International Journal on Food, Agriculture, and Natural Resources
Volume 6, Issue 1, Page 59-64
ISSN: 2722-4066
http://www.fanres.org

*Original Paper*

# Determinants of Agricultural Extension Service Uptake by Smallholder Grape Farmers in Dodoma, Tanzania

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Received: 24 November 2024; Revised: 24 November 2024; Accepted: 27 December 2024
DOI: https://doi.org/10.46676/ij-fanres.v6i1.433

***Abstract*—Agricultural extension services are essential for enhancing smallholder farmers' productivity, promoting sustainability, and improving resilience in developing countries. However, socioeconomic, institutional, and technological challenges restrict the use of these services, despite their importance. In addition, the uptake of these services remains uneven in developing countries. This study examines the determinants of extension service uptake among smallholder grape farmers in Dodoma, Tanzania. Using a probit regression model on survey data from 120 small grape farmers, the analysis revealed significant factors influencing service uptake, including the farmer's gender, farming experience, and grape harvests. Male farmers were less likely to use extension services than their female counterparts, demonstrating gender barriers. The farming experience positively influenced the use of extension services, with more experienced farmers recognizing their benefits. In addition, higher harvests increased the likelihood of engagement, demonstrating that profitability motivates farmers to seek expert support. This study emphasizes on gender-sensitive interventions and outreach programs for inexperienced farmers, as well as improved access to extension services for low-harvest farmers. The interventions could bridge existing gaps, improve productivity, and unlock the economic potential of the grape sector.**

***Keywords*—Agricultural Extension Service, Service Uptake, Smallholder Farmers, Grape Farming, Probit Model**

## I. INTRODUCTION

Agriculture is the foundation of the global economy, accounting for a significant share of the food supply, economic growth, and livelihoods [9]. While technological advances in wealthier countries have transformed agriculture into a highly productive system [18], agriculture remains a vehicle sector in developing countries, employing a significant proportion of the population and driving economic growth. The sector is predominantly occupied by smallholder farmers [23]. In Tanzania, agriculture provides employment and is a vital source of income for most households [13], [19]. Despite its importance, the sector faces persistent challenges, such as limited access to modern technology, unpredictable markets, and increasing environmental pressure from climate change. These constraints threaten the productivity and sustainability of agricultural systems.

Farmers in developing countries, including Tanzania, often struggle with low productivity because of a lack of reliable technology, limited market access, and environmental challenges. Agricultural extension services have emerged as a powerful means of addressing these concerns [1]. They equip farmers with the knowledge, skills, and resources necessary to adopt sustainable practices, enhance productivity, and adapt to changing environmental conditions [26]. The availability of extension services reflects the difference between stagnation and growth. In Tanzania, where agriculture is central to the economy, extension services have a significant potential to transform productivity and livelihoods [11]. However, their reach is far from universal, with limited uptake [24].

Socioeconomic factors such as age, gender, income, education, and family size significantly influence farmers' ability to access and benefit from extension services ([25]; [22]; [7]; [12]). Institutional concerns further undermine service delivery, including inconsistent access to extension agents and infrastructural barriers such as poor digital connectivity and inadequate rural roads ([16]; [8]). In addition, research highlights factors such as the frequency of visits by extension agents, proximity to markets, and participation in farmer field days that significantly influence farmers' awareness and willingness to adopt these services ([7]; [14]). However, these findings have mainly focused on staple crops, leaving gaps in understanding farmers' uptake of extension services in sub-sectors, such as grape farming.

Grape farming, particularly in Dodoma, is an economically significant subsector with unrealized potential. The semiarid climate and soil conditions make this a hub for grape farming. However, grape farmers face challenges such as inadequate access to extension services, limited infrastructure, and insufficient knowledge transfer mechanisms. These issues hinder the realization of the full potential of grape farming, which would otherwise drive rural economic growth and diversification.

Tanzanian grape farming has received little attention, despite the proven utility of agricultural extension services.

Most previous studies focused on staple crop production, overlooking the needs and constraints of grape farmers. To address this loophole, this study examines the determinants of the uptake of agricultural extension services by smallholder grape farmers in Dodoma. This study provides valuable information for policymakers, extension service providers, and other stakeholders in the agricultural sector. The findings will guide the design of targeted interventions to improve service delivery and accessibility. Extension services will boost grape farmers' productivity and resilience and help sustain the grape farming subsector.

## II. IMATERIAL AND METHODS

### A. Study Area

Dodoma, the capital city of Tanzania, is widely recognized as a significant grape-producing locality. The semi-arid climate, moderate rainfall, and well-drained sandy loam soils provide suitable conditions for grape cultivation. Smallholder farmers—the agricultural sector's backbone—predominantly perform grape farming in Dodoma. These farmers grow grapes, supplying local markets and the burgeoning Tanzanian wine industry. The region's strategic importance in grape farming makes it a suitable study area for examining the uptake of extension services, as the success of this sector has direct implications for the livelihoods of the local population and the broader agricultural economy.

Grape farming is the potential for economic growth and poverty alleviation for smallholder farmers. Despite this potential, the sector faces significant challenges, such as limited access to modern agricultural practices, inadequate infrastructure, and climatic vulnerability. Extension services are crucial for bridging the knowledge gap and providing technical support to grape farmers.

### B. Sampling and Data Collection

#### 1) Sampling Technique and Sample Size

This study employed a random sampling technique to ensure a diverse representation of grape farmers in Dodoma. A sample size of 120 smallholder grape farmers was used. The respondents were randomly chosen from the Mpunguzi and Hombolo wards, yielding 15 and 85 smallholder farmers, respectively. This distribution was attributed to farmers' interview availability because of other engagements.

#### 2) Data Collection Methods

Data were collected through a mixed-methods approach to capture quantitative and qualitative insights. Structured surveys formed the primary method for gathering quantitative data, focusing on farmer demographics, farming practices and perceptions of extension services. Focus group discussions with key stakeholders, including extension agents and local agricultural officers, were held to provide contextual depth for the findings.

#### 3) Variables and Measurements

Table I. presents an overview of the variables considered in the analysis, outlining their type, measurement, and expected influence on the uptake of extension services. The proposed model captures theoretical assumptions and empirical insights, thus providing an understanding of the factors affecting service uptake. This provides a foundation for interventions to improve the accessibility and effectiveness of extension services for farmers.

TABLE I. VARIABLES AND MEASUREMENTS

| Variable Name | Definition | Type | Measurement | Expected Sign |
|---|---|---|---|---|
| Extension Service Uptake | Indicates whether the farmer has accessed extension services. | Dependent | Binary (1 = Used services, 0 = Did not) | NA |
| Gender | Female farmers may have better access to services and a greater willingness to use them than males. | Binary (1 = Male, 0 = Female) | Independent | Negative (-) |
| Experience | Experienced farmers are more likely to recognize the benefits of extension services. | Years of farming experience | Independent | Positive (+) |
| Household Members | Larger households may provide additional labor to implement recommendations from extension services. | Number of household members | Independent | Positive (+) |
| Information and Training | Prior training is expected to increase awareness and willingness to use services. | Binary (1 = Received training, 0 = Did not) | Independent | Positive (+) |
| Harvest | Farmers with higher yields are likely to seek extension services to sustain or enhance their yields. | Natural logarithm of grape yield | Independent | Positive (+) |
| Farm Size | Larger farms will have more resources and incentives to use extension services. | Size of farm (hectares) | Independent | Positive (+) |

**Source:** *Study construction, 2024*

### C. Data Analysis

#### 1) Descriptive Analysis

Farm size, household composition, training participation, and harvest were analysed to provide information on the profile of farmers in the study area. Frequencies and percentages were calculated for continuous and categorical variables. This step provided a foundational understanding of the sample, allowing for comparisons between farmers who utilized extension services and those who did not.

#### 2) Model Specifications and Estimation

A probit regression model examined the factors influencing smallholder grape farmers' uptake of extension services in Dodoma. This model is appropriate for binary dependent variables, where the outcome represents two distinct states: whether a farmer uses extension services. The Probit model assumes that the error term follows a standard

normal distribution, making it well-suited for analyzing probabilities and ensuring that predicted values remain between 0 and 1 **Error! Reference source not found.**.

*a) Model Specification*

The dependent variable in the model $Y_i$ is defined as:

$$Y_i = \begin{cases} 1 & if\ the\ farmer\ used\ extension\ services \\ 0 & otherwise \end{cases}$$

The probability of $Y_i=1$ modelled as a function of several explanatory variables ($X_i$) using the Probit function as:

$$P(Y_i = 1) = \Phi\ (\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki})$$

Where:

- $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution.
- $\beta_0$ is the intercept term, and
- $\beta_k$ where are the coefficients associated with the explanatory variables $X_{ki}$,

The explanatory variables included in the model capture socioeconomic characteristics. These variables were expected to have varying effects on the likelihood of extension service uptake, with their direction and magnitude determined through regression analysis.

TABLE II. DEMOGRAPHIC CHARACTERISTICS OF SMALLHOLDER GRAPE FARMERS

| Demographics | Category | Extension Users | | Extension Non-users | |
|---|---|---|---|---|---|
| | | Frequency | Percentage | Frequency | Percentage |
| Age | 18-28 | 1 | 1.20 | 1 | 2.70 |
| | 29-39 | 55 | 66.27 | 15 | 40.54 |
| | 40-50 | 26 | 31.33 | 14 | 37.84 |
| | ≥51 | 1 | 1.20 | 7 | 18.92 |
| Gender | Male | 54 | 65.1 | 21 | 56.76 |
| | Female | 29 | 34.9 | 16 | 43.24 |
| Marital Status | Married | 74 | 89.2 | 35 | 94.59 |
| | Unmarried | 9 | 10.8 | 2 | 5.41 |
| Education | Informal | 3 | 3.61 | 2 | 5.41 |
| | Primary | 15 | 18.1 | 7 | 18.92 |
| | Secondary | 39 | 47 | 18 | 48.65 |
| | Tertiary | 26 | 31.3 | 10 | 27.03 |

SOURCE: SURVEY DATA, (2024)

*b) Estimation Procedure*

The probit model coefficients ($\beta_k$) were estimated using the maximum likelihood estimation method. This method determines the parameter values that maximises the likelihood function, ensuring that the observed data are most probable under the specified model. The estimation process refines the coefficient estimates until the convergence criterion is satisfied.

Robust standard errors accounted for potential heteroscedasticity in the data. This ensures that the standard errors of the coefficients are reliable, even when the variance of the error term is not constant across observations.

*c) Marginal Effects*

Marginal effects were calculated to interpret the probit model results in a more practical context. These effects measure the change in the probability of extension service uptake $P(Y_i = 1)$ resulting from a one-unit change in an explanatory variable while keeping other variables constant.

For continuous variables, the marginal effect is expressed as:

$$\text{Marginal Effect} = \Phi(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki}).\beta_j$$

Where:

$\phi$ is the probability density function of the standard normal distribution.

For binary variables, marginal effects represent discrete changes in predicted probability when variable switches from 0 to 1. This approach interprets the effect of categorical factors, such as gender and training participation, on service uptake.

*d) Model Fit Assessment and Diagnostics*

The overall fit of the probit model was evaluated using pseudo-$R^2$, which shows how well the explanatory variables explain the variability in the dependent variable. The Wald chi-square test was used to assess the joint significance of the explanatory variables, ensuring that the model provides meaningful results. This analysis identifies the determinants of extension service uptake and highlights the practical implications of each factor through its marginal effects.

## III. RESULTS AND DISCUSSION

### A. Abbreviations and Acronyms

Table II presents the demographic characteristics of the smallholder grape farmers. This highlights the distribution of variables, which informs the uptake of extension services in the study area.

*1) Age Distribution*

The analysis of age and extension service uptake shows that middle-aged farmers are the most engaged, with 66.27% of users aged 29–39 and 31.33% aged 40–49. In contrast, younger farmers (18–28) and older farmers (50+) show meagre participation, each accounting for only 1.20% of the uptake. Among non-users, farmers aged 29–39 make up the most significant proportion (40.54%), followed by those aged 40–49 (37.84%), while older farmers (50+) and younger farmers (18–

28) account for 18.92% and 2.7%, respectively. These findings show that middle-aged farmers are the most likely to use extension services, whereas younger and older farmers face challenges or lack the motivation to engage. These results align with [17], who found that 83% of farmers belonged to the middle-aged to older age groups. This trend may be attributed to the younger generation's increasing pursuit of education and engagement in non-agricultural activities, which limits their involvement in farming-related extension services.

TABLE III. EXTENSION SERVICE UPTAKE PROBIT RESULTS

| Variables | Marginal Effect | Std. Err | z-value | P-Value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| Gender | -0.1741* | 0.0835 | -2.08 | 0.037 | -0.3377 | -0.0104 |
| Experience | 0.0181* | 0.0073 | 2.47 | 0.014 | 0.0037 | 0.0325 |
| Household Members | -0.0154 | 0.198 | -0.78 | 0.437 | -0.0541 | 0.0234 |
| Training Access | -0.1210 | 0.0873 | -1.39 | 0.166 | -0.2922 | 0.0502 |
| Harvest | 0.0968* | 0.0430 | 2.25 | 0.024 | 0.0125 | 0.1811 |
| Farm Size | 0.0208 | 0.0391 | 0.53 | 0.595 | -0.0559 | 0.0975 |
| Observations | 120 | | | | | |
| Wald $chi^2(45)$ | 24.04 | | | | | |
| Prob>$chi^2$ | 0.0005 | | | | | |
| Log pseudo-likelihood | -64.856841 | | | | | |
| Pseudo $R^2$ | 0.1251 | | | | | |

Note: **and * indicate significance levels of 1% and 5%, respectively.
**Source:** *Analysis results (2024)*

*2) Gender Distribution*

Male farmers represent a more significant proportion of extension service users (65.1%) than female farmers (34.9%), although the gap is not as wide as the age disparity. However, the non-extension uptake data shows that more women (43.24%) do not engage with extension services than men (56.76%), suggesting that gender-specific barriers to accessing extension services must be addressed. These findings are consistent with those of [15], who also reported that male form a more significant proportion of extension service users than their female counterparts. The findings imply that targeted interventions are needed to address gender-specific barriers, ensure access to extension services for female farmers, and foster inclusive agricultural development.

*3) Marital Status*

The analysis of marital status revealed that most extension service users were married (89.2%), showing a potential link between marital status and greater responsibility or motivation to seek external support. Conversely, unmarried farmers account for only 10.8% of uptake, which could be associated with fewer resources or different priorities. Among non-users, married farmers dominate, comprising 94.59% of this group, while unmarried farmers make up just 5.41%. The results align with **Error! Reference source not found.**, who found that most extension service users were married, highlighting the significant role of marital status in influencing farmers' decisions to engage with extension services.

*4) Education Level*

The analysis of education level reveals that farmers with secondary education are the most likely to engage with extension services, accounting for 47% of users, followed by those with tertiary education (31.3%) and primary education (18.1%). Farmers with only informal education showed the lowest uptake (3.61%), possibly linked to literacy barriers or limited awareness of service availability. Among non-users, those with informal education made up 5.41%; primary education holders accounted for 18.92%; secondary education farmers comprised 48.65%; and tertiary education farmers represented 27.03%. These findings are consistent with **Error! Reference source not found.**, who reported that farmers with secondary education are more likely to access agricultural extension services. Higher education levels are positively associated with greater participation in extension services.

*B. Uptake of Extension Service in the Study Area*

The study surveyed 120 grape farmers and found that 83 (69.2%) had accessed extension services, while 37 (30.8%) had not. This shows that most farmers (approximately 70%) could utilise extension services, demonstrating relatively positive engagement with these programs. However, the remaining 30.8% of farmers who did not access the extension services highlighted a potential area of concern. The results contrast those of [12], who found that most farmers lack access to agricultural extension services. However, they align with [10], who reported that most farmers in the study access extension services. Although extension services are relatively well-received, factors hinder full participation. Socio-economic challenges, geographical isolation or potential inefficiencies in service delivery could cause the access gap.

*C. Factors determining extension service uptake*

A probit model was employed to analyse the factors influencing smallholder grape farmers' uptake of extension services. The model examines several variables, including gender, experience, household size, training access, harvest value, and farm size, to assess their impact on the likelihood of farmers using this service. The results of the analysis, presented in Table III, offer information about the factors that influence the adoption of extension services and identify significant variables that drive or hinder uptake.

*1) Gender*

The study revealed that gender significantly influences the uptake of extension services among grape farmers in Dodoma, Tanzania. Specifically, being male reduces the likelihood of using extension services by 17.4% compared to being female, with a statistically significant p-value of 0.037. This finding shows gender disparity, with male farmers less likely to engage with extension services than their female counterparts. This study highlights the gendered barriers affecting male

farmers and the efficacy of initiatives promoting access to extension services among female farmers.

This result is consistent with **Error! Reference source not found.** findings that male farmers are less likely to engage with extension services. However, **Error! Reference source not found.** found that male-headed households were more likely to utilise agricultural extension services than female-headed households. This discrepancy may reflect differences in local contexts, such as regional variations in agricultural practices or the structure of extension services, which can shape how gender influences the use of such services.

The findings of this study highlight the need for interventions that address gender-specific challenges in accessing extension services. Considering the impact of cultural expectations and financial limitations on male farmers in the study region, a more effective and targeted engagement strategy is necessary. The success of gender-related programs that promote female participation in extension services should be acknowledged and further leveraged.

*2) Farming Experience*

The study revealed that gender significantly influences the uptake of extension services among grape farmers in Dodoma, Tanzania. Specifically, being male reduces the likelihood of using extension services by 17.4% compared to being female, with a statistically significant p-value of 0.037. This finding shows gender disparity, with male farmers less likely to engage with extension services than their female counterparts. This study highlights the gendered barriers affecting male farmers and the efficacy of initiatives promoting access to extension services among female farmers.

This result is consistent with [15] findings that male farmers are less likely to engage with extension services. However, [4] found that male-headed households were more likely to utilise agricultural extension services than female-headed households. This discrepancy may reflect differences in local contexts, such as regional variations in agricultural practices or the structure of extension services, which can shape how gender influences the use of such services.

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*3) Harvests*

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### *D. Model Fit Assessment*

*1) Log Likelihood and Pseudo $R^2$*

The model's log-likelihood is reported as -64.86, reflecting the likelihood function log for the estimated parameters. The log-likelihood shows a better fit for the model. A pseudo-$R^2$ of 0.1251 shows that the independent variables explain this proportion of the variance in the likelihood of extension service uptake. Although the pseudo-$R^2$ in probit models does not directly correspond to the $R^2$ used in linear models, a value of 0.1251 suggests that the model explains a moderate proportion of the variance in the uptake of extension services.

*2) Wald Chi-Square Statistic*

The Wald chi-squared statistic of 24.04 with a corresponding p-value of 0.0005 shows that the model is statistically significant at the 1% level. This finding demonstrates a significant influence of at least one model predictor on extension service uptake.

## CONCLUSION

This study identified significant factors influencing smallholder grape farmers' uptake of extension services in Dodoma, Tanzania. An analysis of the findings reveals that gender, farming experience, and harvested yield are influential factors affecting farmers' utilisation of extension services. Male farmers were less likely to use extension services than female farmers, showing that gender-specific barriers may influence uptake. In addition, farmers with more years of farming experience were more likely to use extension services, reflecting their recognition of the value of external support in improving farming practices. Finally, farmers with higher harvests were also more likely to engage with extension services, potentially because of their greater capacity to invest in improving their agricultural practices for higher profitability.

Based on these findings, the following recommendations are made to enhance the effectiveness and accessibility of extension services: -

It is essential to design and implement gender-sensitive extension service initiatives that recognise male and female farmers' different roles and needs. Specific outreach strategies should be developed to increase male farmers' participation and ensure that both genders benefit equally from the services offered.

Extension services should be made more accessible, particularly for less experienced and resource-poor farmers. This can be achieved by expanding extension outreach through mobile technologies, community-based extension agents, and improved infrastructure in rural areas.

Extension programs should be customised based on farmer characteristics, such as age, education level, and farming experience. Programs should also consider local conditions and farm types to ensure the content is relevant and accessible to all farmers.

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