

Farm and household characteristics and their influence on participation intensity for avocado farming in Njombe

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Recommended Reference: Chamy, S. J., Temu, A., & Hokororo, S. (2026). Farm and household characteristics and their influence on participation intensity for avocado farming in Njombe. *African Quarterly Social Science Review*, 3(4), 135–146.

<https://doi.org/10.51867/AQSSR.3.4.11>

ABSTRACT

Avocado has emerged as one of the most rapidly expanding horticultural enterprises in the Southern Highlands of Tanzania, yet the extent to which smallholder farmers commit themselves to the crop varies sharply from one household to the next. This study examines the farm and household characteristics that shape the intensity of smallholder participation in avocado farming in Njombe Region. Theory of Perception and Agricultural Household Model guided this study. A cross-sectional research design was adopted and primary data were collected from 305 randomly selected smallholder avocado farming households in Njombe Town Council and Njombe District Council. Households were classified into three participation intensity categories on the basis of avocado tree counts, namely low (5–99 trees), moderate (100–249 trees) and high (250 trees and above). Primary data was collected from the avocado farming households using household surveys. The interviews with respondents in the survey was carried through designed and pre tested questionnaires. A multinomial logit model with the low intensity class as the base outcome was fitted to identify the factors influencing the probability of falling into each intensity class, and average marginal effects were computed for ease of interpretation. The marginal effect of supplemental irrigation on the probability of being a high-intensity farmer was 0.230, the largest of any covariate, while registration in a marketing group raised the same probability by 0.168. The findings suggest that the transition from low to high intensity in avocado farming in Njombe is not driven by farm size or experience alone, but by a coordinated bundle of institutional, infrastructural and human-capital assets. Policy support that targets these specific assets, particularly irrigation investment and farmer-group formation, is therefore likely to be the most effective in deepening smallholder participation in the avocado subsector. The study concludes that the transition from low to high participation intensity in Njombe's avocado subsector is driven by a coordinated bundle of institutional, infrastructural, and human capital assets rather than by farm size or experience alone. It is therefore recommended that extension and local government agencies prioritise investments in supplemental irrigation infrastructures and actively support the formation and strengthening of farmer marketing groups, as these were the two strongest levers for deepening smallholder participation identified in this study.

Keywords: Avocado Farming, Participation Intensity, Njombe, Multinomial Logit, Marketing Groups, Supplemental Irrigation, Smallholder Farmers

I. INTRODUCTION

Avocado (*Persea americana*) farming has emerged as a high-value agricultural enterprise with increasing relevance for smallholder livelihoods in Sub-Saharan Africa. Known as “green gold,” avocado production has expanded rapidly over the past decade due to rising global demand, growing export opportunities, and its potential to generate sustainable income for rural households (Kingu & Kinyondo, 2024). In Tanzania, particularly in the Southern Highlands and Njombe Region, avocado cultivation has gained momentum as farmers diversify away from traditional staple crops toward more profitable horticultural commodities (Jettah et al., 2025). This shift reflects broader trends in agricultural commercialization in low-income countries, where smallholders increasingly engage in market-oriented production to improve household welfare (Sumari et al., 2020; Ngenoh et al., 2019).

Despite the socioeconomic potential of avocado farming, participation among smallholder farmers in Njombe is heterogeneous, varying not only between households but within households across different decisions related to farm use, income expenditure, and labor allocation (Swai & Ubaldus, 2023). Understanding the intensity of participation defined as the degree to which households allocate land, labor, and resources to avocado production is crucial for developing targeted interventions that support equitable and inclusive growth in the sector. Farm and household characteristics such as farm size, education, access to credit, gender dynamics in decision-making, and infrastructure can significantly shape participation intensity, yet empirical evidence in the Tanzanian context remains limited (Sambuo

& Safari, 2025). This study investigates how key farm and household attributes influence the intensity of participation in avocado farming in Njombe, thereby providing insights that can inform policy and extension strategies for sustainable agricultural development.

Avocado farming in Tanzania has transitioned from niche cultivation to a more commercially oriented enterprise, particularly in the Southern Highlands. In Njombe, land previously used for annual staple crops is increasingly diverted to avocado cultivation, reflecting farmers' responses to market signals and potential for higher returns (Jettah *et al.*, 2025). Evidence suggests that this rapid expansion has implications for local food crop production and household food security, indicating tradeoffs that smallholder farmers navigate when allocating limited land resources (Jettah *et al.*, 2025). Moreover, avocado production is reported to contribute to household income diversification and improved livelihood outcomes, though the degree of benefit varies across households based on socio-economic factors and farm attributes (Malekela, 2022; Kingu & Kinyondo, 2024).

Research on agricultural participation intensity highlights the importance of household demographics, human capital, and institutional factors in shaping farmers' engagement in specific enterprises. Household decision-making dynamics, particularly regarding income use and plot allocation for avocado farming, are often gendered, with men predominating in strategic decisions and women frequently relegated to implementation roles (Swai & Ubaldus, 2023). Such intra-household dynamics can influence how much land and labor households commit to avocado production. Similarly, access to credit, infrastructure, and advisory services are recognized as critical enablers of participation in high-value crop production, enhancing farmers' ability to invest in inputs and market transactions (Sambuo & Safari, 2025; Ngenoh *et al.*, 2019).

Farm characteristics such as size, tenure security, and resource endowments also significantly affect participation intensity. Larger farms tend to have more capacity to diversify into high-value crops, while smaller plots may constrain investment and limit production scale (Sumari *et al.*, 2020; Ngenoh *et al.*, 2019). Access to extension services and market information can further differentiate high-participation households from those with limited engagement, as they enable farmers to adopt improved practices and negotiate better market terms (Sumari *et al.*, 2020; URT, 2025). Despite recognition of these determinants in other agricultural contexts, specific empirical evidence linking farm and household characteristics to avocado participation intensity in Njombe remains scarce, highlighting the need for focused investigation.

Against this backdrop, the present study pursues a single principal objective, namely to examine how farm and household characteristics influence the intensity of smallholder participation in avocado farming in Njombe Region. The specific contribution of the paper is twofold. First, it provides a quantitative classification of avocado farmers in Njombe along three intensity categories using avocado tree counts as the indicator of participation depth. Second, it uses a multinomial logit model with average marginal effects to identify the precise farm and household characteristics that drive movement between these categories, distinguishing between determinants of moderate participation and determinants of high participation. The findings are intended to inform agricultural extension, rural finance and value-chain development efforts in the Southern Highlands of Tanzania. The study mainly intends to assess the determinants of smallholder farmers' participation in avocado farming in Njombe region.

1.1 Research Objective

To assess farm and household characteristics that influence the intensity of smallholder farmers' participation in avocado farming in Njombe region.

II. LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Theory of Perception

James J. Gibson's Theory of Perception, introduced in his 1979 work "The Ecological Approach to Visual Perception," emphasizes the direct relationship between perceivers and their environment. The theory's key concept is "affordances," which are the action opportunities that objects and environments offer, perceived directly without cognitive processing. Gibson argued that perception is an active, continuous process of picking up information from the environment, focusing on detecting invariants stable properties that remain constant despite changes in perspective. In the context of avocado farming, understanding farmers' perceptions of benefits and challenges is crucial for promoting adoption and sustained engagement in avocado farming. Perception in this context is reliant on livelihood outcomes, risks, and challenges accrued during avocado farming (Mlambo *et al.*, 2024).

While Gibson's framework is useful for understanding how farmers read and act upon environmental cues, its application to participation intensity requires an explicit bridge between the perceptual constructs it offers and the measurable farm and household variables used in this study. Following this logic, infrastructural and institutional assets such as supplemental irrigation, marketing-group membership, and access to extension and credit are treated as

environmental affordances: objectively present opportunities for commercial deepening that are only acted upon when a household possesses the complementary human and social capital needed to perceive and exploit them. A household head with more schooling, for instance, is better placed to recognize irrigation or group membership as an actionable opportunity for intensification, whereas a less-educated head facing the same environmental conditions may not translate the same favorability into a comparable production response. This reasoning motivates the inclusion of socio-demographics which are human-capital variables (age, education) alongside infrastructural and institutional variables in the empirical model, since perception theory implies that the two must be considered together rather than as competing propositions.

2.1.2 Agricultural Household Model

Because perception theory speaks primarily to how opportunities are recognized rather than to how scarce household resources are allocated once an opportunity has been recognized, the study also draws on the Agricultural Household Model (Singh *et al.*, 1986), which treats the farm household simultaneously as a production unit and a consumption unit operating under conditions of missing or thin labour, credit and insurance markets. Under this framework, decisions about labour allocation, land allocation to a long-gestation perennial crop, and the use of off-farm income are made jointly and are shaped by the household's endowments of land, labour and capital, and by the shadow prices that emerge when markets fail to clear. The model provides a direct theoretical rationale for including household labour force, marital status, off-farm income and access to credit as explanatory variables: in a setting of imperfect labour and credit markets, a larger effective labour force (via marriage or household size) relaxes the labour constraint on establishing and maintaining a perennial orchard, while access to credit relaxes the liquidity constraint that would otherwise bind given avocado's delayed returns. Off-farm income enters the model ambiguously, since it can either relax the liquidity constraint (encouraging intensification) or raise the opportunity cost of household labour devoted to the farm (discouraging intensification).

2.2 Empirical Review

Empirical evidence on avocado farming in Tanzania and the wider East African region remains comparatively young but is expanding rapidly. In Tanzania, Jettah *et al.* (2025) documented the rapid conversion of land from staple food crops to avocado in the Southern Highlands and highlighted the food-security trade-offs this conversion can create, while Sambuo and Safari (2025) examined the drivers of contract-farming adoption among avocado growers in Njombe District and found that credit inclusiveness and infrastructure accessibility were significant predictors of contract uptake, a finding broadly consistent with the roles played by credit and irrigation infrastructure in the present study. Kingu and Kinyondo (2024) similarly reported that avocado export participation in Wanging'ombe District was associated with household asset endowments and market access, reinforcing the view that commercial deepening in Tanzanian avocado systems is asset-driven rather than a function of farm size alone. In neighbouring Kenya, Amare *et al.* (2019) used a switching-regression framework to show that participants in avocado export markets were systematically older, better trained and more likely to grow the Hass variety and to live near a functioning marketing group than non-participants, a pattern that closely equates the marketing-group and Hass-variety effects identified in Section 4.4 of this study. Kwizerimana *et al.* (2023) further demonstrated, using data from Murang'a County, that collective marketing participation raised smallholder avocado incomes, lending additional support to the marketing-group findings reported here.

Beyond avocado specifically, a wider literature on participation intensity in other perennial cash crops offers useful points of comparison. In Ghana's cocoa sector, Aneani *et al.* (2012) found that farmer characteristics, including education and access to extension, jointly predicted the extent of technology adoption and, indirectly, production intensity, while in Ethiopia's coffee sector Minten *et al.* (2018) showed that certification participation, a proxy for commercial depth, was systematically related to household asset endowments and market linkages. Both studies, like the present one, treat participating in avocado farming as a graded rather than binary outcome, an approach that is comparatively rare in the smallholder-commercialisation literature, which more commonly models participation as a binary market-access decision. This gap is important, because pooling moderate and high-intensity farmers into a single 'participant' category, as much of the binary-choice literature implicitly does, would mask participation levels, a fair participation status metric, this is a distinction that is only visible when intensity is modelled as an ordered or multinomial outcome, consistent with Rapsomanikis's (2015) broader characterisation of smallholder heterogeneity across nine countries.

Methodologically, studies of participation intensity in the literature have used a variety of proxies, including the share of cultivated land allocated to the crop, the share of household income derived from it, and, as in Parker *et al.* (2019) and the present study, the count of productive trees or plants. Tree-count measures have the advantage of being directly observable and less prone to recall bias than income-share measures, but they are less sensitive to differences in husbandry quality or yield per tree, meaning that two farmers with the same tree count may in practice occupy different

points on the underlying commercialisation continuum. This measurement limitation is acknowledged in Section 5.1 and should be borne in mind when comparing the magnitudes reported here with studies that use income- or land-share-based intensity measures.

III. METHODOLOGY

3.1 Research Design

A cross-sectional research design was adopted to examine the influence of farm and household characteristics on participation intensity in avocado farming in Njombe. The design was appropriate because it enabled the study to collect data from avocado farming households at a single point in time, thereby providing a snapshot of their socioeconomic and farm characteristics and levels of participation in avocado production. It was also suitable for examining relationships between the identified characteristics and participation intensity without requiring prolonged follow-up of the respondents.

3.2 Study Area

The study was conducted in Njombe Region, located in the Southern Highlands Zone of Tanzania. Geographically, the region lies between latitudes 8°40' and 10°32' South and longitudes 33°47' and 35°45' East. Njombe Region is bordered by Iringa Region to the north, Morogoro Region to the east, Mbeya Region to the west, Ruvuma Region to the south, and the Republic of Malawi via Lake Nyasa to the northwest. Njombe Region is characterized by a cool highland climate, fertile volcanic soils, and relatively reliable rainfall, conditions that are well suited for perennial horticultural crops, including avocado. These agro-ecological advantages have positioned the region as one of Tanzania's emerging avocado-producing areas, with increasing adoption of avocado farming among smallholder households.

3.3 Target Population

The target population comprised households engaged in avocado farming in Njombe Region. The study focused on household heads or other household members directly involved in avocado production and decision-making, as they were considered to possess relevant information on household characteristics, farm characteristics, and the extent of participation in avocado farming. The target population was drawn from the selected avocado-producing areas of Njombe where avocado farming constitutes an important agricultural activity.

3.4 Sampling and Sample size

To obtain the sample size the Yamane (1967) formula was used where the population size of avocado farmers was known. The population was obtained from most recent national agricultural survey of 2022/2023, which stated that there are nearly 195 146 avocado farming households in Njombe. This study deals with farmers with different intensities of avocado farming, the aforementioned farming households are considered as N (study population) while e is the margin of error (5%) as calculated in the formula hereunder;

$$n = \frac{N}{1 + N(e)^2} \text{-----}(1)$$

$$n = \frac{195,146}{1 + 195,146 (0.05)^2} = 399 \text{ Avocado farming households.}$$

Sample households were drawn using proportionate simple random sampling from the sampling frames of registered avocado-farming households maintained by the ward agricultural offices in Njombe Town Council and Njombe District Council, with the target of 399 allocated across the two councils in proportion to their respective avocado-farming household populations. Therefore, a total of 399 farming households were supposed to be drawn randomly from the target population for data collection; however, owing to time and logistical constraints in the data-collection work plan, most notably the limited number of enumerator-days available relative to the wide dispersion of avocado-growing wards across the two councils, 305 respondents were ultimately interviewed, an achievement rate of 76.4%. This achievement rate compares favourably with the average response rate of 52.7 % reported for individual-level survey research by Baruch and Holtom (2008), and the realised sample of 305 households remains well above the minimum required for stable estimation of a multinomial logit model with the number of explanatory variables used here (Long and Freese, 2006; Bolarinwa, 2020). The findings should nonetheless be generalized to the wider Njombe avocado-farming population with appropriate caution, and replication with a fully realized sample is recommended as an avenue for future research.

3.5 Data source

Primary data was collected from the avocado farming households using household surveys. The interviews with respondents in the survey was carried through designed and pre tested questionnaires. The information collected includes (but not limited to) resources owned by household, farming production (plant densities for capturing intensity of participation) and other related data like household income flow and food consumption patterns. In addition, data was collected using KoBo Tool Box which was installed in tablets and being used to collect information from respondents.

3.6 Data Analysis

3.6.1 Farm and Household Characteristics

The descriptive analysis was firstly used to assess and understand the farm and household characteristics of the avocado farmers in the area. The analysis includes the use of statistical measures such as mean, standard deviations and percentages to give awareness and understanding of the selected farming household in terms of social, economic and institutional characteristics in Njombe region.

3.6.2 Participation Intensity to Avocado Farming in Njombe

The second stage was inferential. A multinomial logit model with low intensity as the base outcome was estimated to identify the factors influencing the probability of being in the moderate or high intensity category. The choice of the multinomial logit framework over a simple binary probit reflects the categorical and unordered nature of the outcomes from a behavioural standpoint, since households at the low end of the distribution are typically dominated by the constraints they face, those in the middle are usually transitioning, and those at the top tend to be commercially oriented. Average marginal effects were computed instead of raw coefficients in order to make the magnitudes economically interpretable. The model is specified as follows:

The multinomial logit model for the participation decision is specified below.

$$P(Y = j | X) = \frac{\exp(X\beta_j)}{1 + \sum \exp(X\beta_j)} \text{ for } j = 0, 1, 2 \text{ -----(2)}$$

where Y denotes the participation intensity category (0 = low, 1 = moderate, 2 = high), X is a vector of explanatory variables, and β is the corresponding parameter vector for category j . The explanatory variables include household head age, gender, marital status, education, household labour force, avocado farming experience, main variety planted, source of seedlings, access to extension services, access to credit, registration in a marketing group, presence of supplemental irrigation, presence of off-farm income, and interest in value addition. Statistical significance was assessed at the 1, 5 and 10 percent levels.

3.7 Ethical Consideration

Ethical considerations were observed throughout the study. Participation was voluntary, and respondents were informed about the purpose of the study before providing informed consent. They were assured that the information provided would be treated confidentially and used strictly for academic purposes. Respondents were also informed of their right to decline participation or withdraw from the study at any stage without penalty. No personal information that could directly identify individual respondents was disclosed in reporting the findings.

IV. FINDINGS & DISCUSSION

4.1 Farming household characteristics

Table 1 presents the summary statistics of the sampled households. The average household head was 48 years old, with about 11 years of formal schooling, suggesting that the typical respondent had attained at least lower-secondary education. The average household had roughly two members available for farm labour, and 63 percent of the households were male-headed. Cultivated land averaged 6.7 acres but ranged widely (1–35 acres), reflecting considerable heterogeneity in farm scale. Avocado farming experience averaged six years indicating avocado farming is still new cultivation enterprise in the area. The average number of avocado trees per acre was 125 (range 7–200), suggesting a dominance of moderate-scale growers.

Table 1*Avocado Smallholder Characteristics*

Variable	Mean	Standard Deviation	Minimum	Maximum
Household head age	48.121	10.363	27	71
Household head years spent in education	10.81	3.179	0	17
Household labor force	2.187	1.086	1	6
Household head gender	.633	.483	0	1
Total land cultivated	6.695	7.367	1	35
Main land tenure	.681	.483	0	1
Household head experience in avocado	6	2.893	1	15
Main Variety planted	.692	.463	0	1
Number of avocado trees	125	59	7	200
Source of avocado seedlings	.662	.474	0	1

Note on variable coding: Main land tenure = 1 if the household holds formal/documented tenure (e.g. a Certificate of Customary Right of Occupancy or equivalent title), 0 if tenure is informal or undocumented (including customary allocation without documentation, inheritance without formal transfer, or borrowed/rented land); Household head gender = 1 if male, 0 if female; Main variety planted = 1 if predominantly Hass, 0 if other/local variety; Source of avocado seedlings = 1 if obtained primarily from a formal, registered nursery, 0 if from an informal source (own trees, neighbours or informal traders). These binary codings capture category but not within-category quality variation; this is discussed as a measurement limitation in Section 5.1.

Nearly 68 percent of farmers had formal land tenure, an essential factor that may encourage long-term investment in a perennial crop. Avocado farming experience averaged six years (range 1–15), suggesting the crop is relatively new in the area. Almost 70 percent of farmers grew the main improved variety (predominantly Hass), and about 66 percent obtained their seedlings from formal sources/nurseries indicating higher chance of using clean seed planting materials.

4.2 Use of support services

Table 2 reports household access to extension, credit and farmer-group membership. Slightly less than 40 percent of farmers reported any contact with extension services in the year preceding the survey, while membership in collective marketing groups stood at 36.4 percent. Average reported credit used for avocado farming was very low (TZS 9,836 per household), with most households reporting zero borrowing, although a few outliers had borrowed up to TZS 1.5 million for running avocado enterprise directly. The pattern points to a generally weak institutional support environment in the study area.

Table 2*Use of Support Services among Avocado Farmers in Njombe*

Variable	Mean	SD	Minimum	Maximum
Interactions with extension officers	.39	.489	0	1
Borrowings for avocado investment	9836.41	106846.08	0	1500000
Membership in collective action	.364	.482	0	1

4.3 Participation intensity in avocado farming

Following Parker *et al.* (2019), participation intensity was classified into three groups: low (5–99 trees per homestead), moderate (100–249 trees) and high (250 trees and above). In the 305 households, 29.2 percent (89 farmers) were classified as low-intensity, 34.1 percent (104 farmers) as moderate-intensity and 36.7 percent (112 farmers) as high-intensity. The fact that more than 70 percent of farmers fell into the moderate or high groups suggests that avocado is moving well beyond a supplementary crop and is becoming a dominant commercial activity in the study area.

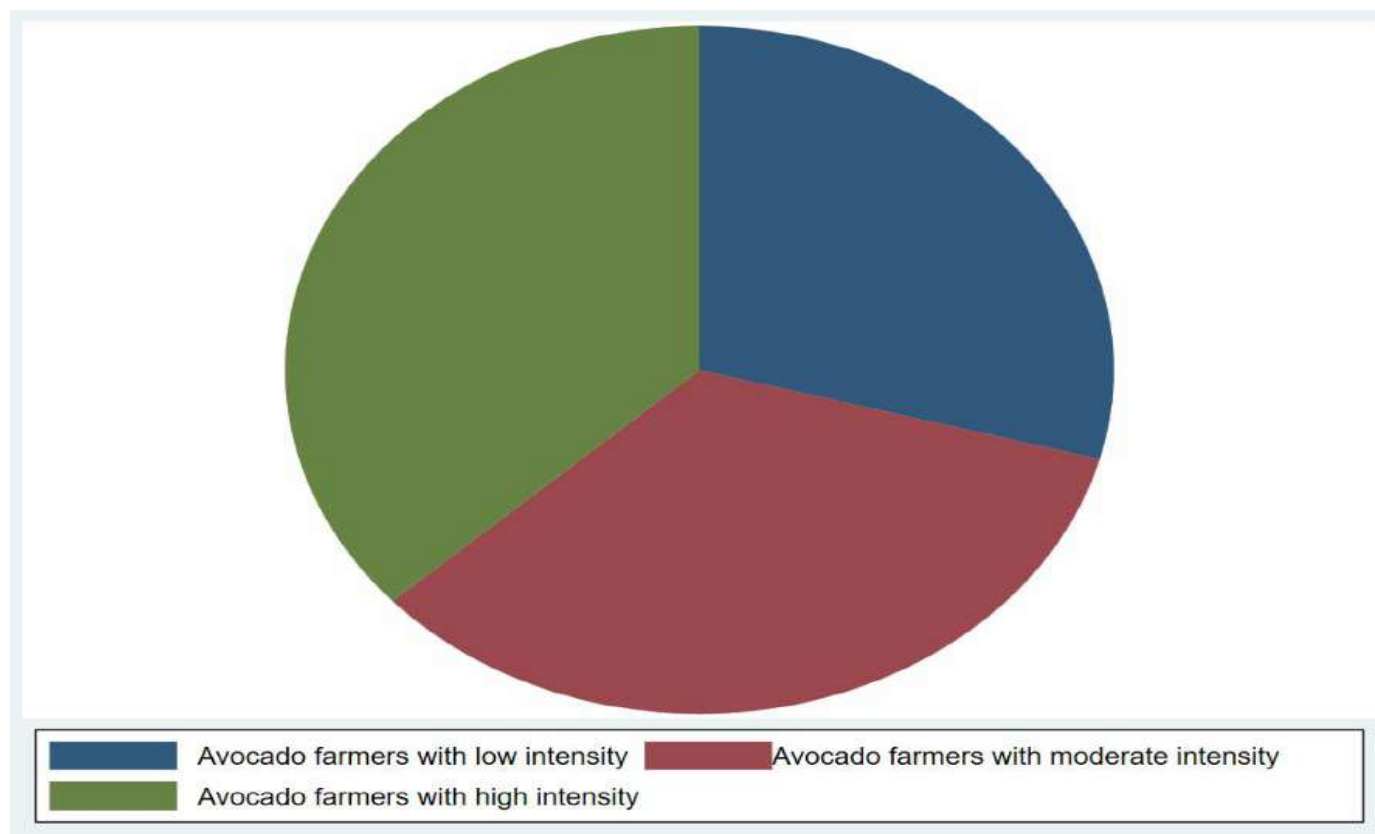


Figure 1
Distribution of Participation Intensity among Surveyed Farmers

4.4 Average marginal effects for participation intensity

Following the multinomial logit estimation, average marginal effects were computed for each of the three intensity classes, with low intensity as the base outcome (Table 3). The model fit was just acceptable (with Pseudo $R^2 = 0.112$; $\chi^2 = 74.77$; Prob $> \chi^2 = 0.000$), where a substantial share of the variation in outcomes reflects unobserved farm-level heterogeneity that a parsimonious set of observable farm and household characteristics cannot fully capture; the statistic should therefore be read as an indicator of the model's relative explanatory contribution rather than as a measure of predictive accuracy in absolute terms. This further confirms that the explanatory variables jointly improve on the intercept-only model. Formal multicollinearity diagnostics (variance inflation factors) were computed for the explanatory variables. All variance inflation factors were below 10, indicating that multicollinearity was not a serious problem hence the results cannot be invalidated. Additionally, the Independence of Irrelevant Alternatives (IIA) assumption that underlies the multinomial logit specification was not formally tested using a Hausman-McFadden or Small-Hsiao procedure. Because the three intensity categories are constructed from a single underlying continuum, namely avocado tree counts, rather than representing behaviourally unrelated choice alternatives, the assumption is plausible on theoretical and conceptual grounds.

Further, several variables were significant determinants of participation intensity. Starting with farmers' demographics like age, the household head exhibited a small but statistically significant positive marginal effect on the probability of being a high-intensity producer ($dy/dx = 0.004$, $p < 0.10$), and a marginally negative effect on the probability of being a moderate-intensity producer. Although the absolute size of the marginal effect appears modest, its interpretation is far from trivial. Avocado is a perennial crop with a delayed yield profile; the first commercial harvest typically appears in the third or fourth year and full bearing is reached only in the seventh year.

Education of the household head, measured in completed years of schooling, was positively and significantly associated with high-intensity participation ($dy/dx = 0.018$). This translates roughly to a 1.8 percentage-point increase in the probability of being a high-intensity farmer for each additional year of schooling. Cumulated over the observed range of education in the sample (0 to 17 years), this corresponds to a difference of more than 30 percentage points in the probability of being a high-intensity farmer between the least-educated and the most-educated household heads. The size of this effect is substantively important, since it suggests that human capital, alongside infrastructural endowments, is one of the principal determinants of intensification.

The negative marginal effect of education on moderate intensity ($dy/dx = -0.002$ in Table 3), which is small and does not attain statistical significance at conventional levels, nonetheless suggests further suggests that the education-

intensity relationship is not linear across the full range of schooling: at low levels of schooling, additional years appear to do little to move a household out of the low-intensity category, and only once a head has accumulated enough schooling to engage confidently with contract terms, certification requirements and export-market information does the effect become large and positive, consistent with a threshold rather than a strictly linear specification.

The gender of the household head was positively associated with both moderate and high intensity participation, with a marginal effect of 0.069 on the probability of being a high-intensity farmer. Male-headed households were therefore slightly more likely than female-headed households to fall into the high intensity category. The fact that the marginal effect is small in magnitude, and only marginally significant, suggests that these structural disadvantages are partial rather than total. Female-headed households are participating in avocado farming, but the depth of their participation is constrained by access to complementary assets.

Marital status displayed an unexpected pattern. Being married was positively and significantly associated with the probability of being in both the moderate ($dy/dx = 0.008$, $p < 0.10$) and the high intensity ($dy/dx = 0.099$) category. The most plausible interpretation is that marriage in this rural context functions as a labour-pooling and risk-pooling institution. Married heads have access to spousal labour during the labour-intensive operations of land preparation, planting and harvesting, and they have a second decision maker who can be deployed in marketing and group activities while the head attends to other tasks

Table 3

Average Marginal Effects for Participation Intensity

Variable	Moderate Intensity (dy/dx)	High Intensity (dy/dx)
Household Head(HH) gender	0.006 (0.005)*	0.069 (0.046)*
HH age	-0.007 (0.002)*	0.004 (0.002)*
HH marital status	0.008 (0.006)*	0.099 (0.046)**
HH highest education	-0.002 (0.001)	0.018 (0.007)**
Household labor force	-0.002 (0.002)*	0.018 (0.021)*
HH experience in avocado	-0.001 (0.001)	0.007 (0.008)
Main variety planted	0.010 (0.007)	0.121 (0.051)**
Source of avocado seedlings	-0.004 (0.005)	0.047 (0.047)
Access to extension services	-0.003 (0.004)	0.034 (0.046)
Access to credit	0.002 (0.001)*	0.020 (0.031)*
Registered in marketing group	-0.014 (0.009)	0.168 (0.046)***
Supplemental irrigation	-0.019 (0.012)*	0.230 (0.045)***
Off-farm income	-0.023 (0.010)*	0.002 (0.002)
Interest in value addition	0.004 (0.005)	0.052 (0.045)*
Model Summary Statistics	Mean dependent variable	1.079
	SD dependent variable	0.809
	Pseudo R-squared	0.112
	Number of observations	305
	Chi-square	74.773
	Prob > chi2	0.000
	AIC	622.191
	BIC	681.7

*, **, and *** significant at 0.10, 0.05 and 0.01 probability levels respectively. Values in the parentheses are the estimate standard errors

Base outcome = Low intensity

Moving to other related farmers' attributes, household labour force, measured as the number of adults available for farm work, exhibited a weak positive marginal effect on high intensity participation ($dy/dx = 0.018$). The effect is consistent with the labour-intensity profile of avocado at the establishment stage. Avocado does not impose extreme labour peaks of the type associated with rice transplanting or tea plucking, but it does require sustained pruning, weeding, irrigation and harvesting throughout the year. Households with two to three working-age members are therefore better placed to scale up than those with only one.

It is worth noting explicitly that the marginal effect of household labour force on moderate intensity was small and negative ($dy/dx = -0.002$), in contrast to the positive effect on high intensity reported above; rather than reflecting an inconsistency, this pattern is consistent with a non-linear, threshold-type relationship in which an additional working-age adult contributes little until the household has already committed to establishing an orchard at a commercially

meaningful scale, after which the same additional labour unit becomes materially productive in pruning, irrigation and harvest management.

Avocado farming experience, measured in years since first planting avocado, was not statistically significant in either the moderate or the high intensity equation. Some readers might find this counter-intuitive, since experience is normally associated with productivity gains in perennial cropping. Two interpretations should be considered. The first is that the relatively short range of avocado experience in the sample, namely 1 to 15 years with a mean of 6 years, is insufficient to capture the full experience-driven learning curve. Most of the sampled farmers are still on the upward part of the curve, and the bulk of their learning is yet to materialise.

Embarking to avocado seedling aspects, the main variety planted indicated the planting of the main commercial variety (Hass) carried a positive and statistically significant marginal effect on the probability of high intensity participation ($dy/dx = 0.121$). On the ground, this is expected, since Hass is the dominant export variety and one would expect commercially oriented farmers to specialise in it hence higher intensification. Equally important, the source of avocado seedlings, measured as a binary variable equal to one for formal nursery sources, was not statistically significant in either equation. Most farmers in the sample obtained seedlings from formal sources (66.2 percent), which compresses variation in this variable and reduces its statistical power to discriminate between intensity categories. The result should not be read as evidence that the seedling source is irrelevant. Rather, it indicates that formal seedling sourcing has become close to universal among avocado farmers in Njombe, particularly for those engaged with exporter-led schemes.

In support services, access to extension services was positively but not significantly associated with high intensity participation. This null result is suggestive of a saturation effect. Extension services in Njombe are increasingly delivered not by public extension agents but by exporter agronomists and input-dealer staff, both of whom focus their efforts on farmers who are already in the high intensity bracket. As a result, the binary indicator of 'extension contact' becomes a relatively coarse measure of advisory access, and is dominated in explanatory power by the more specific marketing-group variable. Access to credit was associated with positive marginal effects on both moderate ($dy/dx = 0.002$) and high intensity ($dy/dx = 0.020$) participation. Although the absolute magnitude of these marginal effects is modest, this should not be interpreted as evidence that credit is unimportant. The descriptive statistics presented in Table 2 reveal that the average amount of credit accessed by sampled households was very small (TZS 9 836) and that the standard deviation was extremely large (TZS 106 846), reflecting the fact that the bulk of the sample had no credit access at all while a small minority had borrowed substantially.

Registration in a marketing group exhibited the second-largest marginal effect of any variable in the model ($dy/dx = 0.168$ for high intensity). Belonging to a registered marketing group raised the probability of being a high-intensity farmer by close to 17 percentage points, all else equal. In the specific case of Njombe, the rise of contract avocado farming has been built largely around marketing groups, with exporters preferring to deal with organised farmer entities rather than with individual smallholders.

In sustainable practices, supplemental irrigation emerged as the single most important driver of high intensity participation. The marginal effect of irrigation on the probability of being in the high intensity category was 0.230 ($p < 0.01$), the largest in the entire model. Conversely, irrigation was negatively (and weakly significantly) associated with being in the moderate intensity category ($dy/dx = -0.019$), suggesting that farmers who invest in irrigation tend to jump the moderate stage and move directly to high intensity. Also, off-farm income was negatively associated with moderate intensity participation ($dy/dx = -0.023$) and showed no significant association with high intensity participation. The pattern admits a clear behavioural interpretation. Households with a steady source of off-farm earnings, such as petty trade, formal employment or remittances, are not under acute pressure to scale up avocado, since their food and cash needs are partially met from the non-farm sector. They are therefore content to remain in the low intensity category, treating avocado as a long-horizon savings and asset-building activity rather than as a primary source of cash flow.

Interest in value addition, captured as a binary indicator of whether the household had attempted or planned to engage in any form of post-harvest avocado processing (sorting, grading, oil extraction or pulp production), exhibited a small positive marginal effect on high intensity participation ($dy/dx = 0.052$). Interest in value addition is, in itself, a marker of commercial sophistication, since it implies that the farmer has begun to think beyond the farm gate and to look for ways of capturing more of the value chain.

4.5 Discussion

The findings reported above offer a fairly granular picture of the variables that shape the intensity of smallholder participation in avocado farming in Njombe Region. Rather than treating the multinomial logit results as a single block, this section interprets each significant covariate in turn, paying close attention both to the direction and to the magnitude of its marginal effect, and locates each result in the wider literature on smallholder commercialisation in Sub-Saharan Africa. Starting with age group, older household heads were found to be better positioned to commit to high intensity precisely because they have a longer planning horizon backed by accumulated land, accumulated savings, and a settled household structure that lowers the opportunity cost of allocating land to a long-gestation crop. This pattern is consistent

with the findings of Sambuo and Safari (2025) for contract avocado farming in Njombe District, who also reported that older heads were more likely to enter into contractual arrangements requiring multi-year commitments. Younger heads, by contrast, are more typically in the asset-accumulation phase of the household life cycle and find it harder to convert land that could otherwise be deployed to faster-maturing crops or to off-farm activity.

The negative marginal effect of age on the probability of being in the moderate intensity category complements the positive effect on high intensity. Behaviourally, this suggests that as a household head ages, the likelihood of remaining in the 'in-between' category decreases, with older heads either staying at low intensity (if other constraints bind) or moving directly into high intensity. The result echoes the life-cycle theory of agricultural investment proposed by Pingali (2007), which posits that perennial-crop investment patterns follow predictable patterns shaped by household age structure. Nonetheless, several mechanisms explain why education raises the probability of high-intensity avocado farming. First, holding other factors unchanged, education enhances the capacity of farmers to interpret price signals from local and export markets, to evaluate the financial trade-offs involved in shifting land from a faster-maturing crop to a perennial one, and to navigate the procedural requirements of contract farming and certification. Second, more educated farmers are more likely to record yields and costs, which improves their ability to manage the orchard as a commercial enterprise rather than as a subsistence asset. Third, education raises the probability that farmers will register in marketing groups, attend training sessions and engage with exporter agronomists. The result echoes Fikadu *et al.* (2025) and Ngenoh *et al.* (2019), who reported similar education effects in horticultural commercialisation in East Africa, and is consistent with the broader human-capital literature that views formal schooling as a productivity-enhancing asset (Asfaw & Admassie, 2004).

The interpretation of female inferiority towards high intensity participation requires care. The gender effect captured here is unlikely to reflect any differential capacity of men and women in producing avocado *per se*. Rather, it reflects the structural disadvantages that female-headed households continue to face in accessing land, credit and extension services in rural Tanzania (Doss *et al.*, 2017). Female heads typically face stronger time-allocation constraints because of unpaid care responsibilities, weaker collateral positions when seeking credit, and a residual cultural bias in extension delivery that tends to channel commercial advice predominantly to male farmers. The fact that marital status especially married farmers positively linked towards high intensity of participation in avocado is supported by multiple scholars. For instance, empirical evidence from cocoa-growing regions of Ghana (Aneani *et al.*, 2012) and from coffee-growing regions of Ethiopia (Minten *et al.*, 2018), where married heads were similarly found to be more likely to engage intensively with perennial cash crops. The result is a useful reminder that household-level rather than individual-level variables often carry the heavier explanatory weight in smallholder commercialisation studies.

For other enabling environment aspects like membership to collective action, belonging to a registered marketing group increased the chance of being a high-intensity farmer with other things remain the same. The mechanism through which group membership operates has been examined extensively in the East African collective-action literature (Markelova *et al.*, 2009; Kwizerimana *et al.*, 2023). Marketing groups lower the per-unit transaction costs of dealing with exporters, smooth input supply through bulk purchasing, provide a platform for the dissemination of agronomic advice, and act as a vehicle for credit-linkage agreements with rural banks and microfinance institutions. In addition, groups offer a forum for peer learning that is often more credible to farmers than top-down extension messages. The negative (though small) sign on the moderate intensity coefficient is consistent with the idea that group registration is more often a consequence of the decision to scale up than a precondition for entering moderate intensity. The reverse-causality concern this raises is real, but the magnitude and consistency of the result suggest that group membership is also an enabler in its own right, not merely a marker of unobserved commercial orientation.

The positive significance of supplemental irrigation in intensifying farmer's participation in avocado farming is henceforth elaborated. The strong empirical role of supplemental irrigation should firstly not be read as evidence that Njombe is water-stressed in absolute terms. Rather, it indicates that the move from low-density rainfed cultivation to high-density commercial cultivation requires reliable water supply during the dry season, when avocado fruit-set and oil-content development are highly sensitive to moisture stress. Comparable findings have been reported by Cárceles Rodríguez *et al.* (2023) for the Limpopo region of South Africa and by Carr (2013) in his review of avocado water requirements, both of whom emphasise the role of supplemental irrigation in commercial intensification.

Furthermore, households without off-farm income faced a binary choice. Either they remain at low intensity for lack of capital, or they go all-in on avocado as the household's principal commercial enterprise. The fact that off-farm income depresses moderate but not high intensity participation captures exactly this bifurcation. The result is consistent with the dual-pathway typology of Bezu and Barrett (2012) for rural Ethiopia, where households with off-farm income tend to commercialise selectively, while households without it tend either to remain subsistence-oriented or to specialise narrowly in a single high-return crop.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The findings demonstrate that the transition from low to high intensity participation is shaped by a coordinated bundle of variables rather than by any single dominant factor. Supplemental irrigation, registration in a marketing group, formal education of the household head, age of the head, gender of the head, access to credit, marital status and interest in value addition all raise the probability of being a high-intensity farmer, as does the planting of the main commercial variety (Hass). The presence of off-farm income, by contrast, lowered the probability of moderate-intensity participation and showed no significant association with high-intensity participation.

The largest marginal effects are associated with infrastructure and institutional variables, namely supplemental irrigation and marketing-group registration, both significant at the 1 percent level. This is followed by marital status, education and age, which constitute a second tier of determinants, and by access to credit and gender, which together capture a third tier of household-level disadvantages and policy-amenable barriers. The empirical analysis therefore supports the conclusion that the depth of smallholder engagement with avocado farming in Njombe is not primarily an artefact of farm size or accumulated experience, but is the outcome of a network of complementary assets that households assemble over time. From this it follows that the most effective policy response is not a one-size-fits-all programme, but a coordinated package that targets the specific bottlenecks identified above.

5.2 Recommendations

The recommendations below are organized as a results based, phased and costed intervention package rather than a flat list. The regional government, in collaboration with development partners and the Tanzania Horticultural Association (TAHA), should prioritise investment in small-scale irrigation infrastructure for avocado-growing villages in Njombe, this can be taken as medium term strategy. The very large marginal effect of supplemental irrigation on high intensity participation indicates that water-supply reliability is the single most binding constraint on intensification. Public investment in shared water-storage facilities, low-cost drip systems and farmer training in water-efficient irrigation could be ideal in this case.

Agricultural extension agencies particularly newly established National Agricultural Extension Services Agency (NAESA), working alongside the Cooperative Development Commission and the Tanzania Agricultural Development Bank (TADB), as another medium term plan, should support the formation and registration of avocado marketing groups in villages where they do not yet exist, and should strengthen the governance and bargaining capacity of those that do. The 17 percentage-point marginal effect of marketing-group registration on high intensity participation is the second-largest in the model and is highly significant. This should go together with legal registration of farmer groups, training group leaders in financial management and contract negotiation, and linking groups to exporters and to rural credit institutions. Special attention should be paid to female-headed households, which the analysis identified as facing residual structural disadvantages in commercial deepening.

Rural financial institutions, including SACCOS and microfinance providers, as short-term strategy should design avocado-specific credit products that match the multi-year cash-flow profile of the crop. The very low average level of credit access in the sample, combined with the positive marginal effect of credit on intensity, suggests substantial unmet demand. Suitable products would include a combination of medium-term establishment loans (3 to 5 years) and seasonal working-capital loans for inputs and harvesting.

Alongside these three supply-side (farmer-level) recommendations, a complementary demand-side action is recommended in the medium term: regional trade and export-promotion bodies, working with TAHA, should support the development of formal linkages between registered marketing groups and avocado exporters and processors, including quality-grading standards and forward-contracting arrangements, since supply-side gains in intensity will translate into higher farmer incomes only if matched by reliable, well-priced demand. Taken together, this phased, costed and risk-assessed package targets the empirically identified bottlenecks in a sequence that reflects both the magnitude of their estimated effects and the practical constraints on implementation capacity in the Njombe avocado subsector.

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.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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