International Journal of
Agriculture
(IJA)

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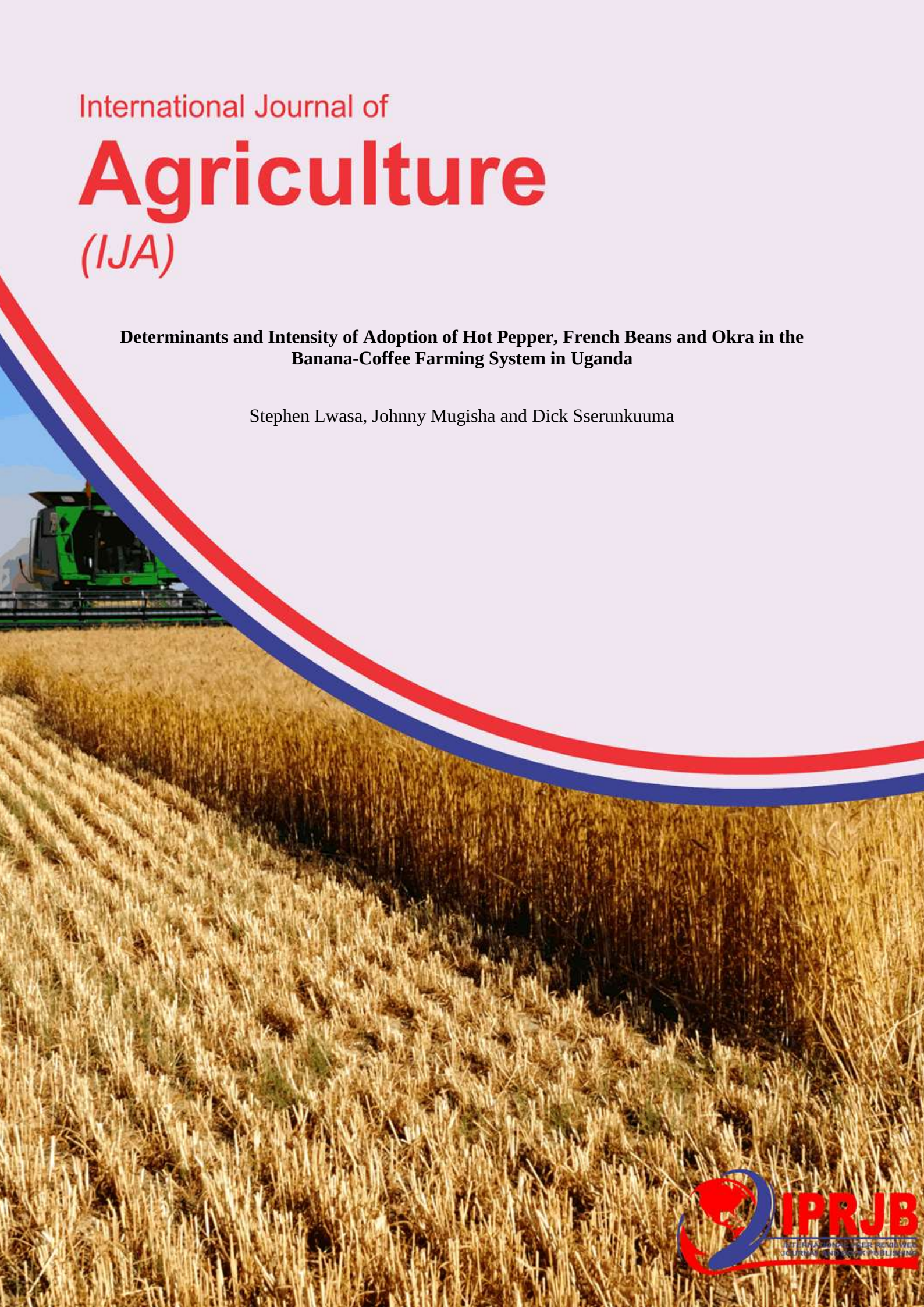

International Journal of Agriculture

ISSN 2520-4629X (Online)
Vol.10, Issue 1, No. 1. PP. 1 - 22, 2025

www.iprjb.org

Determinants and Intensity of Adoption of Hot Pepper, French Beans and Okra in the Banana-Coffee Farming System in Uganda

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Article History

Received 3rd July 2025

Received in Revised Form 9th August 2025

Accepted 2nd September 2025

How to cite in APA format:

Lwasa, S., Mugisha, J., & Sserunkuuma, D. (2025). Determinants and Intensity of Adoption of Hot Pepper, French Beans and Okra in the Banana-Coffee Farming System in Uganda. *International Journal of Agriculture*, *10*(1), 1–22. https://doi.org/10.47604/ija.3486

Abstract

Purpose: This study explores the shift among Ugandan smallholder farmers, traditionally reliant on banana-coffee systems, toward cultivating high-value crops (HVCs) like Hot Pepper, French Beans, and Okra, which offer strong economic potential.

Methodology: A cross-sectional survey of 522 households (273 adopters, 249 non-adopters) was conducted using income quartile stratification and binary and ordered logistic regression to assess adoption patterns and socio-economic influences.

Findings: Findings show that HVC adopters have significantly higher income and expenditure, and are concentrated in upper income quartiles. Adoption is positively linked to factors such as; education level of the most educated child, access to agricultural training and credit, frequent engagement with local leaders, strong village networks, and overall household income. Adoption intensity increases with involvement in agricultural projects, hired labor, off-farm income, and land access, but declines with older household heads and road remoteness.

Unique Contribution to Theory, Practice and Policy: The study recommends promoting hired labor due to the labor-intensive nature of HVCs and improving access to credit to support inclusive agricultural transformation and enhance smallholder investment in high-value crops.

Keywords: *High-Value Crops, Adoption, Smallholder Farmers*

JEL Code: *Q12*

INTRODUCTION

Over the past two decades, Uganda has implemented a series of macroeconomic and institutional reforms aimed at enhancing resource allocation efficiency and reducing poverty. Initially guided by the Poverty Eradication Action Plan (PEAP), which served as the national development framework from 1997 to 2008, the country transitioned to the National Development Plan (NDP) in 2010 to pursue broader goals of economic transformation and wealth creation (National Planning Authority [NPA], 2020).

The NDP, alongside the Development Strategy and Investment Plan (DSIP), emphasizes agricultural commercialization as a pathway to increased household incomes. These frameworks advocate for optimal resource use and the promotion of high-value crops (HVCs), which offer superior price-to-volume ratios (Dhivya & Arunkumar, 2025), compared to traditional staples (Ministry of Agriculture, Animal Industry and Fisheries [MAAIF], 2021). The shift toward HVCs is driven by declining returns from conventional exports e.g Tea, and fluctuating prices (e.g coffee) and the expanding opportunities in global markets (World Bank, 2023).

Ugandan farmers are increasingly integrating HVCs such as hot pepper (*Capsicum annuum*), French beans (*Phaseolus spp.*), and okra (*Abelmoschus esculentus*) into their banana-coffee farming systems. These crops are cultivated alongside traditional staples and livestock enterprises, reflecting a diversification strategy aimed at income stabilization, labor optimization, and year-round resource utilization (Chege et al., 2022). However, regional disparities in resource endowments and market access influence the feasibility and profitability of HVC adoption (Bashangwa et al., 2020).

In Uganda, horticultural crops are widely perceived as HVCs due to their export potential, contribution to resource use efficiency (MAAIF, 2023) owing to their high price to volume ratio Their integration into farming systems aligns with national goals of poverty reduction and agricultural modernization. Despite their promise, the adoption of HVCs remains uneven and inadequately understood. Farmers face challenges such as declining profitability of traditional crops, pest and disease pressures, particularly banana and coffee wilt, and limited access to inputs and markets. This study seeks to address the knowledge gap surrounding the extent and intensity of HVC adoption and its implications for household welfare and agricultural transformation.

Previous research on high-value crops in Uganda has adopted a crop-specific approach, examining individual commodities in isolation. For instance, Buyinza and Mugagga (2010) focused on economics of hot pepper, while Nsabiyera et al. (2012) addressed select agronomic aspects without fully engaging with the broader economic dimensions. Such fragmented analyses fail to capture the synergistic potential of combining high-value crops and overlook their poverty alleviation potential. Further, while high-value crops are known to offer economic potential, there was insufficient empirical evidence on why certain smallholder farmers adopt them while others do not. Without understanding the socio-economic and institutional factors influencing adoption, policy interventions risk being misaligned or ineffective (Bayiyana, et al., 2024). This study addresses that gap by offering a comprehensive assessment of the socio-economic that should shape smallholder farmers' engagement in high-value crop markets. By investigating these factors, the research contributes to enhancing farmers' capacity to make informed decisions, thereby improving household incomes and livelihoods. The findings also provide action areas for policymakers and development practitioners, enabling the formulation

of targeted interventions, such as financial inclusion, and capacity-building programs, that promote inclusive agricultural growth. Agricultural extension agents and non-governmental organizations can also leverage these results to refine advisory services, optimize training efforts, and strengthen farmer organizations in fulfilling their strategic roles.

METHODOLOGY

Study Area, Sampling and Data Collection

This study employed cross-sectional data from a household survey conducted between July and August 2018 within Uganda's banana-coffee farming system. The selected districts—Luwero, Masaka, Mpigi, Mukono, Rakai, and Wakiso—were chosen due to their agro-climatic suitability and proximity to high-value crop (HVC) markets (Uganda Coffee Development Authority [UCDA], 2023; MAAIF, 2021). A multi-stage purposive sampling approach was used at the farming system, zonal, and district levels, guided by production statistics and reconnaissance visits. This method facilitated efficient targeting of relevant farming households (Kule et al., 2025).

Sampling frames were constructed using data from the Horticultural Exporters Association of Uganda (HORTEXA), enabling random selection of 273 adopters who had cultivated hot pepper, French beans, or okra for at least three consecutive years. To ensure geographic representation, adopters were drawn across districts rather than proportionally. Additionally, 249 non-adopters were randomly selected from Local Council 1 registers within the same localities to control for spatial heterogeneity. In total, 522 smallholder households were surveyed.

Data collection involved structured, pre-tested questionnaires administered through face-to-face interviews, covering three agricultural seasons: the second season of 2017 and both seasons of 2018. The survey captured socio-demographic characteristics, enterprise decision-making, farm income, access to productive assets, and social capital indicators such as group membership and community leadership roles. These were complemented by focus group discussions, key informant interviews, and direct field observations.

Analytical Model

It is hypothesized that the decision of a farmer to include (or not include) a crop in a farm plan is influenced by several factors. Following Judge, *et al*. (1988) we assume that the utility derived from the farmer's choice is governed by the attributes of the choice itself and those of the decision maker. For the i^{th} farmer, let utility of option 1 (the decision to include a high-value crop into the production plan) be denoted as μ_1 and that of option 2 (the decision not to include high-value crop into the production plan) as μ_2 (equations 1 and 2). Then,

$$\mu_1 = \mathbf{x}_i'\beta_1 + \varepsilon_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$\mu_2 = \mathbf{x}_i'\beta_2 + \varepsilon_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

where $\mathbf{x}_i$ is a vector of characteristics and β_j (j = 1,2) is a vector of parameters.

It is assumed that the random disturbances (ε_1 and ε_2) are independently and identically distributed and they are drawn from a log-Weibull distribution. The utilities μ_1 and μ_2 are random variables and the i^{th} farmer is assumed to choose option 1 only if $\mu_1 > \mu_2$.

International Journal of Agriculture

ISSN 2520-4629X (Online)
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The probability, P_1, that the farmer will choose option 1 is given by the cumulative density of $(\varepsilon_2 - \varepsilon_1)$ to the point $\mathbf{x}_i'(\beta_1 - \beta_2)$. The cumulative density function of the difference $(\varepsilon_2 - \varepsilon_1)$ is given by a logistic function. By setting $(\beta_1 - \beta_2)$ equal to β, we get (equations 3 and 4):

$$P_1 = \exp\{\mathbf{x}_i'\beta\}/[1 + \exp\{\mathbf{x}_i'\beta\}]. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

The corresponding likelihood function is

$$L = \Pi_j \{e^{x'\beta}/(1 + e^{x'\beta})\}\Pi_k \{1/(1 + e^{x'\beta})\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

where j denotes the farmer that chooses option 1 and k the one that chooses option 2. The objective is to maximize the likelihood function with respect to the vector β.

This argument can be extended to multiple-choice alternatives. Suppose there is a choice between *M* different alternatives indexed $J = 0, \ldots M,$ with the ordering being arbitrary. Assume that the utility that the i^{th} farmer attaches to each alternative is given by μ_{ij}, $J = 1, 2, \ldots M.$ The farmer will prefer alternative *J* if it is expected to give him/her the highest utility. That is, $\mu_{ij} = \max \{\mu_{i0} \ldots\ldots \mu_{iM}\}$,

The probability that the i^{th} farmer prefers option *J* among *M* alternatives is given in equation 5, by,

$$P(C_i = j) = p\{\mu_{ij}, = \max \{\mu_{i0} \ldots\ldots \mu_{iM}\}\}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where C_i denotes the preferences of i^{th} individual.

Assuming that the error term in the utility functions is independently and identically distributed (IID) then one can use the probit or logit model (Choe et al., (2019). Logit models have been found to be more appropriate to model factors influencing preferences when the explanatory variables consist of individual's specific characteristics that influence choice. In this study, the error terms are logistically distributed and therefore the logit models are the most appropriate. If the outcome variable is of a multivariate nature this gives rise to multinomial logit models (Zegeye, 2021), and the probability that a farmer prefers an alternative choice (equation 6) is given by;

$$P(C_i = j) = \frac{e^{\beta jXi}}{e^{\beta oXi} + e^{\beta iXi} + \ldots\ldots + e^{\beta mXi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where $\beta_0, \beta i, \beta_j$ and βm are a vector of coefficients to be determined that represent different alternatives and *Xi* represents variables that were collected from the farmer.

A farming household with any of the three study HVCs (hot pepper, French beans and okra) was assigned a value of 1, and 0 if a farmer was a non-adopter. If Pi is the probability that a farmer produced at least one of the HVCs), and 1 – Pi the probability that the farmer did not, then the logit (L) summarized in equation 7;

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$$L_i = In\left(P_i/(1-P_i)\right) = Z_i = \beta_o + \sum_{i=1}^{k} \beta_i X_i + e \quad \text{.....7}$$

The underlying logit model is based on the cumulative logistic probability distribution function. The dependent variable Zi is the logarithm of the odds that a particular choice will be made. It is an index reflecting the combined effects of Xi factors that promote or deter adoption. The importance of each factor is influenced by the coefficients of the adoption equation (βi).

Data analysis

Quantitative data were analyzed using STATA version 17. Descriptive statistics (t-tests and chi-square tests) were applied to compare adopters and non-adopters. To assess wealth distribution and economic outcomes, households were stratified into quartiles and compared across adoption categories (0, 1, 2, or 3 HVCs). Binary and ordered logistic regression models were used to identify adoption drivers, following established econometric frameworks (Danso-Abbeam et al., 2020; Mnukwa et al., 2025).

The Empirical Model

The empirical model was specified as:

$$In\left(P_i/(1-P_i)\right) = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k + e \quad \text{.....3.8}$$

Where, X_1 to X_k are the explanatory socio-economic variables that the study attempted to identify. These included those used in recent adoption and welfare studies such as Katya Kule et al. (2025), Adams & Jumpah (2021), Mnukwa et al. (2025), Jambo & Mukanyau (2025), and Moges et al. (2025). These variables include: age and education of the farmer (in years), household size, number of close village associates, period in marriage (in years), whether the household head has ever borrowed money (dummy, 1 for yes, 0 otherwise), access to training during the last 2 years (dummy, 1 for yes, 0 otherwise), and holding a post in a farmers' group (dummy, 1 for yes, 0 otherwise). Other variables included distance from the farm to the nearest tarmac road (in kilometers) or distance from the farm to the main road (in kilometers), whichever of the two gave better results; household wealth, represented by the value of all assets owned (in shillings); and annual off-farm income. The error term (e) is the disturbance term to capture other variables that influence the dependent variable beyond those specified.

In order to determine factors that influence intensity of inclusion, the ordered logit model, as used by Jambo & Mukanyau (2025), was utilized. Four measures of intensity were captured using ordered scales: $0 < 1 < 2 < 3$, reflecting the polychotomous nature of the dependent variable. Values of 0, 1, 2, and 3 were assigned to households with none, one (either hot pepper, French beans, or okra), two (a combination of either hot pepper and French beans, hot pepper and okra, or French beans and okra), and all three of the HVCs respectively. The assumption made is that the HVCs, by and large, are similar in many aspects despite their known and documented physiological differences. This assumption is based on the fact that they are horticultural crops of high value, which require purchased inputs (seeds, fertilizers, and chemicals) for optimal performance, are labor-intensive, and are of export importance. Therefore, they require intensive planning and similar investment.

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The empirical model was built around the latent variable y*, defined as:

$$y^* = \alpha_o + \sum \alpha_i X_i + \varepsilon \quad \text{.....3.9}$$

Where y^* is unobservable, but we do observe:

$$y = 0 \quad if \quad y^* < 0$$
$$y = 1 \quad if \quad 0 \le y^* < \mu_1$$
$$y = 2 \quad if \quad \mu_1 \le y^* < \mu_2$$
$$\vdots$$
$$y = J \quad if \quad \mu_{J-1} < y^* \quad \text{.....3.10}$$

Where, J is the number of categories, in this case, four Xi is a vector of the exogenous socio-economic variables influencing intensity of HVCs adoption. These exogenous variables included those used in the binary logit model (defined in equation 3.9) and others such as; education of highest educated child of the farmer (years), total annual household expenditure (in shillings), and whether the farmer holds a post in community. The disturbance term (ε) captures other variables that influence the dependent variable other than those specified. The ordered logit algorithm simultaneously estimates the parameter vectors for α and μ. The estimated μ's indicate the dividing lines between Y = 0 and 1 (μ0), Y = 1 and 2 (μ1), Y = 2 and 3 (μ2), and so on, for the probability that an outcome 1, 2, 3, or more.

Regression diagnostics to check on how well the data meet the assumptions were carried out. Firstly, unusual and influential data may bias the coefficients. Therefore variables were subjected to normality tests, and where variables were skewed, the variables were transformed to natural logs or square roots. To test for normality of residuals the kernel density estimate and Shapiro-Wilk W test were used. Presence of any severe outliers should be sufficient evidence to reject normality at a 5% significance level. Multicollinearity was tested using the Variance Inflation Factor (VIF). According to recent studies such as Jacob and Varadharajan (2024), a VIF value greater than 10 is considered indicative of strong multicollinearity, which can distort regression estimates and inflate standard errors. For heteroskedasticity, the Breusch-Pagan / Cook-Weisberg test was employed. Akewugberu et al. (2024) provide a comprehensive evaluation of this test's performance across various data structures, confirming its reliability in detecting non-constant variance in regression models, especially when sample sizes are moderate to large. Diagnostic tests included normality checks with logarithmic transformations, multicollinearity assessment via variance inflation factors (VIF), and model fit evaluation using the Hosmer-Lemeshow test.

RESULTS AND DISCUSSIONS

This section highlights the distribution of farmers who adopted the HVCs by district. It also provides details of the distribution of adopters by wealth, expenditure and income quartiles and comparison of selected characteristics of adopters and non-adopters. The factors that influence the decision to adopt any of the HVCs and intensity of adoption, ranging from non-adoption to adoption of the three HVCs are also analysed.

The High Value Crops Adopted in the Different Locations of the Study Area

The study findings show that out of the 273 (52%) farming households that adopted the HVCs, the majority (41%) were adopters of hot pepper, followed by French beans (40%) and okra (19%) among the one crop category (Table 1). In the two crop adopters' category, the dominant combination was hot pepper and okra (50%), followed by French beans and hot pepper (37%).

Among the one crop adopters category of farmers, Wakiso and Luwero dominated in French beans and okra crops, while Wakiso and Masaka dominated in hot pepper production. The majority of the three crop adopters were also in Wakiso. These results depict that it is relatively uncommon for farmers to grow more than one of the crops. This could partly be rooted in uncertainty especially with regard to markets since they are purchased by few specific companies with whom they did not have contractual arrangements to assure them of clear market incentives. Further to this is lack of technical capacity to handle more than one.

Table 1: Distribution of Farmers by District and Crops Adopted

Area	n	Hot Pepper	French beans	Okra	French beans & Hot pepper	French beans & okra	Hot Pepper & Okra	ALL the crops
Luwero	80	12	23	10	3	1	3	2
Masaka	75	25	12	3	3	0	1	0
Mpigi	47	11	6	2	2	2	2	0
Mukono	80	8	5	5	1	2	10	0
Rakai	54	7	8	3	1	0	5	1
Wakiso	186	37	42	23	32	10	35	27
Aggregate	**522**	**100**	**96**	**46**	**42**	**15**	**56**	**30**

The farmers revealed that the companies for which they were producing the HVCs rarely visited them during the course of production but could interface with them during the periods of harvest. They were challenged by failure to precisely identify and control pests and diseases and access to high quality planting materials.

The dominance of hot pepper is attributed to the ease of accessing planting materials and markets relative to other markets. It was reported that Icemark (U) Limited, HORTEXA and individual private sector traders and exporters were the dominant horticultural exporting companies. These stationed their agents in various production locations that were involved in the distribution of planting materials, purchasing, weighing, initial packaging and payment of farmers for the harvests of mainly hot pepper. This improves farmer's incentives to engage in production of the crops. There is a clear dominance of the two and three crop combinations in Wakiso district compared to other districts. This was attributed to proximity to the inputs (especially seeds) and output markets. These HVCs are largely adopted for the export market (Muyonga et al. 2023) whose quality requirements are stringent. Since they are perishable it is imperative that after harvesting they must be quickly delivered to the market if the quality requirements are to be adhered to.

Distribution of Adopters by Wealth, Expenditure, and Income Quartiles

Farmers were arranged by quartiles in ascending order and their distributions in the various quartiles compared by total annual farm income, total income (includes farm and non-farm), total annual consumption expenditure and total value of wealth (Table 2).

Table 2: Distribution of Adopters among Different Quartiles by Farm Income, Total Income, Total Expenditure and Wealth

Quartile	Status of adoption	Farm Income (%)	Total Income (%)	Expenditure (%)	Wealth (%)
	0	87.8	90.1	53.4	49.6
1	1	53.4	54.9	51.9	42.0
	2	31.5	26.9	48.5	47.7
	3	17.7	18.5	36.9	51.5
	0	6.9	4.6	29.8	35.9
2	1	30.5	29.0	28.3	34.4
	2	40.8	43.1	28.5	22.3
	3	37.7	39.2	33.8	23.1
	0	4.6	3.8	16.0	13.0
3	1	13.7	15.3	16.8	16.8
	2	20.8	21.5	18.5	23.1
	3	31.5	30.0	20.0	17.7
	0	4.6	1.5	2.3	1.5
4	1	2.3	0.8	3.1	6.9
	2	6.9	8.5	4.6	6.9
	3	13.1	12.3	12.3	7.7

Starting with total farm income, results show that the first quartile (the lowest in ascending order) is dominated by the non-adopters (87.8%), followed by adopters of one (53.4%), two (31.5%), and the lowest proportion was by adopters of three crops (17.7%). By and large, a similar trend is observed in the second, third, and fourth quartiles. This indicates that households that adopted more of the HVCs were in the higher farm income categories, consistent with findings that adoption of high-value crops significantly boosts farm income among smallholders (Liu et al., 2025; Mnukwa et al., 2025).

With respect to total income, the first quartile was also dominated by the non-adopters (90.1%), followed by adopters of one HVC (54.9%), adopters of two HVCs (26.9%), while adopters of three HVCs were the least (18.5%). This trend is repeated in the second, third, and fourth quartiles. The implication is that farmers who adopted more study crops had more money at their disposal. These findings align with broader evidence showing that crop diversification and adoption of export-oriented horticulture increase household income and financial resilience (Giller et al., 2021; Rubhara et al., 2020).

These findings collate well with results of the analysis of expenditure. Farmers who did not adopt any or who adopted fewer HVCs dominated the lower quartiles. The pattern, therefore, is toward having the more adopters of the HVCs spend more, which is consistent with studies showing that increased income from crop adoption leads to higher household expenditure, particularly on food and agricultural inputs (Rubhara et al., 2020; Ndhlovu, 2025).

Results of the quartile analysis for value of wealth indicate no clear pattern that can be attributed to the production of the study crops. For example, for the first quartile, the non-adopters were 49.6%, the one HVC adopters were 42.0%, the two HVC adopters 47.7%, and the three HVCs adopters 51.5%. This implies that they are almost the same in this quartile. In the second wealth quartile, we observe a decline in number from non-adopters to the one, two, and three HVCs adopters respectively, contrary to what would be expected. For the third wealth

quartile, still the trend is not distinct. The trend is only clear in the case of the fourth quartile where we see more adopters dominating. These findings are supported by Lwasa et al. (2025), who found that while HVC adoption may influence income and expenditure in the short term, its impact on wealth accumulation is limited and not immediately observable.

There is weak evidence of higher wealth among farmers that adopted more of the HVCs compared to the strong evidence for farm income, total income, and total expenditure. This attests to the fact that wealth accumulation is a long-term phenomenon that is not just a function of only production or non-production of HVCs and for a limited period (Lwasa et al., 2025; Mnukwa et al., 2025). These findings also prove the existence of a significant difference between adopters and non-adopters with respect to total annual farm income, total annual income, and total annual expenditure as highlighted in the section below and in Tables 3 and 4. Farmers who adopted one HVC have significantly lower total annual farm income compared to those who adopted three HVCs. Those who adopted the three HVCs have significantly higher total farm income compared to those who adopted only two, except for the case of the last quartile where there is no significant difference between the two categories of farmers.

Table 3: Statistical Comparisons of Farm Income, Total Income, Expenditure and Wealth between Non- Adopters and Adopters of 1, 2 and 3 HVCs by Quartile

Adoption Status	Quartile	Total Annual Farm Income ('000 Ushs)	Total Annual Income ('000 Ushs)	Total Annual Expenditure ('000 Ushs)	Total value of Wealth ('000 Ushs)
0 Vs (1)	1	33.1 (268.0)***	59.8 (548.8)***	525.0 (722.4)***	925.8 (1,417.0)**
	2	175.4 (699.6)***	250.6 (1,460.3)***	1,210.0 (1,407.7)***	4,043.0 (5,224.5)**
	3	444.9 (1,537.3)***	685.3 (2,864.7)***	2,066.5 (2,536.9)***	9,374.4 (12,643.8)***
	4	4,023.7 (7,076..3)	6,600.4 (14,808.9)***	5,311.7 (6,394.1)***	67,155.3 (34,870.6)*
0 Vs (2)	1	33.1 (357.7)***	59.7 (599.3)***	525.0 (614.3)*	925.8 (1,413.8)***
	2	175.4 (948.7)***	250.5 (1,764.7)***	1,210.0 (1,479.8)***	4,043.0 (4,237.0)
	3	444.9 (2,380.8)***	685.3 (4,028.6)***	2,066.5 (2,504.4)***	9,374.4 (8,396.2)*
	4	4,023.7 (37,199.8)**	6,600.4 (41,084.9)**	5,311.7 (5,966.8)	67,155.3 (63,114.1)
0 Vs (3)	1	33.1 (684.0)***	59.8 (1,221.4)***	525.0 (1,225.6)***	925.8 (2,068.5)***
	2	175.4 (1,737.5)***	250.6 (2,727.0)***	1,210.0 (2,584.9)***	4,043.0 (5,965.0)***
	3	444.9 (3,692.9)***	685.3 (5,357.3)***	2,065.5 (4,262.3)***	9,374.4 (11,621.1)***
	4	4,023.7 (31,105.0)***	6,600.4 (33,685.8)***	5,311.7 (7,464.4)	67,155.3 (44,261.2)

NB: (i) Figures in parenthesis refer to adoption status as indicated in the first column. (ii) ***, ** and * refer to 1%, 5% and 10% levels of significance

International Journal of Agriculture

ISSN 2520-4629X (Online)
Vol.10, Issue 1, No. 1. PP. 1 - 22, 2025

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Table 4: Statistical Comparisons of Farm Income, Total Income, Expenditure and Wealth between Adopters of 1, 2 and 3 HVCs by quartile

Adoption Status	Quartile	Total Annual Farm Income (Ushs)	Total Annual Income (Ushs)	Total Annual Expenditure (Ushs)	Total value of Wealth (Ushs)
1 Vs (2)	1	268.0	548.8	722.4	1,417.0
		(357.7)***	(599.3)	(614.3)*	(1,413.8)
	2	699.6	1,460.3	1,407.7	5,224.5
		(948.7)***	(1,764.7)**	(1,479.8)	(4,237.0)
	3	1,537.3	2,864.7	2,536.9	12,643.8
		(2,380.8)***	(4,028.6)***	(2,504.4)	(8,396.2)***
	4	7,076.3	14,808.9	6,394.1	34,870.6
		(37,199.8)*	(41,084.9)	(5,966.8)	(63,114.1)
1 Vs (3)	1	268.0	548.8	722.4	1,417.0
		(684.0)***	(1,221.4)***	(1,225.6)***	(2,068.5)*
	2	699.6	1,460.3	1,407.7	5,224.5
		(1,737.5)***	(2,727.0)***	(2,584.9)***	(5,965.0)
	3	1,537.3	2,864.7	2,536,9	12,643.8
		(3,692.9)***	(5,357.3)***	(4,262.3)	(11,621.1)
	4	7,076.3	14,808.9	6,394.1	34,870.6
		(31,105.0)***	(33,685.8)**	(7,464.4)	(44,261.2)
2 Vs (3)	1	357.7	599.3	614.3	1,413.8
		(684.0)***	(1,221.4)***	(1,225.6)***	(2,068.5)*
	2	948.7	1,764.7	1,479.8	4,237.0
		(1,737.5)***	(2,727.0)***	(2,584.9)***	(5,965.0)***
	3	2,380.8	4,028.6	2,504.4	8,396.2
		(3,692.9)***	(5,375.3)***	(4,262.3)***	(11,621.1)***
	4	37,199.8	41,084.9	5,966.8	63,114.1
		(31,105.0)	(33,685.8)	(7,464.4)	(44,261.2)

NB: (i) Figures in parenthesis refer to adoption status as indicated in the first column.
(ii) ***, ** and * refer to 1%, 5% and 10% levels of significance

With regard to total wealth, no clear inclination is observed between adopters of none, one, two, and three. This is further testimony that wealth is a long-term phenomenon that is not a result of a few years of operations, note being taken that the period of adoption was only three years at the time of the study. Wealth is an important determinant of the financial status of farms as it provides security, freedom to manoeuvre resources, and economic and political power (USDA Economic Research Service, 2025). In essence, the results have shown that farm income is higher in most of the cases of adopters of more of the HVCs. Total farm income, being a function of other off-farm activities, is not directly associated with the production of more HVCs. This is the case with expenditure and wealth. There is some evidence of HVCs contributing modestly to improved household welfare if farm income, total income, and expenditure are considered as proxy indicators of welfare.

International Journal of Agriculture

ISSN 2520-4629X (Online)
Vol.10, Issue 1, No. 1. PP. 1 - 22, 2025

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Comparison of Adopters and Non-Adopters by Selected Variables

Adopters and non-adopters were compared by selected variables that were categorized into farm/household specific, farmer specific, assets/capital endowments, and location specific. These variables are discussed in a sequential order as given in Table 5. Among the farm/household variables, age, farming experience, and education of farmers were not significantly different between adopters and non-adopters. This is contrary to a priori expectations and other empirical findings. For example, Achukwu et al. (2023) reported that these variables influence one's decision to adopt new innovations.

Younger farmers are more enthusiastic and possess the energy to take risks on new innovations, as noted by Masi et al. (2022). Farming experience can generate or erode confidence. In other words, with more experience, a farmer can become more or less risk averse to new technology or innovation. However, no significant difference is noted in years between adopters and non-adopters. Several studies have shown that education helps a farmer to understand new technologies and innovations. Rizzo et al. (2024) and Ndaba et al. (2022) found education to influence awareness and use of innovations since it increases chances of acquiring, interpreting, and using information and of being able to understand situations much better than the lowly educated. With regard to age of the farmer, Ndaba et al. (2022) reported that age influences intensity of use of ICT among farmers, with younger farmers using more internet and mobile phones to access market information.

Table 5: Comparison between Non-Adopters and Adopters of the Study Crops by Selected Qualitative and Quantitative Variables

Type/Category of asset	Mean values		p-value
I. Farmer variables	**Non adopters**	**Adopters**	
Age of the household head (years)	38.53	37.35	0.281
Farming experience of head (years)	16.2	15.4	0.470
Education of household head (years)	7.20	7.24	0.894
Farmers that have attended training in farming (%)	0.00	16.0	0.000
Farmers that have participated in NGO agric. projects (%)	2.00	21.0	0.000
Farmers that have ever been in Government agric. projects (%)	2.00	25.0	0.000
II. Household specific variables			
Farmers that have ever accessed credit (%)	26.3	38.1	0.100
Family labour (number)	5.54	4.67	0.001
Farmers who hire labour	3.00	69.0	0.000
Farmers that get remittances	31.0	45.0	0.001

Lack of skills to use relevant inputs and recommended agronomic practices remains a major hindrance to the adoption of new crops and innovations among Ugandan farmers (Ilukor et al., 2025). Exposure and access to agricultural knowledge and skills were found to be higher among adopters. This is evidenced by indicators such as attendance of courses, demonstrations, and training in farming. Such training improves farmers' confidence and enthusiasm to excel in agriculture (Barekye & Tamwesigire, 2024). More adopters also participated in NGO and

government agricultural programs compared to non-adopters. These programs are designed to impart knowledge and skills, thereby increasing participants' capacity and confidence to undertake new innovations, consistent with findings from the USAID Digital Agriculture Assessment (USAID, 2022).

The variables analyzed under the category of farm-specific variables were all significant. The first was access to credit—more adopters had borrowed money compared to non-adopters. Credit access has been shown to positively influence adoption, as it enables farmers to acquire inputs like seed and fertilizer (Mwalupaso et al., 2025). Use of family labor was significantly lower among adopters, attributed to larger households prioritizing food crop production over cash crops. A higher proportion of HVC adopters used hired labor, reflecting both the labor-intensive nature of HVCs and the adopters' higher disposable income, which enables them to hire labor (Sebaggala et al., 2019).

Production of HVCs is capital intensive and often requires external funding. Remittances were significantly more accessible to adopters, supporting their need for operational funds to purchase inputs like agricultural chemicals. Remittances have been shown to support diversification into farm and non-farm enterprises, particularly livestock and non-staple crops (Kinuthia, 2020). They also improve household welfare and buffer against economic shocks through increased investment and income (Adeduntan & Adeagbo, 2025).

In the category of assets/capital endowments, the number of close village associates was significantly higher among adopters than non-adopters, likely due to enhanced information access. This underscores the importance of social capital in agricultural decision-making (Tengapoe et al., 2024). Analysis of categorized consumption expenditure on food, transport, and fees revealed higher mean values among HVC adopters, indicating greater disposable income and improved household welfare.

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The proportion of HVCs adopters who grew bananas was significantly higher than that of non-adopters. Bananas are the major food and cash crop in this area, and as such farmers do raise income from them. Being a perennial crop with a number of routine operations such as mulching, desuckering and pruning that need substantial amounts of money which the HVCs adopters are able to raise, and also earn income from them which they also use to meet the capital requirements of the HVCs. It was also observed that more adopters of HVCs grew coffee.

Agricultural diversification toward high-value crops such as coffee, avocado, and macadamia has gained momentum in Uganda due to their potential to boost household incomes and enhance food security. Coffee remains Uganda's leading agricultural export, with the government targeting 20 million 60-kg bags annually by 2025 (Uganda Coffee Development Authority [UCDA], 2023). This strategic push is supported by initiatives to improve planting material, post-harvest handling, and farmer organization, aligning with the broader agro-industrialization agenda (Ministry of Agriculture, Animal Industry and Fisheries [MAAIF], 2021). The adoption of high-value crops is influenced by several factors, including land access,

household labor availability, and proximity to infrastructure. Households with secure land tenure and access to all-weather roads are more likely to allocate land to cash crops (Bashangwa et al., 2020). Moreover, food self-sufficiency plays a critical role; households that meet their staple food needs are more inclined to diversify into commercial crops (MAAIF, 2021).

Table 6: Comparison between Non-Adopters and Adopters of the Study Crops by Selected Qualitative and Quantitative Variables

Type/Category of asset	**Mean values**		
I. Asset/Capital Endowment variables	**Non-adopters**	**Adopters**	**p-value**
Close village associates that influence decisions (number)	1.62	2.60	0.000
Expenditure on food (million Ushs/year)	0.959	0.175	0.015
Expenditure on transport (million Ushs/year)	0.224	0.328	0.020
Expenditure on fees (million Ushs/year)	1.467	1.887	0.009
Farmers grow bananas (%)	22.0	30.0	0.029
Farmers grow coffee (%)	19.0	27.0	0.043
Farmers rear livestock (%)	71.0	83.0	0.000
Farmers purchase inputs	3.00	79.0	0.000
Total land accessed (hectares)	4.26	5.29	0.299
Expenditure (million Ushs/year)	2.439	2.924	0.049
Farm income (million Ushs/year)	1.405	5.707	0.047
Off-farm income (million Ushs/year)	0.491	2.042	0.000
Total annual income (million Ushs/year)	2.337	5.852	0.022
Wealth (million Ushs/year)	20.58	15.40	0.280
II. Location specific variables			
Distance to main road (in kms)	1.11	0.59	0.000

Non-farm income diversification also contributes to agricultural technology adoption and welfare improvements. Households engaged in non-farm activities are better positioned to invest in productivity-enhancing technologies such as Zai pits and irrigation systems, which mitigate climate risks and improve yields (Danso-Abbeam et al., 2020). The integration of climate-smart agriculture with non-farm employment has shown to reduce multidimensional poverty and increase resilience (Yitbarek & Tesfaye, 2022). However, challenges persist, including limited access to credit, high marketing costs, and inadequate extension services. Government strategies now emphasize partnerships with nucleus farmers to scale up production of strategic crops like avocado and macadamia, leveraging economies of scale and ensuring quality standards (MAAIF, 2023).

Efforts to promote high-value crops must also address land fragmentation and infrastructure gaps. Studies in East Africa reveal that land scarcity and poor road access hinder the adoption of horticultural crops, despite their profitability (Mpozi et al., 2020). To overcome these barriers, policy interventions should focus on improving land tenure systems, expanding rural infrastructure, and supporting farmer cooperatives. As Uganda and other African nations pursue agro-industrialization, aligning agricultural investments with climate resilience and market access will be key to sustainable growth and poverty reduction.

Determinants of Adoption of any of Hot Pepper, French Beans or Okra

Table 7 provides the summary of the results on determinants of adoption of any of the High Value Crops, and in the section below, they are discussed. The education level of the household's most educated child significantly influences the likelihood of adopting high-value crops (HVCs), with an odds ratio of 1.051 at the 10% significance level. Interestingly, the education of the household head was not statistically significant, suggesting that intergenerational knowledge transfer plays a pivotal role in shaping agricultural decisions. Educated children often serve as conduits for accessing and interpreting agricultural information, thereby enhancing household awareness and receptivity to innovation. This finding aligns with earlier studies that emphasize the role of education in facilitating technology adoption through improved access to market information and ICT-based agricultural services (Kiiza et al., 2011; Lwasa et al., 2011). It also reflects the evolving dynamics of rural households, where younger members increasingly influence production decisions, particularly in contexts where mobile phone use and digital platforms are expanding access to agricultural knowledge.

Household size, commonly used as a proxy for family labour availability, was negatively associated with HVC adoption, with an odds ratio of 0.923. This contrasts with conventional expectations that larger households provide more labour for agricultural activities. The negative relationship may be attributed to increased subsistence demands in larger households, which divert labour and resources away from export-oriented crops. While earlier studies reported a positive association between family labour and adoption of improved technologies, recent evidence suggests that labour availability alone is insufficient unless complemented by access to information, training, and market infrastructure (Mnukwa et al., 2025; Tennhardt et al., 2024). In Uganda, where household labour remains a critical input, demographic pressures and intra-household labour allocation may constrain the flexibility required to engage with high-risk, high-return crops such as HVCs.

Participation in Agricultural Training Agricultural training significantly boosts the likelihood of adopting high-value crops (HVCs), increasing adoption odds by a factor of 13.389 at the 5% level. Such training exposes farmers to new technologies, enhancing understanding and encouraging risk-taking in innovation uptake (Turinawe & Ainembabazi, 2024). Demonstrations and extension events provide practical experiences that positively influence adoption behavior (Mnukwa et al., 2025; NaCRRI, 2024; Kule et al., 2025; FAO, 2025; Mishra et al., 2024).

Borrowing Money (Credit Access) Borrowing decreases adoption odds by a factor of 0.565 ($p < 0.10$), pointing to credit constraints as a barrier to technology adoption. Credit is critical for resource-limited farmers to afford inputs during early adoption stages. It improves liquidity and risk capacity, aiding decision-making under uncertainty (Amadu et al., 2020; Mwalupaso et al., 2025; Zhang et al., 2025; FAO, 2025).Interaction with Influential People Engagement with influential community figures, like Local Council 3 and 4 chairpersons, significantly increases adoption odds by a factor of 3.221 ($p < 0.05$). These individuals disseminate current agricultural insights. Farmers benefit from informal knowledge-sharing networks, which often outperform formal extension systems (Freeman & Qin, 2020; Kule et al., 2025; Mishra et al., 2024; Mujawamariya et al., 2025; FAO, 2025).

Table 7: Determinants of Adoption of Any of the Three HVCs: Results of a Maximum Likelihood Robust Logistic Regressions Reporting Odds Ratios

Variables	Odds Ratio	Robust Standard Error	Z	p>z
Farmer variables				
Age of the respondent (years)	0.999	0.012	-0.050	0.962
Education level of highest educated child (years)	1.051	0.030	1.760	0.079
Household size	0.923	0.042	-1.740	0.082
Participated in agricultural training for last 5 years (dummy)	13.389	14.755	2.350	0.019
Household specific variables				
Whether farmer has ever borrowed money	0.565	0.195	1.650	0.098
Interacted with Chairperson LC3/LC5 (dummy)	3.222	1.691	2.230	0.026
Ever participated in Government and NGO Agricultural Project (dummy)	5.704	3.154	3.150	0.002
Members of a farmers' group (dummy)	0.485	0.136	-2.590	0.010
Assets/capital variables				
Number of village associates that influence farmers' decisions	1.117	0.046	2.670	0.008
Total value of cattle owned (Ushs)	1.000	0.000	-1.960	0.050
Total land accessed (Hectares)	0.996	0.009	0.382	0.702
Total Household annual income (Ushs)	2.026	0.216	6.610	0.000
Location specific variables				
Distance from farm to nearest tarmac (in kms)	0.927	0.028	-2.490	0.013

n = 491, Wald chi2 (13) = 102.37, Prob > chi2 = 0.000, Log pseudolikelihood = -210.332 Pseudo R^2 = 0.3779

Participation in a Government or NGO Project Involvement in government or NGO agricultural initiatives increases adoption odds by a factor of 5.704. Such programs introduce productivity improvements, promote input use, and enhance market access. On-farm trials and demonstrations are instrumental in boosting farmers' skills and confidence in adopting new practices (NaCRRI, 2024; FAO, 2025; AVCP, 2025; AU, 2025). Membership in Farmers' Groups Unexpectedly, group membership decreases adoption odds by a factor of 0.485 ($p < 0.01$). This could result from misalignment between group objectives and HVC promotion. While groups enhance access to information, their effectiveness hinges on relevance to farmers' production goals (Mishra et al., 2024; Kule et al., 2025; Mnukwa et al., 2025).

International Journal of Agriculture

ISSN 2520-4629X (Online)
Vol.10, Issue 1, No. 1. PP. 1 - 22, 2025

www.iprjb.org

Determinants of Adoption Intensity of High-Value Crops

Recent studies have identified a range of socio-economic and structural factors that significantly influence the intensity of High-Value Crop (HVC) adoption. Age continues to show an inverse relationship with adoption intensity, with younger farmers more likely to adopt technology-intensive practices (Mnukwa et al., 2025; Erick et al., 2025). However, regional and contextual variations persist, and no universal consensus exists on age-related effects (Kule et al., 2025).

Educational attainment, particularly of household members involved in decision-making, remains a strong positive determinant. Higher education levels correlate with increased adoption intensity due to improved capacity to interpret agricultural information and engage with extension services (Valdes et al., 2023; Kiiza et al., 2011; Lwasa et al., 2011). Similarly, access to formal credit has a statistically significant positive effect ($p < 0.01$), as financial liquidity enables farmers to invest in diversified cropping portfolios (Mwalupaso et al., 2025; Mnukwa et al., 2025).

Table 8: Determinants of intensity of adoption of Hot pepper, French Beans and Okra

Variable	Coefficient	Standard Error	Z	pr > z
Farmer specific variables				
Age of household head (years)	-0.019	0.009	-2.15	0.032
Marital status (1 Married, 0 Otherwise)	0.169	0.235	0.72	0.472
Education of highest educated child (years)	0.050	0.023	2.19	0.028
Household size	-0.034	0.037	-0.92	0.357
Household specific variables				
Ever borrowed money (1 Yes, 0 No)	0.652	0.252	2.59	0.010
Ever participated in Government/NGO agricultural project (1 Yes, 0 No)	0.594	0.319	1.86	0.063
Use of hired labour (1 Yes, 0 No)	3.586	0.300	11.94	0.000
Receives remittances (1 Yes, 0 No)	0.181	0.204	0.89	0.374
Farmer grows bananas (1 Yes, 0 No)	0.312	0.221	1.41	0.158
Farmer grows coffee (1 Yes, 0 No)	-0.047	0.232	-0.20	0.839
Assets/capital variables				
Number of close village associates	0.062	0.030	2.03	0.042
Total land accessed (Hectares)	0.010	0.005	2.12	0.034
Total off-farm income (Ushs)	0.001	0.001	2.64	0.008
Number of cattle owned	-0.022	0.027	-0.81	0.417
Location specific variables				
Distance (farm to nearest tarmac in kms)	-0.256	0.095	-2.69	0.007
/cut1	-0.557	0.664		
/cut2	2.138	0.716		
/cut 3	4.179	0.737		

n = 522, LR chi2 (15) = 256.75, Prob. > chi2 = 0.0000, Log pseudolikelihood = -420.43, Pseudo R^2 = 0.319

Participation in government or NGO-led agricultural programs contributes positively to adoption intensity ($p < 0.10$), as such programs often expose farmers to agronomic innovations and market-oriented strategies (Kule et al., 2025; NaCRRI, 2024; Valdes et al., 2023). The ability to hire labor also shows a strong positive influence ($p < 0.01$), reflecting the labor-intensive nature of HVCs and the need for external labor inputs in the face of rural demographic shifts (Kotir et al., 2020; Mwalupaso et al., 2025).

Social capital, measured through the number of influential village-level associates, is positively associated with adoption intensity. Informal networks and peer learning often outperform formal extension mechanisms in disseminating practical agricultural knowledge (Erick et al., 2025; Kule et al., 2025; Kiiza et al., 2011).

Land access remains a critical factor, with larger landholdings enabling enterprise diversification and greater adoption intensity (Erick et al., 2025; Mnukwa et al., 2025). Off-farm income also plays a significant role, providing financial flexibility for input acquisition and labor hiring (Valdes et al., 2023; Mwalupaso et al., 2025). Finally, proximity to tarmac roads enhances adoption intensity by improving access to markets, inputs, and extension services (Kule et al., 2025; Mnukwa et al., 2025; Haile, 2023).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The empirical evidence presented in this study substantiates the modest but meaningful contribution of High-Value Crops (HVCs) to household welfare in rural agrarian settings. Econometric analyses confirm that relatively wealthier households are more inclined to adopt HVCs, with income level emerging as a statistically significant determinant. Adoption propensity is further influenced by the educational attainment of the household's most educated child, access to agricultural training, engagement with local governance structures, participation in externally supported agricultural interventions, and overall household income.

Conversely, the likelihood of adoption declines among households characterized by larger size, limited access to credit, possession of cattle and land, and membership in farmer groups. The unanticipated inverse relationship between membership to farmer groups and adoption of HVCs, could be attributed to farmers being members in groups that are not oriented to horticultural crops under study. The intensity of HVC engagement is positively associated with child education, labor hiring capacity, exposure to agricultural programs, off-farm income diversification, and intra-community farmer interactions. However, it is inversely affected by the farmer's age, credit constraints, and physical remoteness from road infrastructure. These findings suggest that both socioeconomic status and spatial connectivity play pivotal roles in shaping adoption behaviors.

Recommendation

To stimulate adoption of HVC cultivation, several policy measures warrant prioritization. Strengthening agricultural advisory services, through Extension agents will be critical. This calls for intensification of the ongoing recruitment of more public and private Extension staff at District and Sub-county levels and facilitating them to reach farmers regularly. This is a continuous process. This should be undertaken by The Government of Uganda, and some NGOs that are rural based with agriculture as a focus area. This should further be augmented with formulating and implementing more Government and Horticultural based NGO Agricultural Project to impart more skills to the grassroot farmers. The NGOs may include;

Horticulture Exporters Association (HORTEXA) Brac and Treescape planet Organization. To further enhance adoption, Leaders at all levels must support farmers to increase total household incomes, through household and community level cottage and small scale industries. The time frame for these proposals is medium term (5-10 years) period.

To increase intensity of adopting these HVCs, farmers ought to be encouraged to hire more labour given that these crops are labour intensive, and farmers do not have to depend on family labour. This message should be disseminated by Extension staff who are also expected to share the deeper explanation behind this recommendation. Central and Local Governments should make it more conducive for farmers to access finance from formal institutions under friendly terms (that should include lower interest rates and longer loan payment periods). This recommendation can be implemented in a period of 5 – 10 years. In order to track progress on the implementation of these recommendations, the line Ministry of Agriculture, Animal Industry and Fisheries and that of Local Government ought to include these issues in their Central Monitoring and Evaluation Systems.

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