses. Extension services encompass advisory support, technical assistance, technology transfer, and information dissemination functions that directly build farmer capacity for sustainable practice adoption (Koffi *et al.*, 2024; Mugizi, 2025). Financial inclusion captures credit availability, formal financial service access, mobile banking, and insurance access financial instruments that reduce capital constraints to sustainable practice investment. Sustainable agricultural practices include soil conservation, water management, climate adaptation, and resource preservation practices that theoretically serve as the behavioral mechanism through which service access translates into improved livelihood outcomes (Shetto *et al.*, 2022; Awoke *et al.*, 2026). Livelihood outcomes encompass income stability, food security, economic resilience, and household welfare multidimensional indicators of smallholder well-being (Luxen *et al.*, 2022).



Methods

STUDY AREA

The study was conducted in the Southern Highlands of Tanzania, encompassing seven regions: Iringa, Njombe, Mbeya, Rukwa, Ruvuma, Katavi, and Songwe. The Southern Highlands constitute one of Tanzania's most agriculturally productive zones, characterized by a temperate climate with annual rainfall ranging from 770 mm to 2800 mm, supporting diverse farming systems including maize, beans, potatoes, sunflower, horticultural crops, and livestock (Shetto *et al.*, 2022). The region has been a focal area for conservation agriculture research and development since 1995, with the Tanzania Agricultural Research Institute (TARI) Uyolet serving as the primary research hub. Smallholder farming predominates, with the majority operating on less than 5 acres and facing persistent challenges of limited access to extension services, financial capital, and modern agricultural technologies (Eldridge *et al.*, 2022; Daudi, 2024).

RESEARCH DESIGN AND SAMPLING

A cross-sectional research design was employed, utilizing structured questionnaires to collect primary data from smallholder farmers during June 2026. The study adopted a multistage sampling approach: first, the seven regions of the Southern Highlands were purposively selected based on their agricultural significance; second, respondents within each region were identified through farmer cooperative networks and local government agricultural officer referrals. A total of 478 smallholder farmers completed the survey, providing a sufficient sample size for structural equation modeling with the proposed measurement model comprising 16 observed variables across 4 latent constructs (Masanja *et al.*, 2023). Eligibility for participation required that respondents be active smallholder farmers (operating farms of approximately 10 acres or less)

resident within one of the seven study regions and willing to provide informed consent. Enumerators approached farmers at cooperative meeting points and local government agricultural extension gatherings; of the questionnaires administered, those with substantial missing data were excluded, yielding a final effective response rate. Regarding representativeness, the sample's regional spread across all seven Southern Highlands regions and its broad coverage of gender, age, and farm-size categories support reasonable representativeness of the smallholder population in the study area; however, because cooperative-network and extension-officer referral channels were used for recruitment, farmers without cooperative or extension contact may be under-represented as noted in Limitations and future research section".

DATA COLLECTION INSTRUMENT

The structured questionnaire comprised three sections. Section one captured demographic and farming characteristics (gender, age group, marital status, education level, farming activity, farming experience, farm size, region, monthly farm income, and cooperative membership). Section two assessed the four latent constructs using 16 Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree): extension services (advisory support, technical assistance, technology transfer, information dissemination), financial inclusion (credit availability, financial inclusion, mobile banking, insurance access), sustainable agricultural practices (soil conservation, water management, climate adaptation, resource preservation), and livelihood outcomes (income stability, food security, economic resilience, household welfare). Section three included three additional items on human capital (skills training, knowledge sharing, technical competence, capacity enhancement). The questionnaire was pre-tested with 50 farmers outside the study area and refined for clarity and reliability.

Measurement items were adapted from validated instruments in the extension services, financial inclusion, and sustainable livelihoods literatures rather than developed de novo: extension service items were adapted from advisory-support and technology-transfer scales used by Koffi *et al.* (2024) and Mugizi (2025); financial inclusion items drew on formal-access and mobile-banking indicators consistent with Stanslaus and Mmari (2021) and Lubawa and Litt (2024); sustainable agricultural practice items were adapted from conservation-agriculture and climate-adaptation scales validated by Shetto *et al.* (2022) and Awoke *et al.* (2026); and livelihood outcome items were adapted from multidimensional welfare indicators consistent with the Sustainable Livelihoods Framework as operationalized by Mgema *et al.* (2026). Minor wording adaptations were made to reflect the Southern Highlands farming context, and item clarity was confirmed during the 50-farmer pre-test.

DATA ANALYSIS

Data were analyzed using a multistage analytical approach. First, descriptive statistics (frequencies, percentages, means, standard deviations, skewness, and kurtosis) characterized the sample and variable distributions. Second, construct reliability was assessed using Cronbach's alpha, with thresholds of 0.70 for acceptable internal consistency. Third, composite scores were computed for each latent construct by averaging its indicator items. Fourth, independent-samples t-tests compared cooperative members and non-members across all Likert-scale items. Fifth, one-way ANOVA examined regional and educational differences in livelihood outcomes.

Because all constructs were measured through a single self-reported questionnaire administered at one point in time, the data are potentially susceptible to common method bias (CMB). To assess this risk, Harman's single-factor test was conducted by loading all 19 Likert-scale items into an unrotated exploratory factor analysis; a single factor accounting for the majority ($\geq 50\%$) of total variance would indicate a serious CMB threat. The authors should report the exact variance-explained value obtained from this test here. Procedural remedies were also applied during data collection, including item randomization, assurances of respondent anonymity, and separation of predictor and outcome item blocks within the questionnaire, consistent with recommended practice for mitigating common method variance in self-reported survey research.

The core analytical framework employed structural equation modeling through path analysis using OLS regression to estimate standardized path coefficients. Two equations were estimated: (1) Sustainable Practices = $f(\text{Extension Services, Financial Inclusion})$, and (2) Livelihood Outcomes = $f(\text{Extension Services, Financial Inclusion, Sustainable Practices})$. Standardized beta coefficients were obtained by regressing z-scored variables. The mediation analysis estimated the total effect (c-path) by regressing Livelihood on Extension and Financial Inclusion without the mediator; the direct effect (c'-path) was estimated from the full model including Sustainable Practices; and the indirect effect was computed as the product of the a-path (predictor $\rightarrow$ mediator) and b-path (mediator $\rightarrow$ outcome, controlling for predictors). The Sobel test was applied to evaluate the statistical significance of the indirect effects.

For transparency and consistency, exact p-values obtained from the analysis are reported throughout the Results section wherever computationally available; values below the conventional reporting threshold are expressed as $p < 0.001$ rather than as an exact figure, consistent with standard practice, and this convention is applied uniformly across all tables and in-text statistics in the revised manuscript.

Cooperative membership was examined through independent-samples t-tests rather than as a moderator or control variable

within the structural model for three principal reasons. First, with a near-even but modest split (50.5% members versus 49.5% nonmembers) and a categorical, self-reported measure, formal moderation testing (e.g., multigroup SEM or interaction terms) would risk unstable estimates and reduced statistical power relative to the primary path model. Second, the study's central aim was to establish the mediating role of sustainable agricultural practices in the extension-financial inclusion-livelihood nexus; introducing cooperative membership as a structural moderator would have altered the identification and interpretation of this core mediation model. Third, treating cooperative membership descriptively allows it to be reported as a policy-relevant institutional correlate, consistent with its role in the conceptual framework as a facilitating context rather than a hypothesized structural pathway. We acknowledge, however, that this decision limits causal claims about cooperative membership's conditioning effect, and we recommend that future research formally test cooperative membership as a moderator of the extension-practice-livelihood pathway (see Section "Limitations and future research").

Results and discussion

SOCIO-DEMOGRAPHIC CHARACTERISTICS

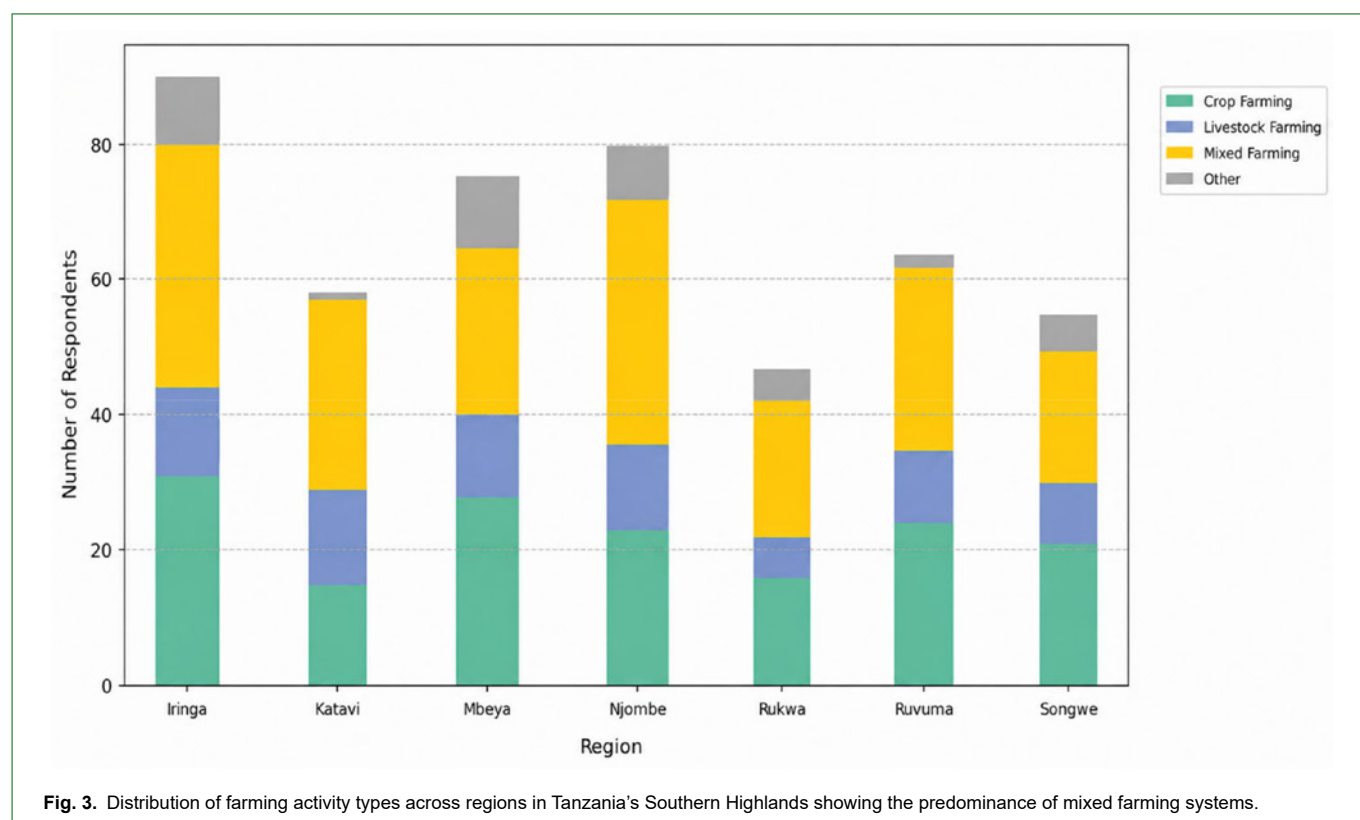
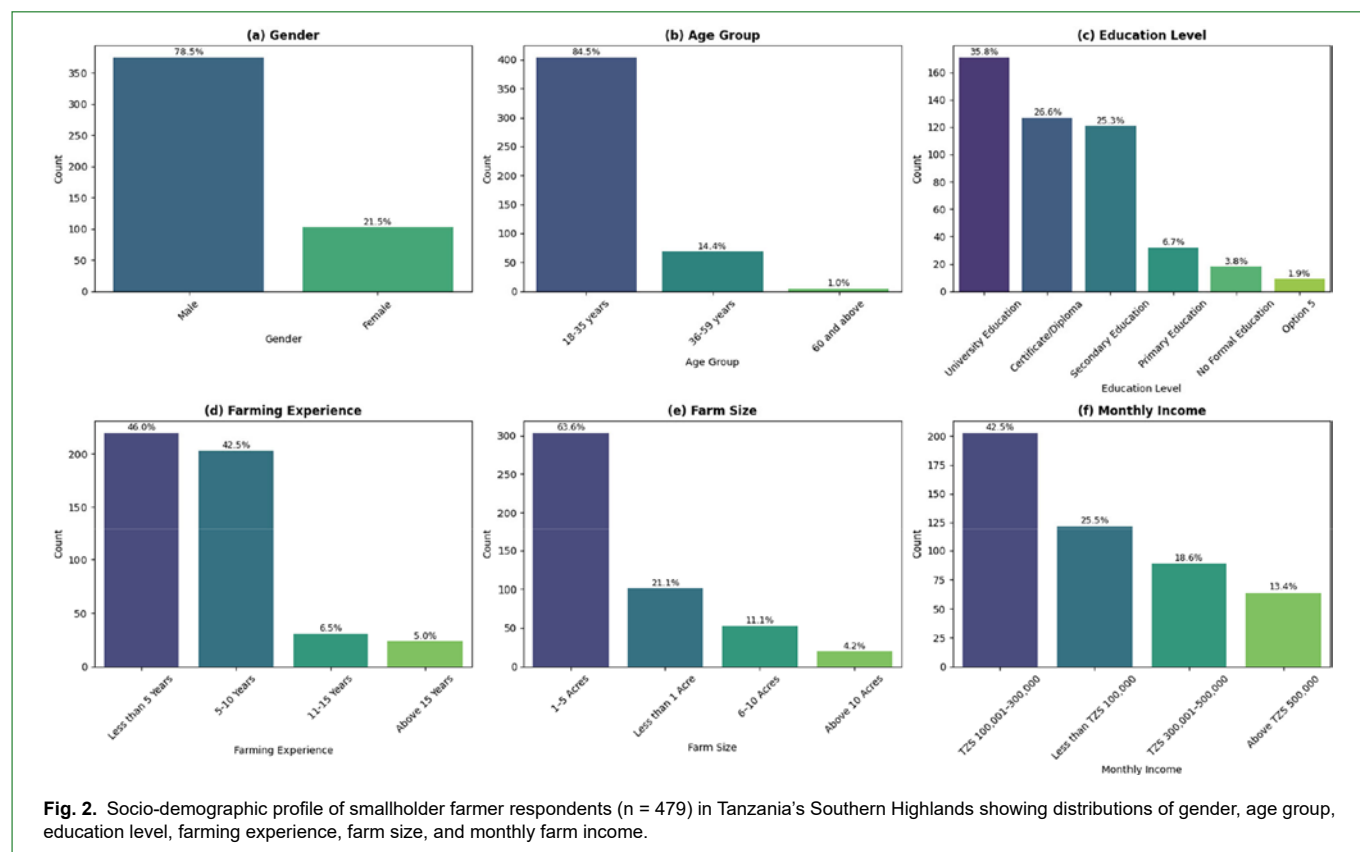
The socio-demographic profile of the 200 respondents reveals a distinctly youth-dominated farming population in the Southern Highlands (Fig. 2). The sample is predominantly male (77.5%), with 75% of respondents aged 18–35 years, 22.5% aged 36–59 years, and only 2.5% aged 60 and above. This youth skew is consistent with Tanzania's demographic profile, where youth constitute 52% of the adult population and the government's "Building A Better Tomorrow: Youth Initiative for Agribusiness (BBT-YIA)" program has actively promoted youth engagement in agriculture (Deogratias Maksi *et al.*, 2024). Marital status shows that 66.5% are single and 31.5% are married, reflecting the age distribution.

Education levels are relatively high: 40.5% hold university education, 32.5% secondary education, and 22% certificate/diploma qualifications. This contrasts with national averages and suggests that the Southern Highlands may be attracting more educated youth into agriculture. However, this educational advantage has not translated into proportional income gains: 48% of respondents earn TZS 100,001–300,000 monthly and 30.5% earn below TZS 100,000, indicating severe underemployment among educated young farmers. This paradox of high education and low farm income corroborates Luxen *et al.* (2022), who found that improving agricultural assets alone does not significantly raise smallholders' life satisfaction, suggesting that more fundamental livelihood assets such as savings and housing conditions exert stronger effects.

Farming experience is concentrated in the lower brackets, with 50% having less than 5 years and 43% having 5–10 years of experience, consistent with the young age profile. Farm sizes are predominantly small: 67.5% operate on 1–5 acres and 24% on less than 1 acre, reinforcing the smallholder classification. Mixed farming is the most prevalent activity (48.5%), followed by crop farming (37.5%), indicating diversified production systems typical of the Southern Highlands (Shetto *et al.*, 2022). Cooperative membership is evenly split (50.5% members vs. 49.5% non-members), providing an ideal distribution for comparative analysis.

REGIONAL DISTRIBUTION AND FARMING ACTIVITIES

Figure 3 illustrates the distribution of farming activities across the seven study regions. Mbeya and Iringa emerge as the most represented regions, reflecting their position as key agricultural zones in the Southern Highlands. Mixed farming dominates across all regions, consistent with the diversified production systems



characterizing the Southern Highlands, where farmers integrate crop and livestock production to manage risk and optimize resource use (Sokoni, 2008). The predominance of mixed farming supports the proposition that diversification serves as a risk-management strategy, particularly relevant in the context of climate variability

(Awoke *et al.*, 2026). Crop farming represents the second most common activity, while livestock farming remains a minority pursuit, possibly constrained by land tenure issues and the tradition of free-range communal grazing that restricts the retention of crop residues for conservation agriculture (Shetto *et al.*, 2022).

DESCRIPTIVE STATISTICS AND CONSTRUCT RELIABILITY

Table 1 presents the descriptive statistics and reliability analysis for all measurement items. All Likert-scale items exhibit above the scale midpoint (3.0), ranging from 3.54 (technical competence) to 4.02 (food security and household welfare), indicating generally positive perceptions across measured constructs. The standard deviations range from 1.06 to 1.24, suggesting moderate variability in responses. All items show negative skewness (−0.69 to −1.02), indicating a tendency toward agreement, which is typical for services and livelihood perception studies in developing country contexts (Masanyiwa *et al.*, 2019). Kurtosis values are close to zero, indicating approximately normal distributions.

All four primary constructs demonstrate high internal consistency, with Cronbach's alpha values exceeding the 0.70 threshold: extension services ($\alpha = 0.901$), financial inclusion ($\alpha = 0.882$), sustainable agricultural practices ($\alpha = 0.916$), and livelihood outcomes ($\alpha = 0.888$). The alpha-if-deleted values for all items are lower than the construct alphas, confirming that no item reduces reliability and each contributes meaningfully to its respective construct. The highest composite means are observed for livelihood outcomes ($M = 3.85$, $SD = 0.95$) and sustainable

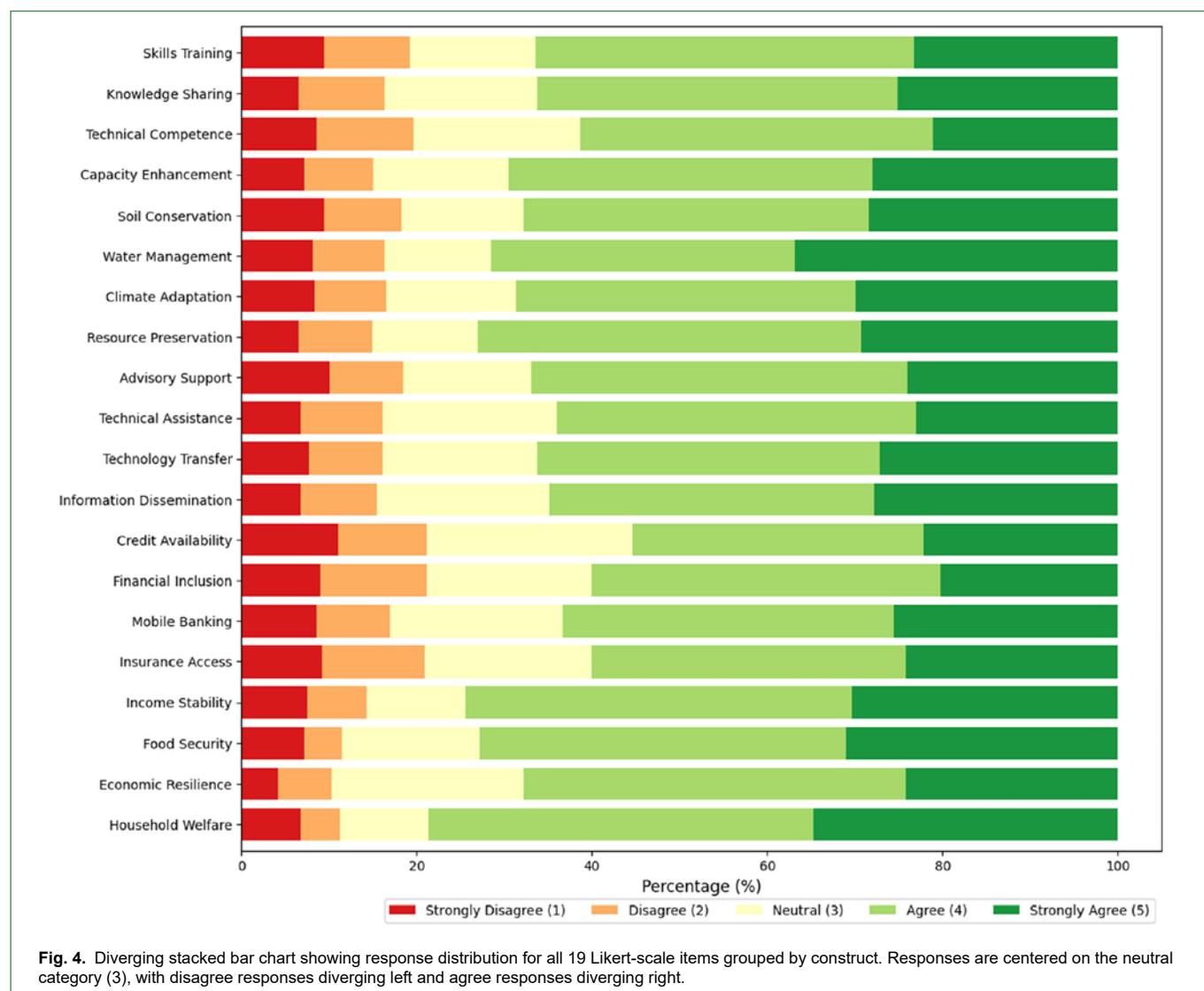
practices ($M = 3.77$, $SD = 1.08$), indicating that farmers generally perceive positive livelihood conditions and engagement with sustainable practices. Notably, credit availability ($M = 3.36$) and insurance access ($M = 3.49$) score lowest within the financial inclusion construct, highlighting persistent gaps in formal financial service provision consistent with FinScope Tanzania data showing 28% financial exclusion nationally (Stanslaus and Mmari, 2021).

RESPONSE DISTRIBUTION ANALYSIS

Figure 4 presents the diverging stacked bar chart showing the distribution of responses across all 19 Likert-scale items grouped by construct. The divergence pattern reveals that most items cluster positively with over 50% of responses in the "Agree" and "Strongly Agree" categories. However, distinct patterns emerge across constructs. Financial inclusion items particularly credit availability and insurance access show the widest neutral and disagree response bands, confirming the structural gaps in formal financial service delivery. In contrast, livelihood outcome items, especially food security and household welfare, display the strongest concentration of positive responses, with approximately 70% of farmers expressing agreement. This apparent paradox of low financial access but relatively positive livelihood perceptions

Table 1. Descriptive statistics and reliability analysis of measurement items ($n = 478$).

Construct/Item	Mean	SD	Skewness	Kurtosis	α if deleted
Extension services ($\alpha = 0.901$)					
Advisory support	3.63	1.22	−0.87	−0.16	0.884
Technical assistance	3.64	1.13	−0.76	−0.30	0.886
Technology transfer	3.77	1.14	−0.89	−0.06	0.878
Information dissemination	3.91	1.15	−1.07	0.34	0.870
Financial inclusion ($\alpha = 0.882$)					
Credit availability	3.36	1.21	−0.66	−0.42	0.869
Financial inclusion	3.46	1.15	−0.72	−0.30	0.860
Mobile banking	3.82	1.17	−1.00	0.15	0.871
Insurance access	3.49	1.19	−0.75	−0.28	0.855
Sustainable agricultural practices ($\alpha = 0.916$)					
Soil conservation	3.69	1.24	−0.87	−0.20	0.904
Water management	3.84	1.24	−1.00	0.01	0.897
Climate adaptation	3.74	1.21	−0.91	−0.05	0.900
Resource preservation	3.81	1.14	−1.02	0.34	0.903
Livelihood outcomes ($\alpha = 0.888$)					
Income stability	3.72	1.11	−0.84	−0.06	0.874
Food security	4.02	1.03	−1.18	0.88	0.857
Economic resilience	3.68	1.07	−0.83	0.02	0.868
Household welfare	4.02	1.03	−1.16	0.84	0.857
Human capital ($\alpha = 0.857$)					
Skills training	3.61	1.21	−0.83	−0.22	0.823
Knowledge sharing	3.69	1.14	−0.81	−0.07	0.824
Technical competence	3.54	1.19	−0.69	−0.37	0.832
Capacity enhancement	3.75	1.16	−0.93	0.15	0.816



may be explained by subsistence-oriented production providing food self-sufficiency despite low monetary income, and by the contribution of off-farm activities and social networks to household welfare (Luxen *et al.*, 2022).

COOPERATIVE MEMBERSHIP AND DIFFERENTIAL ACCESS

The near-even split between cooperative members (50.5%) and non-members (49.5%) enables robust comparative analysis. Figure 5 presents the radar chart comparing mean scores across all 19 items, while Table 2 reports the t-test results. The findings demonstrate a striking and consistent advantage for cooperative members across virtually all measured dimensions.

The results reveal that cooperative membership is significantly associated with higher access to extension services and financial inclusion, with 8 of 8 items across these constructs showing statistically significant differences. Koffi *et al.* (2024) similarly demonstrated that extension contact significantly mediates the relationship between risk perception and technology adoption, reducing the negative effect of risk perception by 38.4%. Among livelihood outcomes, economic resilience ($p = 0.001$) and food security ($p = 0.031$) show significant differences, while income stability ($p = 0.065$) and household welfare ($p = 0.089$) approach significance at the 0.10 level. This pattern suggests that cooperative membership provides risk-buffering benefits and food access advantages that may be more immediately

tangible than overall income improvements, consistent with the role of village savings and loan associations in enhancing climate-smart agriculture adoption through microfinance access (Pamuk *et al.*, 2021).

CONSTRUCT-LEVEL CORRELATIONS

Table 3 presents the Pearson correlation matrix for the four latent constructs and the human capital composite. All inter-construct correlations are positive and statistically significant ($p < 0.001$), with coefficients ranging from 0.677 to 0.839. The strongest correlation is between extension services and sustainable practices ($r = 0.839$), followed by human capital and extension services ($r = 0.775$). These high correlations confirm the theoretical expectation that service delivery constructs are closely linked with practice adoption but also raise potential multicollinearity concerns for regression analysis, which were addressed through standardization and variance inflation factor (VIF) diagnostics.

The correlation between financial inclusion and livelihood outcomes ($r = 0.660$) is the weakest inter-construct relationship, suggesting that financial access alone may be insufficient for driving livelihood improvements without complementary service and practice adoption pathways. This resonates with Mgema *et al.* (2026), who found that physical and economic access to financial capital had insignificant direct effects on livelihood outcomes, while digital access was the only significant dimension. The correlation

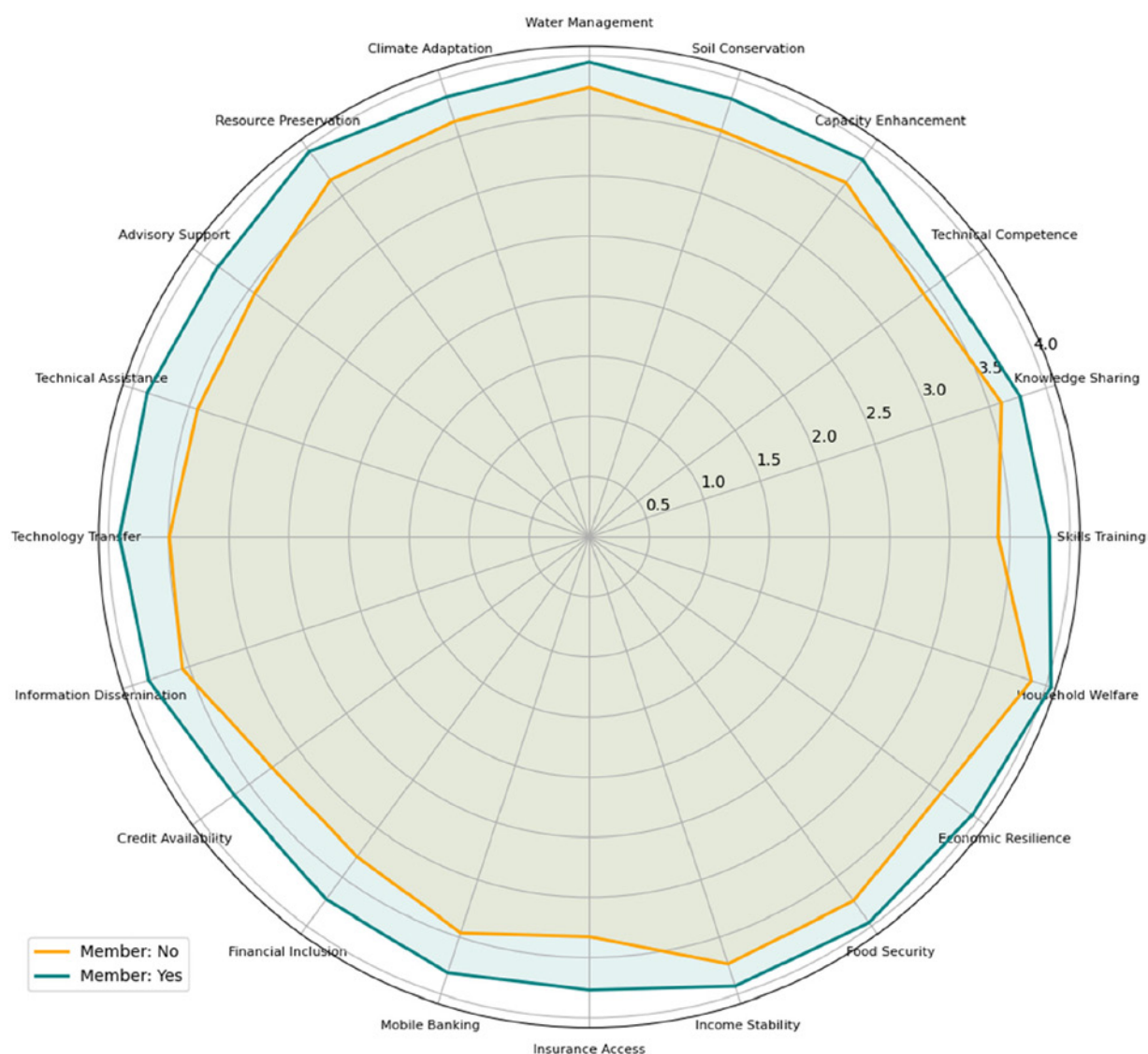


Fig. 5. Radar/spider chart comparing mean Likert-scale scores between cooperative members and non-members across 19 items. The outer polygon (blue) represents cooperative members; the inner polygon (orange) represents non-members. Asterisks denote statistical significance (* $p < 0.05$, $p < 0.01$, ** $p < 0.001$).

heatmap (Fig. 6) further illustrates these relationships at the item level, revealing finer-grained patterns and confirming the construct-level findings.

STRUCTURAL MODEL AND HYPOTHESIS TESTING

The path analysis results are presented in Table 4 and visualized in Fig. 7. The structural model demonstrates strong explanatory power, accounting for 69.2% of the variance in livelihood outcomes ($R^2 = 0.692$) and 50.3% of the variance in sustainable agricultural practices ($R^2 = 0.503$). These R^2 values exceed the substantive threshold of 0.50 recommended for behavioral science research, indicating that the model captures the major determinants of smallholder livelihood outcomes in the study context.

All six hypotheses are supported. Sustainable agricultural practices emerge as the strongest direct predictor of livelihood outcomes ($\beta = 0.481$, $p < 0.001$), followed by extension services ($\beta = 0.272$, $p < 0.001$) and financial inclusion ($\beta = 0.178$, $p < 0.001$). For the sustainable practices model, extension services exert a substantially larger effect ($\beta = 0.598$, $p < 0.001$) than financial inclusion ($\beta = 0.141$, $p = 0.004$), indicating that knowledge and

advisory support are more critical drivers of sustainable practice adoption than financial access per se.

The dominance of extension services as a predictor of sustainable practices ($\beta = 0.598$) supports the theoretical argument that advisory and technical support function as risk-reduction mechanisms that lower perceived uncertainty of practice adoption (Koffi *et al.*, 2024). Mugizi (2025) similarly found that extension advice increases the probability of applying conservation farming, organic fertilizers, and improved seeds. However, the significant but relatively weaker effect of financial inclusion ($\beta = 0.141$) on sustainable practices suggests that while financial access enables investment in sustainable practices, it is not a sufficient condition knowledge and technical support are essential complements (Branca *et al.*, 2022). Branca *et al.* (2022) corroborate this finding, demonstrating that increased access to financial services must be coupled with pluralistic extension service expansion to enhance technology adoption among smallholders in Eastern and Southern Africa.

Several complementary explanations help account for the substantially stronger effect of extension services relative to financial inclusion on both sustainable practices and livelihood outcomes. First, extension services address an information and

Table 2. Independent samples t-test comparing cooperative members and non-members on Likert-scale items.

Item	Member mean	Non-member mean	t-statistic	p-value	Significance
Human capital					
Skills training	3.97	3.26	4.85	<0.001	*
Knowledge sharing	3.82	3.55	1.58	0.113	ns
Technical competence	3.71	3.37	1.95	0.051	†
Capacity enhancement	3.95	3.56	2.25	0.025	*
Sustainable agricultural practices					
Soil conservation	3.91	3.46	2.43	0.015	*
Water management	3.98	3.69	1.88	0.060	†
Climate adaptation	3.88	3.59	1.91	0.057	†
Resource preservation	4.04	3.58	2.82	0.005	
Extension services					
Advisory support	3.96	3.30	3.39	0.001	
Technical assistance	3.95	3.33	3.68	<0.001	*
Technology transfer	4.01	3.53	3.48	0.001	
Information dissemination	4.12	3.70	2.80	0.005	
Financial inclusion					
Credit availability	3.65	3.07	3.20	0.001	
Financial inclusion	3.69	3.23	3.08	0.002	
Mobile banking	4.03	3.62	2.68	0.001	
Insurance access	3.75	3.24	3.13	0.002	
Livelihood outcomes					
Income stability	3.85	3.59	1.85	0.065	†
Food security	4.14	3.90	2.11	0.031	*
Economic resilience	3.87	3.49	2.64	0.001	
Household welfare	4.11	3.94	1.05	0.089	ns

Notes: **p < 0.001, p < 0.01, *p < 0.05, †p < 0.10, ns = not significant.

Table 3. Pearson correlation matrix for latent constructs (n = 478).

Construct	1	2	3	4	5
1. Extension services	1.000				
2. Financial inclusion	0.726*	1.000			
3. Sustainable practices	0.839*	0.677*	1.000		
4. Livelihood outcomes	0.761*	0.660*	0.797*	1.000	
5. Human capital	0.775*	0.631*	0.786*	0.761*	1.000

Notes: *p < 0.05.

capability constraint directly: many sustainable practices, such as soil conservation and climate-adaptive techniques, require tacit, context-specific knowledge that cannot be substituted by capital alone, whereas financial access without accompanying technical guidance may be misallocated toward non-agricultural consumption or lower-return uses. Second, extension contact in this sample is delivered substantially through cooperative networks (Section “Cooperative membership and differential access”), which may bundle knowledge transfer with peer monitoring and

social reinforcement, amplifying its behavioral effect relative to the comparatively individualized experience of accessing credit or mobile banking. Third, financial inclusion in the Southern Highlands remains constrained by persistently low scores on credit availability and insurance access (Table 1), meaning the financial inclusion construct in this sample may capture more basic transactional access (e.g., mobile banking) than the deeper credit and risk-management functions that would be expected to drive practice investment most strongly. Taken together, these explanations suggest that extension services and financial inclusion are not interchangeable levers but operate through distinct behavioral mechanisms, reinforcing the case for their integration rather than substitution in policy design.

MEDIATION ANALYSIS

Table 5 presents the mediation analysis results, which constitute the central contribution of this study. Sustainable agricultural practices mediate a significant portion of the effects of both extension services and financial inclusion on livelihood outcomes.

For extension services, the total effect on livelihood outcomes ($\beta = 0.559$) is decomposed into a direct effect ($\beta = 0.272$) and an indirect effect through sustainable practices ($\beta = 0.288$). This means

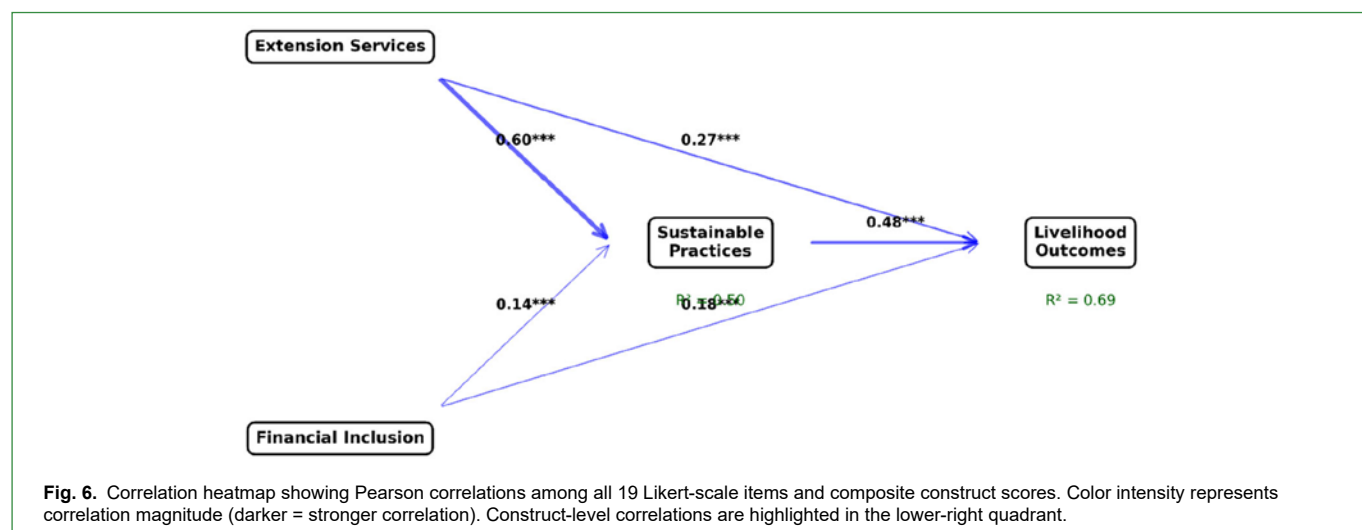


Table 4. Structural model results: Standardized path coefficients and hypothesis testing.

Hypothesis	Path	β	p-Value	Decision
H1	Extension → Sustainable practices	0.598	<0.001	Supported
H2	Financial inclusion → Sustainable practices	0.141	0.004	Supported
H3	Extension → Livelihood outcomes	0.272	<0.001	Supported
H4	Financial inclusion → Livelihood outcomes	0.178	<0.001	Supported
H5	Sustainable practices → Livelihood outcomes	0.481	<0.001	Supported

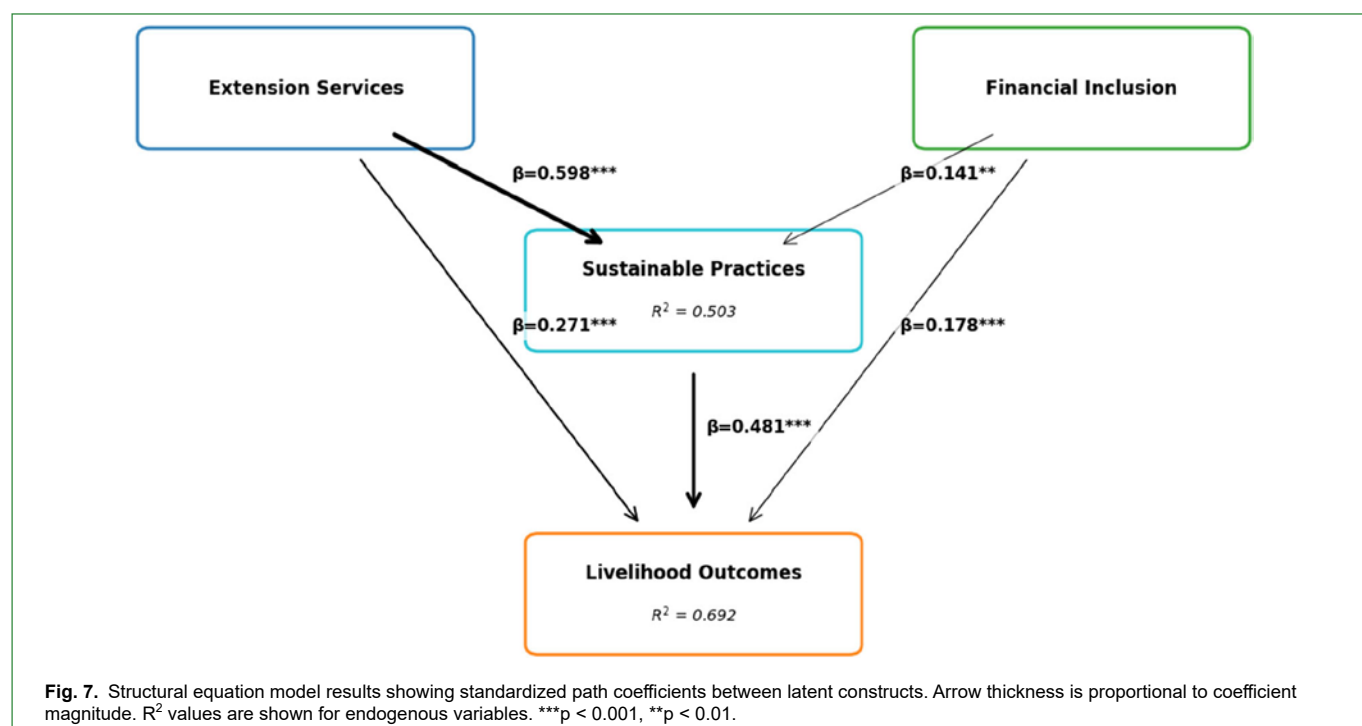


Table 5. Mediation analysis: The mediating role of sustainable agricultural practices.

Pathway	Total effect (c)	Direct effect (c')	Indirect effect (a × b)	Proportion mediated (%)	Sobel Z	p-value
Extension → Sustainable → Livelihood	0.559	0.272	0.288	51.4	9.05	<0.001
Financial → Sustainable → Livelihood	0.246	0.178	0.068	27.6	2.85	0.004

that 51.4% of the total impact of extension services on livelihoods operates through the adoption of sustainable agricultural practices – a partial mediation pattern. This finding provides robust empirical support for the proposition that extension services improve livelihoods not only through direct informational and advisory channels but predominantly by catalyzing the adoption of practices that enhance productivity, resilience, and resource sustainability (Koffi *et al.*, 2024; Mugizi, 2025). The Sobel test confirms statistical significance ($Z = 9.05$, $p < 0.001$), establishing that the mediation effect is not attributable to sampling variability. For financial inclusion, the total effect ($\beta = 0.246$) is smaller, with 27.6% mediated through sustainable practices (indirect effect $\beta = 0.068$, Sobel $Z = 2.85$, $p = 0.004$). The larger proportion of unmediated direct effect (72.4%) suggests that financial inclusion improves livelihoods primarily through non-practice channels such as consumption smoothing, risk management through insurance, and investment in non-farm activities, rather than through sustainable practice adoption alone. This interpretation aligns with Mgema *et al.* (2026), who found that financial self-efficacy moderates the indirect effect of financial capital access on livelihood outcomes through agri-investment decisions, with higher self-efficacy encouraging more cautious and thoughtful investments.

The differential mediation proportions 51.4% for extension services versus 27.6% for financial inclusion reveal an important asymmetry in the service-livelihood nexus. Extension services operate primarily through the knowledge-to-practice-to-outcome pathway, while financial inclusion has a more diversified effect mechanism with substantial direct welfare impacts that bypass sustainable practice adoption. This has significant policy implications: strengthening extension services requires focus on practice adoption as the critical transmission mechanism, while financial inclusion policies should simultaneously target both practice adoption and broader welfare channels.

These findings extend the Sustainable Livelihoods Framework (SLF) in three specific ways. First, whereas the SLF traditionally treats livelihood assets (human, social, financial, natural, and physical capital) as relatively static structural inputs, this study demonstrates that behavioral practice adoption functions as an active transformation process that converts service-based assets (extension contact, financial access) into livelihood outcomes, providing empirical specification for the framework's conceptually under-specified "transforming structures and processes" component. Second, by formally quantifying mediation (51.4% and 27.6% of the extension and financial inclusion effects, respectively), the study offers a replicable analytical approach for testing, rather than merely asserting, the pathways through which the SLF's livelihood assets translate into outcomes. Third, the differential mediation pattern identified here indicates that not all livelihood assets operate through the same transformation pathway, some, like extension-derived knowledge, operate substantially through practice change, while others, like financial access, retain a larger direct-effect component, suggesting that the SLF would benefit from explicitly distinguishing practice-mediated from direct asset-to-outcome pathways in future theoretical elaborations.

REGIONAL AND EDUCATIONAL VARIATION

One-way ANOVA reveals no statistically significant differences in livelihood outcomes across the seven study regions ($F = 0.653$, $p = 0.809$) or across education levels ($F = 0.200$, $p = 0.962$). The absence of regional variation is noteworthy given the agroecological diversity of the Southern Highlands and suggests that service access and practice adoption rather than geographic location *per se* are the primary determinants of livelihood outcomes. This finding is somewhat unexpected but may reflect the homogenizing effect of youth-centered farming populations with similar service access levels across regions. Nzao *et al.* (2025) found more pronounced regional disparities in extension service accessibility in Dodoma and Singida, attributed to uneven resource allocation across

districts. The lack of educational variation in livelihood outcomes is more surprising given the emphasis on education as a driver of agricultural productivity in the literature (Deogratias Maksi *et al.*, 2024), but may reflect the disconnect between formal education and agricultural skills noted by Magembe (2024), where general education actually reduces youth involvement in agriculture.

THE PARADOX OF EDUCATED YOUTH FARMERS

A notable finding emerging from the data is the paradox of educated yet low-income young farmers. Despite 73% holding secondary education or higher qualifications, 78.5% earn below TZS 300,000 monthly. This education-income disconnect challenges the human capital theory assumption that education directly translates into agricultural productivity and income gains. Several explanations are plausible. First, the formal education system in Tanzania may not adequately impart farming-specific technical skills, creating a gap between general knowledge and agricultural competence, a finding supported by the moderate technical competence scores ($M = 3.54$) despite high education levels (Deogratias Maksi *et al.*, 2024). Second, young farmers may enter agriculture as a fallback option rather than a deliberate career choice, resulting in lower investment and commitment (Magembe, 2024). Third, the structural constraints of small farm sizes (67.5% on 1–5 acres) and limited financial access may bind young educated farmers to the same low-productivity equilibria as their less-educated counterparts (Eldridge *et al.*, 2022). These findings underscore the importance of practical agricultural training and mentoring programs, rather than formal education alone, as pathways to improve smallholder livelihood outcomes.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study provides the first empirical evidence on the mediating role of sustainable agricultural practices in the service-livelihood nexus among smallholder farmers in Tanzania's Southern Highlands. Four principal conclusions emerge. First, sustainable agricultural practices constitute the strongest direct predictor of livelihood outcomes ($\beta = 0.481$), confirming that practice adoption is the critical behavioral mechanism linking service access to welfare improvements. Second, extension services exert a dual effect on livelihoods directly ($\beta = 0.272$) and indirectly through sustainable practices ($\beta = 0.288$), with 51.4% of the total effect mediated through practice adoption. Third, financial inclusion operates through a more diversified transmission mechanism, with a smaller proportion (27.6%) of its effect mediated through sustainable practices and a larger direct effect on welfare ($\beta = 0.178$), suggesting that financial services improve livelihoods through multiple channels beyond practice investment. Fourth, cooperative membership is consistently associated with superior access to extension services, financial inclusion, and livelihood outcomes, highlighting the institutional mechanism through which collective action bridges service delivery gaps. The structural model explains 69.2% of the variance in livelihood outcomes and 50.3% of the variance in sustainable practices, demonstrating that the integration of extension services and financial inclusion provides a robust explanatory framework for understanding smallholder livelihood trajectories. The differential mediation proportions, 51.4% for extension versus 27.6% for financial inclusion, reveal an important asymmetry: extension services function primarily through knowledge-to-practice-to-outcome pathways, while financial inclusion has broader direct welfare effects that extend beyond agricultural practice adoption.

Recommendations

Based on the empirical findings, the following policy recommendations are proposed, with each explicitly linked to the corresponding evidence generated by the structural and mediation analyses. First, because extension services and financial inclusion

were found to operate through complementary yet distinct pathways ($\beta = 0.598$ and $\beta = 0.141$ on sustainable practices, respectively; Table 4), agricultural development programs should embed financial literacy and access modules within extension service delivery platforms. The community-based extension model piloted through Farmer Field Business Schools and Village Savings and Loan Associations in Iringa demonstrates promising results for bundling knowledge transfer with microfinance access. The education-income paradox revealed in this study calls for a recalibration of agricultural training programs toward competency-based practical skills rather than academic credentials. Extension curricula should emphasize soil conservation, water management, and climate adaptation techniques the sustainable practices that our analysis identifies as the critical transmission mechanism to livelihood outcomes. *Strengthen Cooperative Infrastructure as a Service Delivery Platform*. The consistent advantage of cooperative members across extension, financial, and livelihood dimensions demonstrates that farmer organizations function as effective institutional intermediaries. Investment in cooperative capacity building particularly leadership training, governance strengthening, and digital platform integration should be a strategic priority for maximizing service delivery reach and efficiency. The dominance of young farmers (75% aged 18–35) with low incomes (78.5% below TZS 300,000) demands targeted interventions. The BBT-YIA initiative should emphasize access to land, capital, and mechanization – the structural barriers that constrain educated youth from translating knowledge into productive agricultural enterprises.

In practical terms, the strong mediating role of sustainable practices (accounting for 51.4% of the extension effect and 27.6% of the financial inclusion effect on livelihoods; Table 5) implies that integrating extension and financial inclusion programming is not merely administratively convenient but empirically warranted: extension agents equipped to also broker access to credit, savings groups, or mobile financial products could simultaneously address the knowledge and capital constraints that jointly limit sustainable practice adoption. Practical integration models could include co-locating extension officers with village savings and loan associations or mobile-money agents, jointly training extension staff and community financial facilitators, and designing bundled advisory-plus-credit packages targeted at the youth-dominated, land- and capital-constrained farmers identified in this study (Section “The paradox of educated youth farmers”). Such integration directly operationalizes the study’s finding that knowledge and capital are complementary rather than substitutable inputs into sustainable rural development.

Limitations and future research

This study acknowledges some limitations. First, the cross-sectional design precludes causal inference; the path coefficients represent associations rather than established causal effects. Longitudinal and quasi-experimental designs, such as the difference-in-differences approach used by Pamuk *et al.* (2021), would strengthen causal claims. Second, reliance on self-reported Likert-scale data introduces common method bias and social desirability effects. Future studies should integrate objective measures of farming practices and livelihood outcomes, including crop yield data and household consumption indicators. Respondent over-reporting to appear favorably (social desirability bias) may be more pronounced for extension and cooperative-related items, given the social visibility of cooperative membership within farming communities, and this possibility should be borne in mind when interpreting the magnitude, though not the direction, of the reported effects. Third, the sample size ($n = 478$) limits the complexity of structural models that can be estimated; larger samples would enable more nuanced multigroup analysis by region, gender, and age. Fourth, the study did not assess the quality or intensity of extension service delivery, only perceived access, a distinction that Nzao *et al.* (2025) identified as critical for understanding service

effectiveness. Future research should examine the moderating role of financial self-efficacy and the potential for digital financial service platforms to serve as both extension and financial delivery channels simultaneously.

Priority should be given to longitudinal panel designs capable of establishing causal ordering between service access, practice adoption, and livelihood change, and to objective, non-self-reported measures of practice adoption and livelihood outcomes, such as remotely sensed land-use indicators, verified yield records, or third-party asset inventories, which would substantially strengthen the causal and validity claims that the current cross-sectional, self-reported design cannot support.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

This study was reviewed and approved by the Research Ethics Committee of Mbeya University of Science and Technology, Approval Reference No. BM/113/295/01 granted on 6 January 2026. The approval was issued through the Directorate of Postgraduate Studies, Research and Publications. In addition, administrative permission to conduct the study was obtained from the respective Government Authorities which monitoring those farmers.

All procedures involving human participants were performed in accordance with the ethical standards of Mbeya University of Science and Technology, relevant national research guidelines and regulations of Tanzania, and the ethical principles of the Declaration of Helsinki (and its subsequent amendments). The study fully adhered to these ethical guidelines throughout its design, data collection, analysis, and reporting.

Participation in the study was entirely voluntary. Before data collection, participants received detailed information about the study objectives, the nature of their participation, their right to decline or withdraw from the study at any time without penalty, and the measures implemented to protect their privacy and confidentiality. Written informed consent was obtained electronically from all participants before they accessed the online questionnaire. Participants indicated their consent by selecting the “Yes” option in the electronic consent section at the beginning of the questionnaire before proceeding to complete the survey. No personally identifiable information was collected. All responses were kept confidential, securely stored, and analyzed and reported only in aggregate form to ensure participants’ anonymity.

AUTHOR CONTRIBUTIONS

MM contributed in conceptualization, methodology, formal analysis, and writing – original draft; WI contributed in data curation, investigation, and writing – review and editing. All authors have read and agreed to the published version of the manuscript.

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DATA AVAILABILITY

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

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