Crop output allocation among smallholder farmers in Tanzania: Evidence on the subsistence–commercialisation trade-off and labour dynamics

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ABSTRACT

This study examines crop output allocation between household consumption and market sales among Tanzanian smallholder farmers along the subsistence–commercialisation continuum. Using 2022/23 Annual Agricultural Sample Survey data (n = 8,531), two fractional logit models analyse shares of output sold and consumed, with emphasis on labour composition, moving beyond binary market participation measures. Results show farmers sell 46% of output on average while reporting about 70% for consumption and related uses. These categories overlap due to storage, seed retention, transfers, and reporting inconsistencies; thus, they are analysed separately rather than as strictly complementary shares. Productive assets (farm size, output, capital inputs), hired labour, irrigation, and pesticide use significantly enhance commercialisation, while older household heads prioritise subsistence. Hired labour supports market-oriented production, whereas family labour sustains both subsistence and commercial activities. The findings support the agricultural household model by confirming non-separability of production and consumption decisions. Policy implications include improving productivity, strengthening rural labour markets, and promoting technology adoption to support inclusive agricultural transformation in Tanzania.

Key words: Agricultural Commercialization, Crop Allocation, Fractional Logit, Labour Composition, Smallholder Farmers, Tanzania

I. INTRODUCTION

The transition from subsistence to market-oriented agriculture is widely recognized as a key pathway for rural transformation and economic development, enabling productivity growth, income diversification, and poverty reduction (Pingali & Rosegrant, 1995; Barrett, 2008). Agricultural commercialization enhances productivity, diversifies income sources, and facilitates farmers' integration into broader value chains, thereby improving rural livelihoods and promoting sustainable development (Food and Agriculture Organization [FAO] et al., 2022). Recent global assessments further underscore the need to transform agrifood systems to enhance resilience and strengthen market integration among smallholder farmers.

In Sub-Saharan Africa, smallholder agriculture remains the backbone of rural economies, employing over 60% of the population and playing a central role in food security (FAO, 2023). However, agricultural commercialization remains low due to limited assets, weak infrastructure, inadequate institutional support, risk-averse behaviour, and pathways shaped by structural transformation and persistent household constraints (Barrett, 2008; Dercon, 2002; Liverpool-Tasie et al., 2020; Kilic et al., 2021). At the same time, smallholder production systems are multifunctional, with output allocated to sales, consumption, seed retention, input payments, and social transfers. This highlights the need to view commercialization as a continuum rather than a binary decision.

In Tanzania, the agricultural sector is predominantly composed of smallholder farmers, with over 80% of agricultural households cultivating plots averaging less than two hectares (National Bureau of Statistics [NBS], 2023). These farmers rely on both family and hired labour and allocate their crop output between household consumption and market sales. Staple crops such as maize and rice are crucial for national food security; however, their commercialization remains constrained by poor market access, high transportation costs, limited access to credit and modern inputs, and inadequate market infrastructure (Research on Poverty Alleviation [REPOA], 2024). Further studies indicate that many smallholders remain in low-intensity commercialization regimes, where efforts to expand market participation often conflict with subsistence-security objectives (Mpogole et al., 2023).

Recognizing the importance of agricultural transformation, the Government of Tanzania has implemented several policy initiatives aimed at promoting productivity and commercialization (Carletto et al., 2017). Notable among these are the National Five-Year Development Plan III (United Republic of Tanzania, 2021) and the Comprehensive Africa Agriculture Development Programme (CAADP) which emphasize strengthening market linkages and enhancing the competitiveness of smallholder farmers. Despite these efforts, many farmers continue to operate within a dual production system, balancing the need for household food security with the objective of generating income through market participation (REPOA, 2024).

Grounded in the Agricultural Household Model, this study examines how smallholder farmers in Tanzania allocate crop output between market sales and household consumption. It contributes to the literature in three key ways: (1) comparative analysis of two interrelated output shares—sold and consumed—rather than treating consumption purely as a residual; (2) explicit modelling of family vs. hired labour composition; and (3) application of fractional logit models (Papke & Wooldridge, 1996; Wooldridge, 2010) to recent nationally representative 2022/23 AASS data (n = 8,531). By advancing understanding of how smallholder farmers balance subsistence and market objectives, this study provides insights for designing policies that support inclusive and sustainable agricultural transformation in Tanzania, in line with national development priorities and regional initiatives such as CAADP.

1.1 Statement of the Problem

Smallholder farmers in Tanzania face persistent trade-offs between selling agricultural produce to generate income and retaining it for household consumption, particularly in environments characterized by production risks, market imperfections, and limited access to productive resources (Jayne et al., 2014). Consequently, many households adopt a dual production system that simultaneously supports subsistence needs and market participation (Mpogole et al., 2023).

While numerous studies (Owusu & İşcan, 2021; Mboma et al., 2026; Mpogole et al., 2023) provide valuable insights into the determinants of market participation, they conceptualize commercialization as a binary decision—whether a household sells produce or not. This approach overlooks the reality that smallholders often both sell and consume their output, suggesting commercialization operates along a continuum rather than as a discrete choice. Furthermore, the role of labour composition—particularly the distinction between family and hired labour—in shaping output allocation decisions remains underexplored, despite its importance for scaling market-oriented production. This study addresses these gaps by employing nationally representative data from the 2022/23 Annual Agricultural Sample Survey (AASS) and applying fractional logit models to analyse the shares of crop output sold and consumed using two complementary fractional logit models estimated separately (Vollrath, 1994).

1.2 Research Objectives

i. To examine the extent to which smallholder farmers allocate crop output between market sales and household consumption.
ii. To analyse the factors determining the share of crop output sold versus consumed, with particular emphasis on labour composition (family and hired labour).
iii. To assess the implications of these allocation patterns for subsistence and agricultural commercialisation in Tanzania.

II. LITERATURE REVIEW

2.1 Theoretical Review

The analysis of smallholder crop output allocation is grounded in the Agricultural Household Model (AHM), which integrates production and consumption decisions within a unified framework (Singh et al., 1986). In this model, households are viewed simultaneously as producers and consumers, and decisions regarding how much output to sell versus consume are treated as part of a joint optimization problem. This contrasts with profit-maximizing models that assume separability between production and consumption decisions. The AHM is particularly relevant for smallholder farmers who operate under imperfect markets, limited liquidity, and strong food-security considerations. Let total agricultural output be denoted by Y, which can be allocated between sales (S), household consumption (C), and other uses (O) such as seed retention, storage, in-kind payments, gifts, or post-harvest losses, such that:

$$Y = S + C + O$$

While the theoretical framework recognises multiple output uses, the available survey data do not permit precise and mutually exclusive identification of all components of O across households. Consequently, the empirical analysis focuses on the reported shares sold and consumed as two related allocation outcomes, but not as strictly complementary

proportions summing to one. The household maximizes utility derived from consumption of own-produced food, market purchases, and other goods:

$$\max U(C, X)$$

Subject to the production function

$$Y = f(L, N_f, N_h, K, \theta)$$

Where L represents land, N_f family labour, N_h hired labour, K capital inputs (such as fertilizers and improved seeds), and θ captures technological and environmental factors including irrigation and soil quality. The variable X denotes other goods consumed by the household. In the presence of imperfect markets, production and consumption decisions are non-separable. Shocks to production directly affect consumption, and risk-averse households may retain a buffer stock for self-consumption even when market prices are attractive (Fafchamps, 1992; Barrett, 2008). Increases in output—through expanded land use, greater reliance on hired labour, or technological adoption—may relax subsistence constraints and enable households to allocate a larger share of output to market sales. Conversely, uncertainty and credit constraints may induce precautionary retention of output for consumption. From this framework, the shares of output sold and consumed can be expressed as functions of household characteristics (Z), production inputs, and technological factors:

Share Sold = g (Z, L, N_f, N_h, K, θ)

Share Consumed = $h\ (Z, L, N_f, N_h, K, \theta)$

The inclusion of labour composition—distinguishing between family and hired labour—follows from the observation that labour allocation reflects both production capacity and commercialization intent (Dercon, 2002). Hired labour is typically associated with market-oriented production when family labour is insufficient, whereas family labour is more closely linked to subsistence activities. Consequently, labour structure provides a direct link between the household's production system and its output allocation decisions.

2.2 Empirical Review

The empirical literature on smallholder agriculture increasingly views commercialization as a continuous and multidimensional process, rather than a simple binary decision. Research shows that household assets, market access, and transaction costs are key determinants of market engagement (Barrett, 2008). Building on the seminal insights of Reardon et al. (2009), more recent studies highlight that commercialization evolves gradually and is influenced by technological adoption, value-chain integration, and supportive policies. As a result, commercialization is commonly measured by the share of output sold, which offers a more nuanced perspective than the traditional "sell or not" approach. This is particularly relevant in Sub-Saharan Africa, where farmers both consume and sell their produce under imperfect markets and production risks.

Recent evidence further shows that commercialization pathways are shaped by structural transformation, changing food systems, and household-level constraints (Liverpool-Tasie et al., 2020; Kilic et al., 2021). These findings reinforce the view that commercialization is gradual and context-specific. Despite these advances, limited attention has been given to the joint allocation of output between sales and consumption. Most studies focus on either market participation or the share sold, treating consumption as a residual rather than a jointly determined outcome (Mpogole et al., 2022). Analysing both shares provides deeper insight into the balance between subsistence and commercialization, especially in rural Tanzania.

Labour dynamics remain another underexplored dimension. Evidence shows that labour allocation depends on household composition and seasonal constraints (Dercon, 2002), while hired labour is associated with market-oriented production. However, the distinct roles of family and hired labour in shaping output allocation remain insufficiently examined. This study addresses these gaps by jointly analysing the shares of output sold and consumed, while incorporating labour composition using nationally representative data from Tanzania. By moving beyond aggregate measures and residual assumptions, it provides a more comprehensive understanding of how smallholder farmers allocate output between subsistence and market channels.

III. METHODOLOGY

3.1 Research Design

This study employs a quantitative cross-sectional research design using secondary data from the 2022/23 Annual Agricultural Sample Survey (AASS) conducted by the National Bureau of Statistics. The design enables the examination of relationships between household, farm, and technology characteristics and crop output allocation decisions.

3.2 Types of Data and Sources

This study uses nationally representative secondary data from the National Bureau of Statistics, specifically the Annual Agricultural Sample Survey (AASS) 2022/23. The dataset provides detailed information on agricultural production, input use, labour allocation, and crop utilization at the household level. The dataset includes smallholder farmers cultivating up to 20 hectares of land as defined by AASS 2022/23.

3.3 Sampling and Sample Size

The study uses data from the Annual Agricultural Sample Survey (AASS), which employs a stratified multi-stage sampling design to produce nationally representative estimates. The analysis focuses on smallholder farmers engaged in crop production. From an initial sample of 15,563 households, a final analytical sample of 8,531 households was obtained after excluding observations with missing values in key variables—such as land area, crop sales and consumption ratios, technology indicators, and household characteristics—and omitting households from Zanzibar. Survey weights were applied to ensure population representativeness, and standard errors were clustered at the enumeration-area level.

3.4 Measurement of Key Variables

Table 1 summarizes the definitions and measurements of the dependent and independent variables used in the analysis of crop output allocation among smallholder farmers in Tanzania.

Table 1

Measurement of Key Variables

Variable	Definition/measurement	Type
Dependent Variables		
Share of output sold	Proportion of total crop output allocated to market sales. Constructed from reported percentages and normalized to lie between 0 and 1 **(S_{sold}).**	Continuous (0–1)
Share of output consumed	Proportion of total crop output consumed by the household. Missing consumption shares recoded to zero where appropriate and normalized to lie between 0 and 1 **(S_{cons}).**	Continuous (0–1)
Production Factors		
Farm size	Total cultivated land area in hectares, log-transformed (**$ln\ A$).**	Continuous
Total output	Total crop production measured in kilograms, log-transformed **($ln\ Y$).**	Continuous
Capital inputs	Monetary value of agricultural inputs, log-transformed (**$ln\ K$).**	Continuous
Labour Variables		
Family labour	Total number of family labour days devoted to crop production, log-transformed **($ln\ L_f$).**	Continuous
Hired labour	Total number of hired labour days used in crop production, log-transformed **($ln\ L_h$).**	Continuous
Technology Adoption		
Inorganic fertilizer use	Dummy variable equal to 1 if the household used inorganic fertilizer, 0 otherwise.	Binary
Pesticide use	Dummy variable equal to 1 if the household applied pesticides, 0 otherwise.	Binary
Access to irrigation	Dummy variable equal to 1 if the household had access to irrigation, 0 otherwise.	Binary
Household Characteristics		
Age of household head	Age of the household head categorized into age groups (1= ≤ 30 years; 2 = 31–45; 3 = 46–60 and 4 = > 60)	Categorical
Education	Number of completed years of formal schooling of the household head.	Continuous
Sex	Dummy variable equal to 1 if the household head is female, 0 otherwise.	Binary
Regional dummy variables	Set of dummy variables representing regions to control for spatial heterogeneity in agro-ecological conditions, infrastructure, and market access.	Categorical

Notes: All logarithmic transformations are natural logarithms and are applied to reduce skewness and allow for elasticity interpretation of coefficients. Dependent variables are bounded between 0 and 1, justifying the use of fractional logit regression models. Regional dummy variables help control for unobserved spatial heterogeneity across mainland Tanzania.

3.5 Empirical Strategy

This study analyses how smallholder farmers in Tanzania allocate crop output between market sales and household consumption. The dependent variables—the shares sold and consumed—are fractional proportions bounded between 0 and 1, making linear regression inappropriate. Instead, the study employs the fractional logit model of Papke and Wooldridge (1996), which ensures consistent estimation and predictions within the unit interval. Although sales and consumption decisions are conceptually related, the survey-reported shares are not strictly complementary because some output may be allocated to storage, seed retention, transfers, or may reflect reporting overlap. For this reason, a joint bivariate fractional response framework requiring mutually consistent shares was not preferred. Instead, two separate but comparable fractional logit models are estimated, allowing transparent identification of factors associated with each allocation margin. This approach is parsimonious, robust, and consistent with the available data structure.

$$\mathrm{E}(Y_i / X_i) = \mathrm{G}(X_i\beta)$$

Where Y_i is the share of output sold or consumed for household i, X_i is a vector of explanatory variables and $\mathrm{G}(.)$ is the logistic cumulative distribution function. The estimating equation is:

$$Y_i = G(\beta_0 + \beta_1 lnA_i + \beta_2 lnQ_i + \beta_3 lnK_i + \beta_4 lnL_{fi} + \beta_5 ln\, L_{hi} + \beta_6 Z_i + \beta_7 H_i + \delta_r)$$

Where $ln\ A_i$ represents farm size capturing land endowment (L), $ln\ Q_i$ denotes total agricultural output, capturing the scale of production and the potential marketable surplus available for allocation. $ln\, K_i$ measures capital inputs such as expenditure on seeds, fertilizers, and other farm inputs. $ln\ L_{fi}$ and $ln\, L_{hi}$ family and hired labour corresponding to N_f and N_h respectively, Z_i is a vector of technology adoption variables, including the use of fertilizer, pesticides, and irrigation, capturing technological and environmental factors (θ). H_i household characteristics (age, education, gender), and δ_r region fixed effects capturing spatial heterogeneity. This specification aligns with the agricultural household model, which emphasizes the joint determination of production and consumption decisions under imperfect market conditions.

3.6 Diagnostic Tests

Table 2 presents the diagnostic tests used to assess the adequacy and robustness of the estimated models.

Table 2

Diagnostic Tests for Fractional Logit Models of Crop Output Allocation

Diagnostic Test	Share Sold	Share Consumed	Interpretation
Number of observations	8,531	8,531	Analytical sample after excluding missing values
Overall model significance	F = 35.43***	F = 37.89***	Explanatory variables are jointly significant
Pseudo R^2 (non-survey model)	0.1015	0.0793	Indicates reasonable explanatory power
Mean of observed dependent variable	0.434	0.704	Reflects commercialization and consumption levels
Mean of predicted values	0.434	0.702	Close to observed means, indicating good fit
Range of predicted values	0.010 – 0.949	0.169 – 0.980	Predictions lie within the theoretical bounds (0,1)
Correlation (observed vs. predicted)	0.478	0.482	Moderate predictive accuracy
Mean Variance Inflation Factor (VIF)	1.47	1.47	No evidence of multicollinearity
Maximum VIF	2.79	2.79	Well below the conventional threshold of 10
Presence of boundary values (0 and 1)	Yes	Yes	Justifies use of fractional logit
Robustness check (weighted OLS)	Consistent	Consistent	Confirms stability of coefficients

Notes: *** $p < 0.01$. Pseudo R^2 values are obtained from non-survey fractional logit models for comparison, as they are not available after svy: fracreg. VIF statistics are computed from a weighted linear regression using the same set of explanatory variables. Boundary values refer to the presence of observations equal to 0 or 1 in the dependent variables. Various diagnostic tests (Table 2) confirm the adequacy of the survey-weighted fractional logit models. Based on 8,531 observations, the models are jointly significant ($p < 0.01$) and exhibit reasonable explanatory power. Predicted values closely match observed means and remain within the theoretical bounds [0,1], indicating good model fit. Multicollinearity is negligible (mean VIF = 1.47; maximum VIF = 2.79), and the presence of boundary values supports the use of fractional logit estimation. Robustness checks using weighted OLS and a manual link test further confirm the stability and correct specification of the models. The fractional logit model is particularly suitable because it accommodates dependent variables bounded between 0 and 1, including observations at the boundaries.

IV. FINDINGS & DISCUSSION

4.1 Findings

This section presents the empirical findings on how smallholder farmers in Tanzania allocate crop output between market sales and household consumption, combining descriptive evidence with econometric analysis.

4.1.1 Summary of Descriptive Statistics

The summary of survey-weighted descriptive statistics is presented in Table 3.

Table 3

Summary of Survey-Weighted Descriptive Statistics

Variable	Mean	Std. Error	95% Confidence Interval
Share of output sold	0.460	0.005	[0.451, 0.470]
Share of output consumed	0.697	0.004	[0.689, 0.704]
Log of farm size (ha)	-0.052	0.015	[-0.081, -0.022]
Log of total output	6.252	0.020	[6.213, 6.291]
Log of capital inputs	4.601	0.070	[4.464, 4.739]
Log of family labour	4.916	0.016	[4.885, 4.946]
Log of hired labour	1.615	0.028	[1.561, 1.670]
Use of inorganic fertilizer	0.280	0.006	[0.269, 0.291]
Use of pesticides	0.350	0.006	[0.338, 0.362]
Access to irrigation	0.064	0.003	[0.058, 0.070]
Age category of household head	2.213	0.012	[2.190, 2.237]
Years of education	4.893	0.051	[4.793, 4.992]
Female-headed household	0.260	0.006	[0.249, 0.271]
Education missing	0.224	0.005	[0.214, 0.235]

Notes: The table reports survey-weighted means based on the Annual Agricultural Sample Survey (AASS). Standard errors are linearized to account for the survey design. Binary variables are expressed as proportions. The analytical sample consists of 8,531 households.

Table 3 presents the survey-weighted descriptive statistics of the variables used in the analysis. On average, smallholder farmers in Tanzania sell approximately 46% of their total crop output while consuming about 70%, highlighting the dual role of agricultural production in supporting both subsistence consumption and market participation. The shares sold and consumed are derived from survey responses and overlap due to the inclusion of multiple uses such as storage, seed retention, and transfers, as well as reporting inconsistencies. As a result, they are analysed separately rather than as strictly complementary proportions. The mean value of the logarithm of farm size (−0.052) indicates that most households cultivate relatively small landholdings, averaging approximately one hectare, since $\exp(-0.052) \approx 0.95$ hectares.

Family labour is the dominant source of labour, reflecting the subsistence orientation of smallholder agriculture, although hired labour is also utilized by a significant proportion of households, indicating varying degrees of commercialization. The adoption of modern agricultural technologies remains limited. Approximately 28% of households use inorganic fertilizer, 35% apply pesticides, and only about 6% have access to irrigation. These figures suggest considerable scope for productivity-enhancing interventions. The average household head falls within the middle age categories and has fewer than five years of formal education. Additionally, about 26% of households are female-headed, and roughly 22% of observations had missing information on education, which was addressed using a missing-indicator approach in the regression analysis. Overall, these statistics underscore the heterogeneity of smallholder farming systems in Tanzania and provide important context for interpreting the econometric results on crop output allocation.

4.1.2 Determinants of Share of Output Sold

The results of the survey-weighted fractional logit model for the share of output sold are presented in Table 4. The model is jointly statistically significant, indicating that the included variables explain a substantial portion of the variation in commercialization behaviour among smallholder farmers.

Table 4

Determinants of Crop Output Allocation among Smallholder Farmers

Variable	Share Sold	Share Consumed
Log of farm size (ha)	0.029*** (0.0066)	0.055* (0.0296)
Log of total output	0.052*** (0.0043)	-0.321*** (0.0211)
Log of capital inputs	0.004*** (0.0012)	-0.018*** (0.0052)
Log of family labour	0.019*** (0.0044)	0.006 (0.0182)
Log of hired labour	0.015*** (0.0021)	-0.099*** (0.0083)
Use of inorganic fertilizer	0.016 (0.0142)	-0.087 (0.0613)
Use of pesticides	0.051*** (0.0117)	-0.062 (0.0485)
Access to irrigation	0.052*** (0.0188)	-0.266*** (0.0753)
Age group 2	-0.045*** (0.0107)	0.296*** (0.0461)
Age group 3	-0.053*** (0.0140)	0.278*** (0.0583)
Age group 4	-0.084*** (0.0152)	0.454*** (0.0628)
Years of education	0.003* (0.0016)	-0.007 (0.0070)
Education missing	-0.010 (0.0145)	0.025 (0.0618)
Female-headed household	-0.006 (0.0102)	-0.061 (0.0447)
Region fixed effects	Yes	Yes
Observations	**8,531**	**8,531**

Notes: The table reports average marginal effects from survey-weighted fractional logit models. Standard errors are presented in parentheses. Reference categories are Age Group 1 and Region 1. All models include regional fixed effects. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4 reveals that production factors play a central role in shaping output allocation decisions. Farm size (ln A) has a positive and statistically significant effect on the share of output sold; a one-unit increase in $ln\ A$ increases the share sold by approximately 2.9 percentage points. Similarly, total output ($ln\ Y$) exhibits a strong positive association with commercialization, a one-unit increase in $ln\ Y$ is associated with an increase of approximately 5.2 percentage points, indicating that higher production relaxes subsistence constraints and enables greater market participation. Capital inputs ($ln\ K$) also have a positive, though relatively modest, effect, increasing the share sold by about 0.4 percentage points. Labour variables are particularly important in explaining commercialization. Both family labour ($ln\ L_f$) and hired labour ($ln\ \ L_h$) are positively and significantly associated with the share of output sold. A one-unit increase in family labour increases the share sold by approximately 1.9 percentage points, while hired labour increases it by about 1.5 percentage points. These findings suggest that labour availability—both within and outside the household—facilitates market-oriented production.

Technology adoption further enhances commercialization. The use of pesticides and access to irrigation significantly increase the share of output sold by approximately 5.1 and 5.2 percentage points, respectively, reflecting productivity gains and improved market integration. In contrast, the effect of inorganic fertilizer is positive but not statistically significant. The relatively large but statistically insignificant coefficient on inorganic fertilizer may reflect heterogeneity in application intensity, timing, soil responsiveness, or the binary nature of the variable, which captures use but not quantity or efficiency.

Among household characteristics, the age of the household head is negatively associated with commercialization. Compared with the youngest age group, households headed by individuals in age groups 2, 3, and 4 sell 4.5, 5.3, and 8.4 percentage points less, respectively. This suggests that younger farmers are more likely to engage in market-oriented production. Education has a positive but statistically weak effect, while female-headed households do not differ significantly from male-headed households in their commercialization behaviour. These results highlight that commercialization is not merely driven by market incentives but is fundamentally constrained by production capacity and household resource endowments.

4.1.3 Determinants of the Share of Output Consumed

The results of the fractional logit model for the share of output consumed provide complementary insights into smallholder production behaviour. Overall, the findings reveal patterns that mirror those observed for the share of output sold, highlighting the trade-offs inherent in output allocation decisions.

Production factors significantly influence consumption behaviour. Total output ($ln\ Y$) has a strong and statistically significant negative effect on the share consumed, indicating that higher production levels reduce reliance on subsistence consumption. Specifically, a one-unit increase in $ln\ Y$ decreases the share consumed by approximately 32.1 percentage points, suggesting that increased productivity enables households to allocate a larger portion of their

output to market sales. Capital inputs ($ln\ K$) also reduce the share consumed by about 1.8 percentage points while farm size ($ln\ A$) has a positive but only weakly significant effect, indicating a modest tendency for larger farms to retain more output for consumption.

Labour dynamics further reinforce this pattern. Hired labour ($ln\ L_h$) has a negative and statistically significant effect on the share of output consumed, reducing it by approximately 9.9 percentage points. This implies that households employing hired labour are more commercially oriented and less reliant on subsistence production. In contrast, family labour ($ln\ L_f$) does not have a statistically significant effect on consumption shares, suggesting that it supports both subsistence and market-oriented activities without strongly shifting allocation decisions.

Technology adoption also influences consumption behaviour. Access to irrigation significantly reduces the share consumed by about 26.6 percentage points, underscoring its role in promoting commercialization and reducing dependence on subsistence production. The effects of pesticide and inorganic fertilizer use are not statistically significant, indicating more limited influence on consumption decisions.

Among household characteristics, the age of the household head is positively associated with the share of output consumed. Compared with the youngest age group, households headed by individuals in age groups 2, 3, and 4 consume 29.6, 27.8, and 45.4 percentage points more, respectively. This indicates that older farmers are more likely to prioritize subsistence production, possibly reflecting greater risk aversion or lower engagement with markets. Education and gender of the household head do not have statistically significant effects on consumption behaviour.

4.2 Regional Effects

Regional fixed effects were included in all model specifications to control for spatial heterogeneity. The detailed marginal effects for each region are presented in Table 5.

Table 5

Fractional Logit Estimates of Regional Effects on Crop Output Allocation

Region (Base = Arusha)	**Share Sold (b/se)**	**Share Consumed (b/se)**
Arusha	0.000 (.)	0.000 (.)
Dar es Salaam	-0.043 (0.026)	0.432*** (0.107)
Dodoma	-0.071* (0.028)	0.824*** (0.108)
Geita	-0.019 (0.021)	0.212** (0.081)
Iringa	-0.021 (0.026)	-0.126 (0.095)
Kagera	0.012 (0.034)	0.345* (0.134)
Katavi	0.070 (0.058)	-0.171 (0.292)
Kigoma	0.243*** (0.028)	0.241 (0.138)
Kilimanjaro	0.079 (0.042)	0.113 (0.150)
Lindi	0.013 (0.023)	0.544*** (0.096)
Manyara	-0.149*** (0.024)	0.473*** (0.096)
Mara	-0.047* (0.023)	0.499*** (0.094)
Mbeya	-0.070** (0.025)	0.796*** (0.095)
Morogoro	-0.196*** (0.020)	1.011*** (0.086)
Mtwara	-0.051* (0.025)	-0.001 (0.107)
Mwanza	-0.127*** (0.037)	0.717*** (0.171)
Njombe	-0.205*** (0.024)	1.403*** (0.107)
Pwani	0.027 (0.027)	0.337*** (0.101)
Rukwa	-0.129*** (0.023)	0.947*** (0.095)
Ruvuma	-0.211*** (0.030)	1.172*** (0.160)
Shinyanga	0.026 (0.027)	0.301** (0.105)
Simiyu	-0.130*** (0.027)	0.527*** (0.120)
Singida	-0.024 (0.078)	0.479 (0.277)
Songwe	0.144** (0.054)	1.001*** (0.215)
Tabora	-0.070** (0.026)	0.810*** (0.104)
Tanga	-0.057* (0.022)	0.702*** (0.091)
Observations	**8,531**	**8,531**

Notes: Coefficients are reported with robust standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. Arusha region is the reference category.

The regional effects in Table 5 show clear heterogeneity in commercialisation patterns across mainland Tanzania. Several regions have significantly lower shares of output sold and higher consumption shares than Arusha, indicating stronger subsistence orientation, while others are more commercialised. Kigoma and Songwe, for example, show relatively higher marketed shares, suggesting stronger market orientation. In contrast, Morogoro, Njombe, and Ruvuma record significantly lower sales shares and higher consumption, reflecting greater reliance on subsistence production. Similar patterns are observed in Manyara, Mwanza, Rukwa, Simiyu, Tabora, and Tanga, which also have lower marketed shares than the reference region. These differences are likely driven by variation in market access, infrastructure, agro-ecological conditions, crop mix, and transaction costs. Better-connected regions with favourable production conditions tend to generate higher marketable surplus, while more remote or constrained areas remain subsistence-oriented.

4.3 Discussion

The findings provide strong empirical support for the Agricultural Household Model (Singh et al., 1986), which posits that production and consumption decisions are jointly determined under imperfect market conditions. The observed allocation of crop output between sales and household consumption confirms the non-separability of these decisions, as households balance income generation with food security objectives. The positive effects of total output and farm size on the share of output sold, alongside their negative association with the share consumed, indicate that increased productivity relaxes subsistence constraints and enables greater market participation, consistent with theoretical expectations. These results highlight the central role of productive capacity in shaping commercialisation outcomes.

The significant role of production capacity aligns with empirical evidence emphasizing asset endowments as key drivers of commercialization. Barrett (2008) demonstrate that households with greater access to land and productive resources are more likely to generate marketable surplus and engage in agricultural markets. Similarly, the positive influence of capital inputs corroborates which underscore the importance of input use and productivity-enhancing investments in facilitating commercialization among Tanzanian smallholders.

Labour dynamics emerge as a critical determinant of output allocation. Hired labour uniquely enables households to expand production beyond subsistence thresholds, significantly reducing consumption shares while family labour maintains dual subsistence-market roles. This distinction supports Dercon (2002) who link rural labour market participation with commercialization and income diversification. The findings echo recent evidence that commercialization pathways in Sub-Saharan Africa reflect both structural transformation and persistent household constraints (Liverpool-Tasie et al., 2020) with labour composition serving as a key mechanism. The positive effects of technology adoption, particularly irrigation and pesticide use, further reinforce the transition toward commercialization. These results align with Reardon et al. (2009) and Khadjavi et al. (2024), which emphasize technological change and infrastructure in enhancing productivity and facilitating market integration. Irrigation, in particular, reduces production risk and stabilizes yields, enabling households to allocate a greater share of output to sales.

Demographic characteristics also shape allocation decisions. The tendency of older household heads to allocate a larger share of output to consumption supports the notion of risk-averse behaviour and stronger emphasis on food security, as suggested by Fafchamps (1992) and Barrett (2008). Conversely, the modest positive influence of education on commercialization, which highlights human capital's role in improving market information access and decision-making. Regional disparities reflect structural and geographic constraints. Variation in market access, infrastructure, and agro-ecological conditions explains differences in commercialisation, with some regions more market-oriented and others subsistence-based. This confirms that commercialisation is shaped not only by household factors but also spatial constraints, supporting region-specific policies. Similar evidence shows that infrastructure and market access strongly affect commercialisation, especially in remote areas with high transaction costs (Abdul Latif Jameel Poverty Action Lab [J-PAL] & Center for Effective Global Action [CEGA], 2024; Khadjavi et al., 2024).

Overall, the comparative analysis of output shares extends the Agricultural Household Model by confirming non-separability under imperfect markets, addressing a gap where consumption is often treated as residual. The results further show that labour composition mediates the subsistence–commercialisation transition, highlighting key structural and household drivers. It should also be noted that the regional fixed effects capture unobserved spatial heterogeneity but do not directly measure specific mechanisms such as transaction costs, road quality, distance to output markets, storage availability, or local price conditions. Future research using geospatial and market-access indicators could more precisely identify how these factors influence crop commercialisation decisions. A further limitation of this study is the cross-sectional nature of the data, which restricts causal interpretation and limits analysis of dynamic commercialisation pathways over time.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study examined how smallholder farmers in Tanzania allocate crop output between household consumption and market sales, and identified the key factors shaping these decisions. The findings confirm that Tanzanian smallholders operate along a subsistence–commercialisation continuum, with production capacity, labour composition, and technology adoption acting as key drivers of transition. In particular, hired labour plays a distinct role in enabling market-oriented production, while family labour supports both subsistence and commercial activities. Overall, the results reinforce the non-separability of production and consumption decisions and highlight labour dynamics as a central mechanism shaping output allocation among smallholder farmers.

5.2 Recommendations

Based on the findings of this study, the following policy and research recommendations are proposed to enhance agricultural commercialisation in Tanzania. Policy efforts should prioritise strengthening productive capacity among smallholder farmers through improved access to land, capital inputs, and productivity-enhancing technologies, consistent with the National Five-Year Development Plan III objective of modernising agriculture and expanding market participation. Expanding irrigation, modern inputs, and extension services can help farmers generate sufficient marketable surplus to move beyond subsistence production. At the same time, strengthening rural labour markets is essential, particularly by improving access to hired labour, which this study identifies as an important driver of market-oriented production. This aligns with national employment creation and rural transformation priorities under Tanzania Development Vision 2025.

In addition, policies should promote youth engagement in agriculture to address the tendency of older farmers to prioritise subsistence production. Encouraging youth participation through targeted training, access to finance, and agribusiness opportunities can support a more dynamic and market-oriented agricultural sector. Given the significant regional disparities identified, investments in rural infrastructure—especially roads, market facilities, and storage systems should be spatially targeted to reduce transaction costs and improve market access in lagging regions.

Furthermore, policy interventions should adopt an integrated approach aligned with national and regional development frameworks, including Tanzania's National Five-Year Development Plan III and the Comprehensive Africa Agriculture Development Programme (CAADP). Such coordination can enhance the effectiveness of efforts aimed at promoting inclusive and sustainable agricultural transformation. Future research should build on these findings by employing longitudinal or panel data to better capture the dynamic nature of commercialisation and its long-term welfare implications. Additional research on intra-household decision-making and gender dynamics would provide deeper insight into how production and consumption decisions are negotiated within households. These efforts would contribute to a more comprehensive understanding of pathways towards sustainable and inclusive agricultural development in Tanzania.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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