Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

ARTICLE

What Drives and Shapes Smallholder Participation in Agricultural Commercialization in Malawi? Evidence from the AGCOM Project

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ABSTRACT

Smallholder agricultural commercialization is increasingly recognized as a pathway for rural transformation, yet its determinants remain underexplored in Malawi. This study examines both the decision to participate in markets and the intensity of commercialization among 2,400 households across 15 districts using data from the Agricultural Commercialization Project (AGCOM) collected in 2023. A double hurdle model was employed, allowing separate analysis of market participation (Probit) and commercialization intensity (Tobit) after diagnostic tests indicated no significant sample selection bias. Results show moderate commercialization, with an average Household Commercialization Index (HCI) of 0.61; 67% of households were commercialized (HCI > 0.5), while 33% were non-commercialized. By value chain, layers (HCI = 0.94), honey (0.91), and coffee (0.88) were the most commercialized, whereas beeswax was the lowest (0.56). Market access, landholding size, labor availability, and institutional support significantly influenced commercialization. Each additional kilometer from a main road reduced participation by 2.4%, households with more working-age members were 3% more likely to commercialize, and larger landhold-

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ARTICLE INFO

Received: 14 September 2025 | Revised: 30 October 2025 | Accepted: 3 November 2025 | Published Online: 7 May 2026
DOI: https://doi.org/10.36956/rwae.v7i2.2734

CITATION

Mkandawire, N.D., Mangisoni, J.H., Pangapanga-Phiri, I., et al., 2026. What Drives and Shapes Smallholder Participation in Agricultural Commercialization in Malawi? Evidence from the AGCOM Project. Research on World Agricultural Economy. 7(2): 388–407. DOI: https://doi.org/10.36956/rwae.v7i2.2734

ings increased commercialization probability by 2.3% per hectare, with diminishing returns beyond 7 hectares. AGCOM participation, credit access, and television ownership further enhanced commercialization. Regional and agroecological disparities were evident: farmers in the North were 27.5% less likely to commercialize, while those in the South, Lakeshore Plains, and Highlands were 8.6%, 24.5%, and 29.4% more likely, respectively, compared to reference areas. The findings highlight the importance of infrastructure, financial inclusion, ICT-enabled information, and programmatic support. Policy should prioritize these areas, while future research should track commercialization dynamics and their links to food security and resilience.

Keywords: Agricultural Commercialization; AGCOM Project; Smallholder Farmers; Market Participation; Credit Access; Double Hurdle Model and Road Access

1. Introduction

Agricultural commercialization (AC) has received an increasingly critical focus in global development, especially in the context of transitioning from subsistence to market-oriented production systems. AC is recognized as an essential pathway for enhancing agricultural productivity, boosting economic growth, and improving rural livelihoods. The process of commercialization involves the shift of agricultural activities from primarily subsistence farming to market-driven approaches, with an emphasis on profit-driven and technologically advanced methods of production, processing, and marketing [1,2]. From a global perspective, AC has been linked to improvements in food security, employment, and poverty reduction, particularly in developing economies where agriculture forms the backbone of economic activity.

In Sub-Saharan Africa (SSA), AC is viewed as vital for addressing food insecurity and unlocking economic potential. Agriculture has been recognized as the main contributor to food security, export earnings, and rural development [3,4]. For example, the sector contributes around 38.2% of Togo's national output, 65.3% in Comoros, and accounts for 60% of export earnings [5,6]. Despite the importance of agriculture in SSA's economic structure, challenges such as limited access to technology, poor infrastructure, inadequate financing, and underdeveloped market systems have hindered the commercialization process. Smallholder farmers, who dominate agriculture in this region, face difficulties ranging from limited access to capital and technology to inadequate storage and processing facilities [7,8]. These constraints reduce their capacity to move from subsistence farming to more market-oriented activities, thereby impeding potential economic transformation.

Malawi, one of the agricultural economies in SSA, faces similar challenges. Agriculture contributes about 22.08% to the country's GDP, employs about 80% of the workforce, and accounts for roughly 80% of export earnings [5,6,9]. While the country has seen some positive strides in agricultural development, commercialization remains slow. The commercial agricultural sector is characterized by smallholder farmers who continue to practice subsistence farming despite policies advocating for the transition to more market-oriented practices. Issues such as poor infrastructure, limited access to credit, low levels of education, and inadequate agricultural extension services further constrain commercialization efforts [10].

The Government of Malawi, in partnership with the World Bank, implemented the Agricultural Commercialization (AGCOM) Project from 2018 to 2024 to advance the national commercialization agenda, with a total funding of USD 95 million. AGCOM enhanced smallholder commercialization through financial, technical, and infrastructural support. Producer Organizations (POs) accessed matching grants, contributing 30% of subproject costs (10% cash, 20% in kind), while the project financed 70% in cash. These grants enabled the acquisition of productive assets such as tractors, warehouses, and dairy equipment, improving productivity and reducing costs. Technical Implementation Support (TIS) brokers provided guidance in governance, financial management, and resource mobilization. The project promoted cooperative development and collective marketing to achieve economies of scale and reduce transaction costs. Through the Productive Alliance approach, POs entered formal agreements with reliable off-takers, securing fair prices. Complementary investments in last-mile infrastructure and a partial credit guarantee facility further enhanced liquidity and market access.

The level of AC in Malawi varies significantly between regions and farming systems. The concept itself has been defined in various ways, including the extent to which a farm allocates resources (land, labor, capital) to produce goods for sale [11] or the degree to which small-scale farmers move toward market-driven agricultural activities [12]. In this study, AC is conceptualized as the degree to which households participate in markets through the sale of their agricultural produce. A threshold of 50% of gross revenue derived from marketed output is often regarded as a clear signal of transition from subsistence-oriented to market-oriented farming [13–15]. To operationalize this concept, the study employs the Household Commercialization Index (HCI), which quantifies commercialization as the ratio of the value of agricultural sales to the total value of production [16–18]. Thus, while AC provides the conceptual framing of the shift towards market participation, the HCI serves as the empirical tool for measuring and comparing the extent of this transition across households.

AC among smallholder farmers is influenced by a range of household, institutional, and locational factors. Gender of the household head plays a role, with male-headed households often having better access to markets, credit, and information, although targeted interventions may also enable female-headed households to participate [19,20]. The age of the household head can have mixed effects, as older farmers may rely on experience and networks, while younger ones may be more innovative and risk-tolerant [20,21]. Education enhances market participation since more educated farmers are better able to understand and respond to market signals [16,22]. Household size provides labor for production, which increases surplus for sale [23,24], while group membership enhances access to information, collective marketing, and reduced transaction costs [19,25]. Similarly, larger landholdings allow farmers to produce higher volumes and sell more output [26], and access to extension services improves market linkages and information flow, thereby promoting commercialization [27]. Finally, locational differences such as district or region also matter, as variations in infrastructure and market access may either constrain or facilitate commercialization [27].

While this study is not the first to explore the determinants of AC in Malawi, prior research has extensively examined its effects on outcomes such as household income, food security, and nutrition [28–31]. However, these studies are often limited in scope and methodology, leaving critical gaps that this study aims to address.

First, existing studies on agricultural commercialization have often been limited by their narrow focus on specific value chains or restricted geographical coverage, which constrains the generalizability of their findings. For example, Kaiyatsa et al. [29] examined the impact of agricultural commercialization on household welfare but concentrated only on a single value chain groundnuts and one district, Mchinji. Similarly, Mgalamadzi et al. [30] analyzed the dynamics of commercialization in Central Malawi, thereby providing useful insights but still restricting the scope of application to a particular region. On the other hand, Mgomezulu et al. [16] analyzed the groundnut value chain's impact on multidimensional poverty, while Mango et al. [32] focused on assessing determinants of agricultural commercialization on the tomato value chain, highlighting Malawi's competitive advantage in this subsector. Similarly, Tchale and Kayser [31] and Chagomoka et al. [28] examined tobacco and traditional vegetable value chains, respectively, but fail to address integrated crop-livestock systems, particularly in Malawi's diverse agricultural context.

Second, methodological limitations persist in the analysis of commercialization. Many studies, such as Nawachukwu and Ezeh [33] and Thanh and Duong [34], focus either on the decision to commercialize or the extent of commercialization without considering both simultaneously. Moreover, models like multiple regression and probit models fail to account for selection bias and unobserved heterogeneity, such as managerial ability or social networks, leading to biased and inconsistent estimates [33]. To ensure methodological rigor, the study adopted the double hurdle model, which offers several advantages. First, unlike standard probit or Tobit models, the double hurdle framework explicitly disentangles the two sequential but distinct decisions that characterize commercialization: (i) whether or not to participate, and (ii) the extent of participation, conditional on the first decision. This aligns with the realities of smallholder commercialization in Malawi, where some farmers may choose not to commercialize at all, while others do so at varying intensities. The double hurdle model also accommodates zero observations without treating them as purely corner solutions, thereby providing more flexibility in modeling the data [34]. Furthermore, the double hurdle model helps to mitigate biases arising from unobserved heterogeneity—such as differences in managerial ability, social capital, or risk preferences—that often affect both the participation and intensity decisions [33].

Third, a further gap in the literature lies in the absence of a clear and consistent benchmark for identifying when a household can be considered commercialized. Most studies conceptualize AC narrowly as the proportion of agricultural output sold in markets, ranging from 0% (pure subsistence) to 100% (full commercialization) [35,36]. This approach not only imposes an arbitrary continuum without a defined cut-off point but also creates unresolved questions on how to holistically define and measure commercialization, and at what threshold a smallholder farmer can meaningfully be classified as commercialized. Unlike most prior studies on smallholder commercialization in Malawi, which typically classify farmers as commercializing if they sell any proportion of their output, our study applies a 50% commercialization threshold [37,38], providing a clearer distinction between subsistence and commercially oriented farmers. This benchmark offers a more precise way to classify farmers as commercialized, while incorporating both the volume and value of sales, thereby capturing a more nuanced shift from subsistence to market orientation. The use of the value of gross sales incorporates the monetary dimension of commercialization, whereas most previous studies relied only on volumes sold. In addition, there is a lack of research on livestock commercialization in sub-Saharan Africa, particularly in Malawi. Most studies focus on crop-based value chains (e.g., groundnuts, cassava, rice), leaving livestock systems, such as dairy, poultry, and honey, underexplored [33,39].

This study makes a significant contribution to the literature by addressing critical gaps in the understanding of AC in Malawi. Unlike previous research that has focused narrowly on single value chains or specific regions, this study adopts a broader perspective, examining commercialization across diverse farming systems and multiple value chains, including crops (soybeans, coffee, rice, groundnuts, beans) and livestock (dairy, layers, broilers, and honey), and using a nationally representative sample.

Beyond methodological and empirical contributions, the study also engages with policy relevance by evaluating the effectiveness of key national strategies promoting commercialization—such as Malawi Vision 2063 and the National Agriculture Policy. By linking empirical findings to actionable recommendations on market access, rural infrastructure, credit systems, and extension services, the study provides evidence-based guidance for policymakers and development partners seeking to strengthen smallholder participation in commercial agriculture.

The remainder of the paper is organized as follows: Section 1 outlines the commercialization context in Malawi. Section 2 presents the conceptual framework and econometric strategy. Section 3 discusses the data and study results, and Section 4 concludes the study with key findings and implications.

2. Materials and Methods

2.1. Estimation Strategy

To address the study objectives on the determinants of smallholder households' participation in agricultural commercialization and the extent of their involvement, the study initially considered the Heckman two-step model, which is widely applied in related literature [39–42]. The Heckman model is designed to correct for potential sample selection bias by jointly estimating the decision to participate in the market (via a Probit model) and the intensity of commercialization (via Ordinary Least Squares). However, the selection bias test returned a statistically insignificant and negative inverse Mills ratio (λ = −0.178; see **Appendix A**), suggesting that selection bias was not a major concern in this dataset. As a result, the study adopted the double hurdle model [43], which is more suitable in contexts where participation and intensity may be influenced by different sets of factors [44,45].

The double hurdle model involves two sequential decisions: (1) whether a household participates in agricultural commercialization, estimated using a Probit model; and (2) the extent of commercialization among participating households, estimated using a Tobit model. This approach is particularly appropriate for Malawi's smallholder setting, where factors such as access to extension services or lead farmer status may drive participation, while other household or market conditions determine commercialization intensity. In this paper, the Probit model is used for the first hurdle of participation, while the Tobit model deals with the extent of commercialization in the second hurdle.

Based on Gujarati [46], the Probit model is specified as follows:

$$Y_i = f\left(X_i,\ D_i\right) \tag{1}$$

where Y_i is the agricultural commercialization decision by a household i, X_i is a vector of continuous factors of agricultural commercialization, while D_i is a vector of categorical factors of agricultural commercialization.

Following Strasberg et al. [38] and Assefa et al. [37], the agricultural commercialization decision is estimated as Y = 1 if the household has an HCI of more than 50% and Y = 0 otherwise. Thus, the probit regression model in (1) is recast as follows:

$$Y^*{}_i = \beta X_i + \varepsilon_i \; with \; Y^*{}_i = \begin{cases} 1 & if\ the\ household\ has\ an\ HCI\ of\ more\ than\ 50\% \\ 0 & otherwise \end{cases} \tag{2}$$

where β is a vector parameter to be estimated, X_i is a vector of explanatory variables, and ε_i is the error term.

In this study, the Tobit model is employed within the double hurdle framework to estimate the extent of agricultural commercialization among Malawian smallholder farmers who participate in markets. The Tobit model is suitable because the commercialization index (proportion of output sold) follows a censored distribution, with non-participating farmers having a value of zero [47,48]. Within the double hurdle framework, the Probit model estimates market participation in the first hurdle, while the Tobit model, used in the second hurdle, accounts for the intensity of commercialization among participants, allowing for different influencing factors such as access to extension services and farm size [43,45]. The Tobit model effectively handles the censored distribution, combining discrete (zero) and continuous (positive) values, and generates reliable estimates by utilizing all available data [49]. In our study, the significant participation of farmers in commercialization results in a censored distribution well-suited to this approach. Perceived agricultural commercialization is observed for values greater than 0. The model is therefore specified as:

$$Y^* = Y_i^* \; if \; Y_i^* > 0; \; 0 \; if \; Y_i^* \leq 0 \tag{3}$$

where Y^* is the observed variable and Y_i^* is the latent variable, which is the perceived agricultural commercialization, and is explained by the following equation:

$$Y_i^* = \beta X_i + u_i, \tag{4}$$

where X_i is the observed demographic, socio-economic, and institutional variable, and β is a vector of parameters to be estimated and u_i is an error term of normal distribution with zero and constant variance of σ^2 explained by $u_i \sim N(0, \delta^2)$.

According to McDonald and Moffitt [50], the marginal effects of the model can be specified as:

$$\frac{\partial Pr(Y > 0/X)}{\partial X_K} = \varphi\left(\frac{X\beta}{\delta}\right)\frac{\beta_K}{\delta}. \tag{5}$$

2.2. Study Area and Sampling Methods

This study draws on cross-sectional secondary data collected in 2023 under the Agricultural Commercialization Project (AGCOM) to examine the determinants of agricultural commercialization among smallholder farmers in Malawi. The dataset covers both project beneficiaries—smallholder farmers organized in Producer Organizations (POs) receiving support such as matching grants for capital investments, training, input supply, and market linkages—and non-beneficiaries, who are farmers outside AGCOM-supported POs but engaged in similar value chains and located in comparable geographical areas. This design enables a robust comparison between the two groups to assess commercialization dynamics and project influence.

A multi-stage sampling strategy was employed to select 2,400 households from 15 districts across Malawi's Northern, Central, and Southern regions, ensuring representativeness of the country's diverse agroecological and socioeconomic conditions. From over 30 agricultural value chains supported by AGCOM, nine were purposively chosen for their economic significance and commercialization potential: poultry, honey, soybeans, rice, beans, dairy, potatoes, groundnuts, and coffee. Within these, 40 POs were randomly drawn from a pool of 296, while 1,200 non-beneficiary households were also randomly selected, maintaining a balanced 50:50 ratio of beneficiaries to non-beneficiaries. This sampling framework ensured the inclusion of households with and without AGCOM support, providing a solid foundation for analyzing commercialization determinants across different contexts.

2.3. Measurement of Agricultural Commercialization

Agricultural commercialization in the current study entails Malawian smallholder farmers selling more than half the value of their total agricultural production in different crop and livestock value chains. This 50% threshold represents a transformation from subsistence-based to market-oriented farming. By measuring value rather than just volume, the current study accounts for price differences across crops and gets a clear picture of farmers' economic real value and position. The Household Commercialization Index (HCI) provides a straightforward measure of this transition by calculating the ratio between what farmers earn from market sales compared to the total value of everything they produce.

Following Tegegne et al.[51], the adopted formula for HCI was:

$$\text{HCI} = \frac{\text{Total value of products sold}}{\text{Total value of products produced}} \tag{6}$$

The index assesses the proportion of total output compared to the total amount sold. The index values range from 0 to 1 due to its fractional nature. Values close to zero suggest that production is mainly for subsistence purposes, while values close to 1 indicate that the household is heavily focused on commercial farming.

3. Results and Discussions

3.1. Levels and Determinants of Agricultural Commercialization Among Smallholder Farmers in Malawi

The results in **Table 1** indicate that AC among Malawian smallholders is moderate, with an average HCI of 0.61. About 67% of households are commercialized (HCI > 0.5), while 33% remain non-commercialized (HCI ≤ 0.5). Commercialized farmers engage more actively in markets (mean HCI = 0.87) compared to their counterparts (mean HCI = 0.07). By value chain, layers, honey, and coffee rank among the most commercialized enterprises, whereas beewax exhibits the lowest commercialization levels. This heterogeneity reflects crop and enterprise specific profitability and market opportunities, consistent with previous findings that commercialization is often commodity-driven and shaped by access to reliable value chains[19,27].

Table 1. Summary of descriptive results of agricultural commercialization in Malawi.

Category / Variable	Group / Value Chain	Mean HCI	Other Key Findings
Overall Commercialization	Total sample (N = 2400)	0.61	67% commercialized vs. 33% non-commercialized
Non-Commercialized	HCI ≤ 0.5	0.07	Low market participation
Commercialized	HCI > 0.5	0.87	High market participation
By Value Chain	Layers	0.94	Highest commercialization
	Honey	0.91	High commercialization
	Coffee	0.88	High commercialization

Table 1. *Cont.*

Category / Variable	Group / Value Chain	Mean HCI	Other Key Findings
	Dairy	0.84	Strong commercialization
	Soybean	0.82	Above average
	Beans	0.81	Above average
	Groundnuts	0.78	Moderate
	Rice	0.66	Lower commercialization
	Bee wax	0.56	Lowest commercialization
Household Size	Commercialized vs. Non	4.55 vs. 4.18	Larger households favor commercialization ($p < 0.01$)
Age of HH Head	Commercialized vs. Non	48.1 vs. 47.2	Older farmers are more commercialized
Land Size (ha)	Commercialized vs. Non	1.15 vs. 1.40	Larger land is not always linked to commercialization ($p < 0.05$)
Distance to Road (km)	Commercialized vs. Non	1.35 vs. 1.38	Closer proximity aids market access
Gender	Male vs. Female	53.1% vs. 14.3%	Strong gender disparity ($p < 0.01$)
Education	No vs. Primary vs. Secondary+	7.6% vs. 57.8% vs. 34.6%	Higher education linked to commercialization
Region	Central (33.6%), North (19.5%), South (15.8%)	—	Regional variations are significant ($p < 0.01$)
AGCOM Participation	Beneficiaries vs. Non	35.1% vs. 33.8%	AGCOM enhances participation ($p < 0.01$)
Extension Access	Yes vs. No	19.8% vs. 47.2%	Extension boosts commercialization ($p < 0.01$)
Credit Access	Yes vs. No	3.6% vs. 96.4%	Credit access is strongly linked to commercialization
Mobile Phone Ownership	Yes vs. No	47.2% vs. 21.7%	ICT access improves market participation ($p < 0.10$)

Source: Authors' estimations (2023 AGCOM survey data).

Socioeconomic and institutional factors also shape participation in commercialization. The results show that commercialized households tend to have larger family sizes, older household heads, and closer proximity to roads. Larger households may provide surplus labor, enabling more production for sale, a finding consistent with Low and Thiele [24] and Ayinde et al. [23]. Similarly, older farmers may leverage their experience and networks to secure markets [22], although past studies also caution that younger farmers can be more market-oriented and risk-tolerant [21]. Education is positively associated with commercialization, in line with Ayinde et al. [23] and Mgomezulu [16], as schooling improves farmers' capacity to understand market signals and negotiate prices. Gender disparities are evident, with male-headed households dominating commercialization, corroborating findings by Peterman et al. [20], although studies such as Mgalamadzi et al. [19] highlight that targeted interventions can improve female participation. Access to extension services, credit, and mobile phones is strongly correlated with commercialization, aligning with evidence that information and institutional support lower transaction costs and enhance market integration [22,26].

3.2. Determinants of Participation in Agricultural Commercialization

Before analysis, diagnostic tests were conducted. The multicollinearity test showed that the Variance Inflation Factors (VIF) ranged from 1.05 to 1.27 with a mean of 1.14, confirming the absence of multicollinearity (VIF < 10) (**Appendix B**). Correlation analysis indicated a relatively high positive correlation (r = 0.38) between Tropical Livestock Units (TLU) and total land size, while other variables showed both weak positive and negative associations (**Appendix B**). The Breusch–Pagan test confirmed the presence of heteroskedasticity (Chi-square = 32.36, $p < 0.01$). To address this, a probit regression model with robust standard errors was estimated. The probit model was significant at the 1% level (Wald χ^2 = 120.37), indicating good model fit, with a pseudo R^2 of 0.0635. Interpretation is based on average marginal effects (AMEs), presented in **Table 2.**

Table 2. Probit model for factors influencing agricultural commercialization.

	Main Model		Validate the HCI Threshold (Sensitivity Analysis)			
HCI Threshold	HCI > 0.5		HCI > 0.4		HCI > 0.6	
Agricultural commercialization	dy/dx	Robust St.Err.	dy/dx	Robust St.Err.	dy/dx	Robust St.Err.
Log of distance to the nearest main road	−0.024*	0.043	−0.033**	0.014	−0.017	0.014

Table 2. *Cont.*

	Main Model		Validate the HCI Threshold (Sensitivity Analysis)			
HCI Threshold	HCI > 0.5		HCI > 0.4		HCI > 0.6	
Agricultural commercialization	dy/dx	Robust St.Err.	dy/dx	Robust St.Err.	dy/dx	Robust St.Err.
Region: base Central						
North	−0.275***	0.236	−0.338***	0.083	−0.231***	0.075
South	0.086*	0.142	0.064	0.045	0.100**	0.047
Age of household head	−0.008	0.015	−0.010**	0.005	−0.007	0.005
Age squared	0.000	0.000	0.000*	0.000	0.000	0.000
Education level: base no education						
Primary	0.041	0.117	0.010	0.038	0.029	0.039
Secondary	−0.022	0.127	−0.050	0.041	−0.022	0.042
TLU	0.007	0.023	0.008	0.007	0.006	0.008
Land size (ha)	0.023*	0.040	0.006	0.010	0.024**	0.013
Land size squared	−0.002***	0.002	0.000	0.000	−0.002***	0.001
Household size	0.030***	0.022	0.035***	0.007	0.030***	0.007
AGCOM project	0.049**	0.064	0.050**	0.020	0.038*	0.021
Credit access	0.138**	0.180	0.209***	0.066	0.148**	0.060
Gender of household head	0.002	0.079	0.014	0.025	0.004	0.026
Ext access	−0.113***	0.068	−0.072***	0.021	−0.116***	0.022
Own mobile phone	0.029	0.069	0.014	0.022	0.032	0.023
Own television	0.059*	0.097	0.057*	0.031	0.059*	0.032
AEZ: base Lower Shire Valley						
Lakeshore Plains and Upper Shire Valley	0.245***	0.224	0.273***	0.063	0.223***	0.068
Mid-altitude Plateau	0.096	0.187	0.064	0.064	0.100	0.067
Highlands	0.294***	0.233	0.302***	0.063	0.259***	0.067
Number of obs = 1944; Wald chi2(20) = 120.37***; Log pseudolikelihood = −1121.3034 Pseudo R2 = 0.0635						

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' estimations.

The results demonstrate that agricultural commercialization in Malawi is strongly shaped by market access, regional location, landholding size, and household labor availability (**Table 2**). Distance to the nearest main road negatively influenced commercialization, with each additional kilometer reducing the probability of market participation by 2.4% ($p < 0.10$). This finding underscores the importance of rural infrastructure in lowering transaction costs and connecting farmers to markets, consistent with evidence from Ethiopia and Kenya [52,53]. Regional disparities were also apparent: compared to the Central region, farmers in the North were 27.5% less likely to commercialize ($p < 0.01$), while those in the South were 8.6% more likely ($p < 0.10$), reflecting variations in market connectivity, infrastructure, and agroecological potential [3]. Landholding size was another important determinant, as each additional hectare increased commercialization probability by 2.3% ($p < 0.10$), although diminishing returns set in beyond about 7 hectares. This result aligns with findings from Nigeria, where the commercialization effects of land expansion were non-linear [54]. This may be because, as farm size increases, operational inefficiencies can arise and, under larger-scale operations, often require mechanization, reducing reliance on manual labor and potentially limiting the extent of commercialization. Household labor availability, measured as the number of working-age members, also had a significant positive influence, with each additional productive member raising the likelihood of commercialization by 3% ($p < 0.01$), supporting evidence from South Africa and Ghana [55,56].

Institutional, informational, and ecological factors further shaped commercialization outcomes. Participation in the AGCOM project significantly increased the probability of commercialization by 4.9% ($p < 0.05$), confirming the program's positive role in strengthening farmer market linkages [29]. Similarly, access to credit raised commercialization probability by 13.8% ($p < 0.05$), underscoring the role of financial access in enabling investments in productivity-enhancing inputs, consistent with findings from Ghana [57]. Information access through media also mattered: households owning a television were 5.9% more likely to commercialize ($p < 0.10$), suggesting that exposure to agricultural and market-related information enhances farmers' decision-making and aligns with earlier evidence [5,6]. Finally, agroecological conditions proved decisive. Farmers located in the Lakeshore Plains and Upper Shire Valley and in the Highlands were 24.5% and 29.4% more likely to commercialize, respectively ($p < 0.01$), compared to those in the Lower Shire Valley. This highlights the significant influence of geography and ecology on production potential and commercialization, as also noted in Ethiopia [58,59].

To validate the HCI threshold, a sensitivity analysis was conducted using alternative cut-off points (0.4 and 0.6) to confirm the robustness of the classification of agricultural commercialization at 0.5 and key coefficients. The key coefficients, such as region, household size, AGCOM project, credit access, owning a television, and agroecological zones, were also significant with the same sign, even at 0.4 and 0.6 thresholds. This showed that the cut-off point of agricultural commercialization at 0.5 and the relationship with key variables were valid.

The marginal effect plot in **Figure 1** indicates that the age of the household head had a negative effect on the likelihood of household agricultural commercialization. Younger household heads were significantly more likely to commercialize their agricultural production compared to older heads. As age increases, the probability of commercialization steadily declines, possibly due to lower risk-taking ability, reduced physical energy, or less willingness to adopt market-oriented farming.

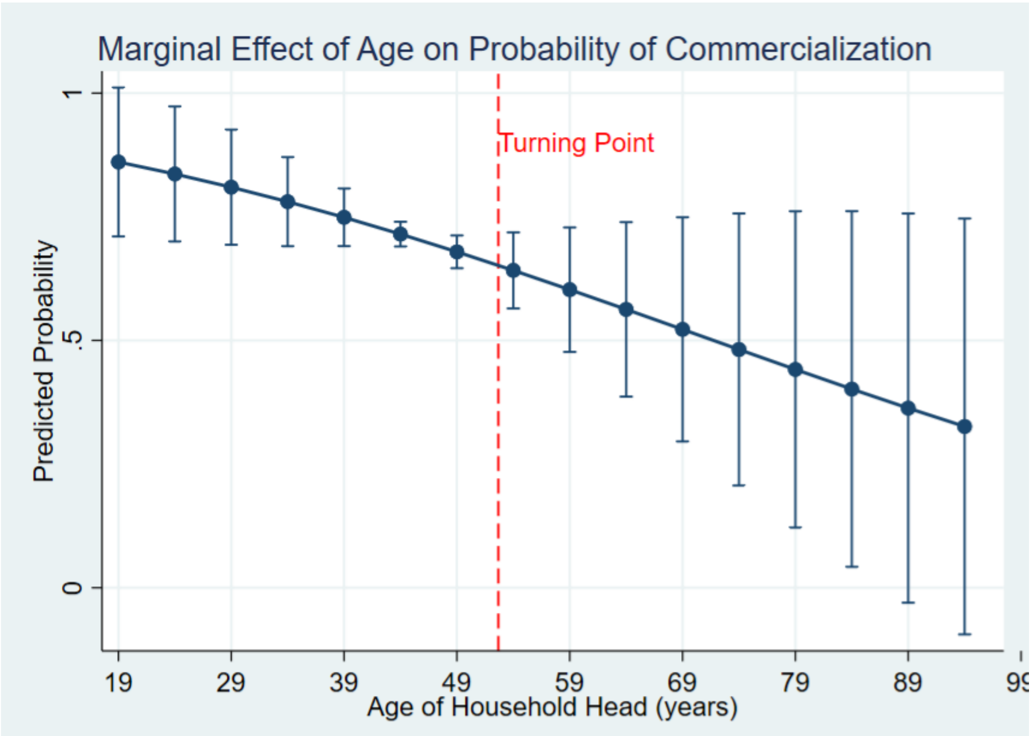

Figure 1. Marginal effects of landholding size on the probability of commercialization.

The marginal effects plot in **Figure 2** revealed that there was a non-linear relationship between landholding size and the probability of agricultural commercialization. The results showed that the probability of agricultural commercialization increases at a decreasing rate beyond 7 hectares.

The study examined a gender analysis to determine whether the effects of credit access and AGCOM project participation differ by the gender of the household head (**Appendix C**). The sample showed a descriptive gender imbalance, with 79% male-headed and 21% female-headed households. In the baseline model without interactions, both credit access and AGCOM project participation were positive and statistically significant, indicating that these interventions improve agricultural commercialization. However, the gender of the household head was not statistically significant. Interaction terms between gender and credit access and between gender and AGCOM project participation were then included to test whether the program impacts differ by household head gender. The interaction terms were not statistically significant, and the main effects became insignificant in the presence of interactions, likely due to the small proportion of female-headed households and collinearity between main effects and interactions. These results suggest that the benefits of credit access and AGCOM project participation do not differ substantially between male and female-headed households, implying that both genders experience comparable program effects despite the descriptive imbalance.

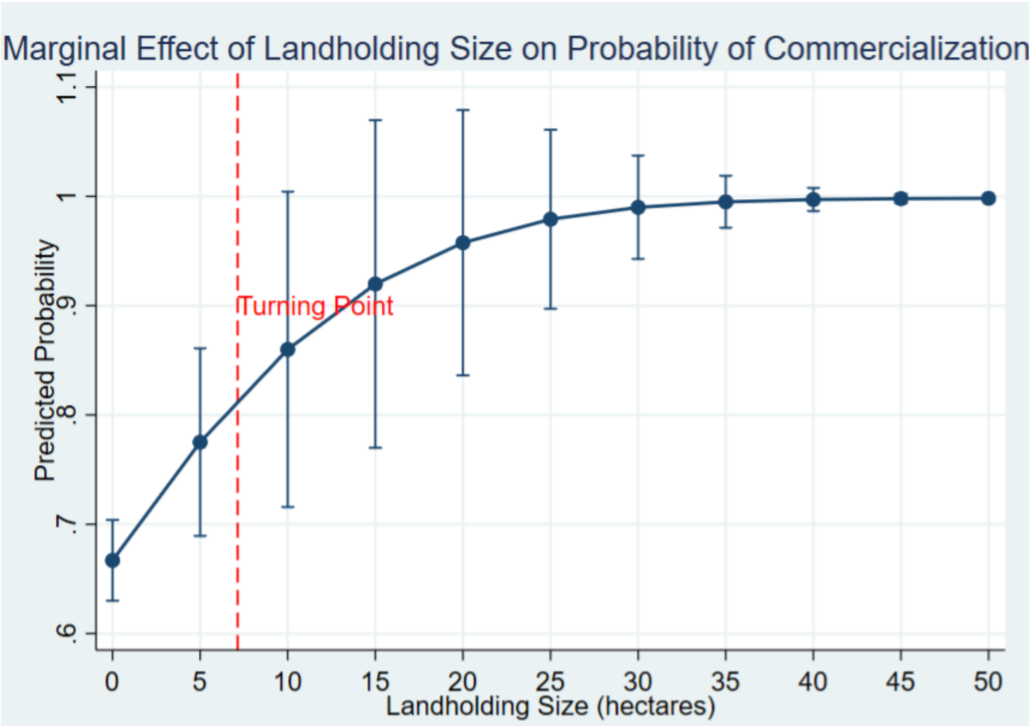

Figure 2. Marginal effects of age on probability of commercialization.

3.3. Extent of Agricultural Commercialization in Malawi

Before analysis, diagnostic tests were conducted to check data suitability. The Variance Inflation Factors (VIF) ranged between 1.05 and 1.24, with a mean of 1.11, confirming the absence of multicollinearity (VIF < 10) (**Appendix D**). Correlation results showed a moderate positive relationship between Tropical Livestock Units (TLU) and total land size (r = 0.38), while other variables showed weak positive and negative associations (**Appendix D**). The Breusch–Pagan test indicated heteroskedasticity ($\chi^2 = 23.01$, $p < 0.01$), prompting the use of a Tobit regression model with robust standard errors. The model was statistically significant at the 1% level (F = 7.10), with a log-likelihood of −1857.08, confirming the joint significance of the explanatory variables. Interpretation is based on marginal effects (dy/dx), which represent the change in the HCI given a one-unit change in the predictor.

The results reveal several factors influencing the extent of commercialization among Malawian smallholders (**Table 3**). The age of the household head had a negative but non-linear effect: commercialization declined with age, reaching a turning point at around 52 years ($p < 0.10$). This suggests that while older farmers benefit from experience and networks, younger farmers may be more market-oriented due to energy, adaptability, and willingness to take risks, consistent with Mutami [60] and Pamela et al. [61]. Household size had a strong positive effect, where each additional working-age member increased commercialization by 5.1% ($p < 0.01$). This aligns with Justus et al. [56] and Agwu et al. [62], who noted that larger households benefit from abundant family labor, higher income needs, and better risk distribution, all of which promote commercialization.

Table 3. Censored Tobit regression model results on factors influencing the extent of agricultural commercialization.

HCI	dy/dx	Robust St.Err.	T-value
Age of household head	−0.014*	0.007	−1.85
Age squared	0.000*	0.000	1.92
Education level: base no education			
Primary	0.059	0.056	1.06
Secondary	−0.011	0.061	−0.19
TLU	0.013	0.010	1.31
Land size (ha)	−0.003	0.014	−0.18
Land size squared	0.000	0.000	−0.94
Household size	0.051***	0.010	5.31
AGCOM project	0.063**	0.031	2.03
Credit access	0.195***	0.056	3.48
Gender of household head	−0.001	0.038	−0.02
Ext access	−0.186***	0.032	−5.78
Own a mobile phone	0.009	0.033	0.27
Own television	0.088**	0.042	2.09
AEZ: base Lower Shire Valley			
Lakeshore Plains and Upper Shire Valley	0.116	0.073	1.59
Mid-altitude Plateau	0.029	0.056	0.52
Highlands	−0.058	0.060	−0.97
Constant	0.481**	0.201	2.39
var(e.HCI)	0.378	0.020	
Number of obs = 1944;Uncensored = 1117 Limits: Lower = 0 ;Left-censored = 469 Upper = 1; Right-censored = 358 F(17, 1927) = 7.10*** Log pseudolikelihood = −1857.0805 Pseudo R2 = 0.0290			

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Author's own computation.

Institutional and informational variables also played a significant role. Participation in the AGCOM project increased commercialization by 6.3% ($p < 0.05$), confirming the project's effectiveness in strengthening farmer capacity and market integration [29]. Access to credit raised commercialization by 19.5% ($p < 0.01$), highlighting the role of liquidity in enabling investment in improved inputs and surplus production. These results are consistent with Agwu et al. [62] but contrast with Edosa [63] and Molla [64], who observed negative effects linked to repayment burdens. Extension service access, however, was unexpectedly negative (−18.6%, $p < 0.01$), possibly because public extension services in Malawi have traditionally emphasized subsistence production and household food security rather than market-oriented farming. This contrasts with findings by Edwalew [19], who reported positive effects of extension on commercialization in Ethiopia. The negative association may also reflect the tendency of more commercialized farmers to transition away from public extension and instead rely on private, NGO-based, or buyer-linked advisory services that are better aligned with market needs [65]. Moreover, public extension systems in Malawi often face resource constraints limited funding, logistics, and human capacity which can hinder their ability to deliver consistent and demand-driven support [66]. These factors together suggest that the effectiveness of extension in promoting commercialization depends greatly on the quality, focus, and resourcing of the extension system. Strengthening coordination between public and private extension actors could therefore enhance inclusivity and responsiveness in advancing Malawi's agricultural commercialization agenda. Finally, media exposure mattered: households owning a television were 8.8% more commercialized ($p < 0.05$), underscoring the role of information in shaping market decisions. This finding aligns with Norton and Alwang [67], who showed that television ownership improves farmers' access to market opportunities, price trends, and agricultural input information. Smallholder farmers in Malawi can enhance commercialization by pooling resources through cooperatives or producer organizations, improving market access and integration into value chains with institutional support.

4. Conclusions

This study examined the determinants of smallholder farmers' participation and intensity in agricultural commercialization in Malawi using the double hurdle model, which allowed separate analysis of market entry and extent of commercialization. The findings reveal that commercialization is moderate, with a Household Commercialization Index of 0.61, and is shaped by a mix of household, institutional, market, and agroecological factors. Market access was particularly critical: a greater distance from main roads significantly reduced participation, highlighting the importance of rural infrastructure in lowering transaction costs and enabling market integration. Land size exhibited a non-linear effect, with modest gains up to medium-scale holdings but diminishing returns beyond seven hectares, while household labor availability strongly enhanced commercialization potential. Institutional factors, including access to credit and participation in the AGCOM program, were also key enablers, underscoring the value of policy interventions that strengthen liquidity and market linkages. Information access, proxied by television ownership, further improved commercialization, confirming the role of media in reducing knowledge asymmetries and supporting informed decision-making.

These results carry important policy implications. First, improving rural road infrastructure and transport services remains central to integrating smallholders into markets. Second, policies that expand access to affordable credit and scale up successful interventions like AGCOM can catalyze commercialization across value chains. Third, targeted support is needed to overcome structural disparities, such as gender gaps and regional imbalances, ensuring that commercialization benefits are more equitably distributed. Fourth, strengthening information delivery through ICT and mass media can complement extension services, which require reorientation towards market-driven advisory support. Thus, there is a need to reorient extension programs toward commercialization and market linkages. Finally, agroecological potential must be factored into commercialization strategies, as regional disparities reflect differences in market access, infrastructure, and ecological suitability. Policies should prioritize region-specific interventions—such as irrigation and road investments in the Lower Shire Valley and the Northern Region, and climate-smart technologies for drought-prone zones. Strengthening aggregation centers and rural market linkages can reduce transaction costs, while tailored extension and agribusiness support can align services with each region's production systems. Such differentiated approaches will promote inclusive and geographically balanced agricultural commercialization in Malawi.. Future research should build on these findings by employing panel data to assess dynamics over time, exploring gender-differentiated impacts in greater depth, and examining how commercialization interacts with food security and resilience in the face of climate variability. These findings align closely with Malawi's Vision 2063 and the National Agricultural Policy, which emphasize market-oriented agriculture, infrastructure development, and value chain integration as key drivers of economic transformation. The study underscores that achieving the vision's goal of a prosperous, food-secure, and commercially vibrant agricultural sector will require targeted interventions that address both structural and institutional constraints identified in this analysis.

Author Contributions

N.D.M.: Conceptualization, Methodology, Formal analysis, Visualization, Writing – Original Draft. J.H.M.: Supervision, Validation, Review & Editing. I.P.-P.: Validation, Review & Editing. K.M.: Review & Editing. All authors have read and agreed to the published version of the manuscript.

Funding

This study was supported by the World Bank Group through the Malawi Agricultural Commercialization Project (AGCOM), Grant No. 6048-MW.

Institutional Review Board Statement

This study did not undergo formal Institutional Review Board (IRB) review because ethical approval was not a mandatory requirement for socio-economic surveys in Malawi during the study period. Nonetheless, it adhered to established ethical standards for social science research. Participation was voluntary, respondents were informed about the study's purpose, and consent was obtained before interviews. Data collection was conducted by experts from the Lilongwe University of Agriculture and Natural Resources (LUANAR), following LUANAR's internal ethical guidelines. All data were handled confidentially and anonymously, consistent with the principles of the Declaration of Helsinki.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study before participation. Respondents were informed about the purpose of the study, confidentiality of responses, and their right to withdraw at any point.

Data Availability Statement

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

Acknowledgments

The authors gratefully acknowledge the support received throughout this research. We thank the government institutions, local authorities, and community members for their time, insights, and data. Special appreciation goes to Dr. Teddie Nakhumwa, National Project Coordinator of the AGCOM Project, for their key roles in facilitating fieldwork and stakeholder engagement. Sincere appreciation to the team from the Lilongwe University of Agriculture and Natural Resources (LUANAR), led by Professor Joseph Dzanja, for their invaluable support in facilitating data collection.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1. Heckman selection model.

HCI	Coef.	St.Err.	*t*-value	*p*-value	Sig
Log of distance to the nearest main road	0.016	0.009	1.87	0.061	*
Region: base Central					
North	0.083	0.055	1.52	0.128	
South	0.001	0.025	0.05	0.96	
Age of household head	0.001	0.003	0.37	0.712	
Age squared	0	0	−0.22	0.824	
Education level: base no education					
Primary	0.002	0.02	0.09	0.926	
Secondary	0.021	0.02	1.09	0.277	
TLU	−0.003	0.004	−0.96	0.336	
Land size (ha)	0	0.009	0.05	0.963	
Land size squared	−0.001	0.001	−1.00	0.319	
Household size	−0.007	0.007	−1.01	0.312	
AGCOM project	−0.023	0.015	−1.62	0.106	
Credit access	−0.051	0.038	−1.36	0.174	
Gender of household head	−0.003	0.011	−0.27	0.79	
Ext access	0.008	0.03	0.26	0.792	
Own mobile phone	−0.004	0.012	−0.37	0.711	
Own television	0	0.018	0.02	0.985	
AEZ: base Lower Shire valley					
Lakeshore Plains and upper shire valley	0.049	0.048	1.03	0.303	
Mid-altitude Plateau	0.045	0.03	1.47	0.142	
Highlands	−0.045	0.059	−0.76	0.446	
Constant	0.976	0.143	6.83	0	***
AC2					
Log of distance to the nearest main road	−0.073	0.044	−1.67	0.094	*
Region: base Central					
North	−0.837	0.233	−3.60	0	***
South	0.263	0.14	1.88	0.06	*
Age of household head	−0.023	0.016	−1.47	0.142	

Table A1. *Cont.*

HCI	Coef.	St.Err.	*t*-value	*p*-value	Sig
Age squared	0	0	1.40	0.162	
Education level: base no education					
Primary	0.124	0.119	1.04	0.299	
Secondary	−0.068	0.129	−0.53	0.596	
TLU	0.02	0.023	0.87	0.386	
Land size (ha)	0.069	0.042	1.66	0.097	*
Land size squared	−0.005	0.003	−1.75	0.08	*
Household size	0.091	0.023	4.04	0	***
AGCOM project	0.148	0.065	2.29	0.022	**
Credit access	0.421	0.183	2.30	0.021	**
Gender of household head	0.007	0.078	0.09	0.926	
Ext access	−0.345	0.068	−5.08	0	***
Own mobile phone	0.089	0.069	1.28	0.2	
Own television	0.181	0.094	1.93	0.054	*
AEZ: base Lower Shire valley					
Lakeshore Plains and upper shire valley	0.77	0.222	3.47	0.001	***
Mid-altitude Plateau	0.278	0.185	1.50	0.132	
Highlands	0.967	0.23	4.21	0	***
Constant	−0.164	0.474	−0.35	0.73	
Lambda	−0.178	0.157	−1.13	0.258	
Rho	−1.000				
Sigma	0.178				
Number of obs = 1944 Selected = 1349 Non selected = 595 Wald chi2(20) = 53.16					

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix B. Multinocinearlity and Heteroskedasicity Tests before Probit Model

Variable	VIF	1/VIF
region	1.27	0.787487
TLU	1.25	0.797926
landha	1.19	0.836865
educ	1.18	0.850792
hh_age	1.14	0.876206
BH	1.13	0.888785
BQ	1.12	0.890945
hh_size	1.12	0.893387
ext_access	1.11	0.900691
agro_zone	1.10	0.908515
benefiagcom	1.10	0.908898
credit_acc~s	1.08	0.923216
hh_gender	1.05	0.951010
lndtr	1.05	0.956345
Mean VIF	1.14	

	lndtr	region	hh_age	educ	TLU	landha	hh_size	benefi~m	credit~s	hh_gen~r	ext_ac~s	BQ
lndtr	1.0000											
region	-0.1457	1.0000										
hh_age	-0.0292	0.1945	1.0000									
educ	-0.0687	0.0164	-0.2040	1.0000								
TLU	0.0258	0.0508	0.1094	0.0933	1.0000							
landha	-0.0513	-0.0588	0.0354	0.0763	0.3780	1.0000						
hh_size	0.0133	0.2239	0.1317	0.0306	0.0675	0.0141	1.0000					
benefiagcom	0.0165	0.0299	0.0714	0.0582	0.0865	0.0463	0.0693	1.0000				
credit_acc~s	-0.0163	-0.1526	0.0435	-0.0180	0.0643	0.0221	-0.0130	0.1915	1.0000			
hh_gender	0.0405	-0.0295	-0.0359	0.1151	0.0898	0.0658	0.1310	0.0237	0.0265	1.0000		
ext_access	0.0800	-0.2049	0.0563	0.0278	0.0924	0.0927	-0.0173	0.1702	0.0975	0.0397	1.0000	
BQ	-0.0186	0.1558	0.0009	0.2122	0.1201	0.0398	0.1748	0.0864	0.0161	0.0683	0.0454	1.0000
BH	-0.0447	0.0779	0.0549	0.2019	0.2077	0.1315	0.0646	0.1396	0.0568	0.0619	0.0353	0.1579
agro_zone	0.0320	-0.1818	0.0043	0.1216	0.1111	0.1010	-0.1139	-0.0320	-0.0228	-0.0534	0.1071	0.0298

	BH	agro_z~e
BH	1.0000	
agro_zone	0.0809	1.0000

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of AC2

H0: Constant variance

    chi2(1) =  32.36
Prob > chi2 = 0.0000
```

Appendix C. Probit Model for Interaction Terms

Table A2. Probit Model for interaction terms.

Agricultural Commercialization	**Coef.**	**Robust St.Err.**	**Coef.**	**Robust St.Err.**
Interacting gender	With Credit		With credit and AGCOM	
Log of distance to the nearest main road	−0.074*	0.043	−0.075*	0.043
Region: base Central				
North	−0.838***	0.236	−0.836***	0.236
South	0.263*	0.142	0.266*	0.142
Age of household head	−0.023	0.015	−0.023	0.015
Age squared	0.000	0.000	0.000	0.000
Education level: base no education				
Primary	0.125	0.117	0.124	0.117
Secondary	−0.068	0.127	−0.067	0.127
TLU	0.020	0.023	0.020	0.023
Land size (ha)	0.069*	0.040	0.070*	0.040
Land size squared	−0.005***	0.002	−0.005***	0.002
Household size	0.091**	0.022	0.091***	0.022
AGCOM project	0.148	0.064	0.070	0.141
Credit access	0.541	0.430	0.584	0.436
Gender of household head	0.011	0.080	−0.033	0.106
Credit access*gender	−0.141	0.469	−0.194	0.477
AGCOM*gender			0.098	0.158
Ext access	−0.344***	0.068	−0.344***	0.068
Own mobile phone	0.090	0.069	0.089	0.069
Own television	0.181*	0.096	0.182*	0.097
AEZ: base Lower Shire Valley				
Lakeshore Plains and Upper Shire Valley	0.770***	0.224	0.766***	0.224
Mid-altitude Plateau	0.278	0.187	0.276	0.187
Highlands	0.967***	0.233	0.964***	0.233
Constant	0.258	0.415	0.299	0.421
Number of obs = 1944; Wald chi2(20) = 120.37***; Log pseudolikelihood = −1121.3034 Pseudo R2 = 0.0635				

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix D. Multiconearity and Heteroskedasicity Tests before Tobit Model

Variable	VIF	1/VIF
TLU	1.24	0.804315
landha	1.18	0.846218
educ	1.17	0.856934
BH	1.12	0.892216
BQ	1.10	0.906531
benefiagcom	1.10	0.911349
hh_age	1.10	0.912171
hh_size	1.09	0.918206
agro_zone	1.07	0.937064
ext_access	1.06	0.942747
credit_acc~s	1.05	0.952645
hh_gender	1.05	0.956224
Mean VIF	1.11	

	hh_age	educ	TLU	landha	hh_size	benefi~m	credit~s	hh_gen~r	ext_ac~s	BQ	BH	agro_z~e
hh_age	1.0000											
educ	-0.2040	1.0000										
TLU	0.1094	0.0933	1.0000									
landha	0.0354	0.0763	0.3780	1.0000								
hh_size	0.1317	0.0306	0.0675	0.0141	1.0000							
benefiagcom	0.0714	0.0582	0.0865	0.0463	0.0693	1.0000						
credit_acc~s	0.0435	-0.0180	0.0643	0.0221	-0.0130	0.1915	1.0000					
hh_gender	-0.0359	0.1151	0.0898	0.0658	0.1310	0.0237	0.0265	1.0000				
ext_access	0.0563	0.0278	0.0924	0.0927	-0.0173	0.1702	0.0975	0.0397	1.0000			
BQ	0.0009	0.2122	0.1201	0.0398	0.1748	0.0864	0.0161	0.0683	0.0454	1.0000		
BH	0.0549	0.2019	0.2077	0.1315	0.0646	0.1396	0.0568	0.0619	0.0353	0.1579	1.0000	
agro_zone	0.0043	0.1216	0.1111	0.1010	-0.1139	-0.0320	-0.0228	-0.0534	0.1071	0.0298	0.0809	1.0000

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of HCI

H0: Constant variance

    chi2(1) =  23.01
Prob > chi2 = 0.0000
```

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