The influence of seed selection on coffee production and farmers' livelihood in Kagera region

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Abstract

This study examines the influence of seed selection on coffee production and farmers' livelihoods in the Kagera region, Tanzania. Using secondary data from the National Bureau of Statistics and the Coffee Board for 2019/2020, along with a sample of 594 respondents, the research employs a multinomial logistic regression model to explore the factors affecting seed selection. Findings reveal that 96% of farmers rely on local seeds, while 2% adopt improved seeds or a combination of both. Larger planting areas increase the likelihood of adopting improved seeds, while high seed costs and limited fertilizer use significantly deter adoption. Furthermore, the results emphasize and recommend the need for targeted interventions, including improved seed supply systems, affordable seed packages, integrated input support, and incentives for large-scale farmers. Strengthening these areas could enhance coffee production and contribute to better livelihoods for farmers in Kagera. These findings provide critical insights for policymakers aiming to improve coffee productivity, improving farmers' economic wellbeing and sustainability.

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1. Introduction

Coffee is one of the world's most traded agricultural commodities, serving as a key source of income for numerous countries across Africa, Asia, and Latin America (Kufa et al., 2011; FAO, 2018; ICO, 2021). The coffee plant, a member of the Rubiaceae family, primarily falls under the genus *Coffea*, which includes over 80 species originating from the equatorial forests of East and West Africa, Madagascar, and the Indian Ocean islands such as Comoros. Among these, *Coffea arabica* L. (Arabica) and *Coffea canephora* Pierre ex A. Froehner (Robusta) stand out as economically significant species (Bridson & Verdcourt, 1988; Charrier et al., 1985; Cannell, 1985; Campuzano-Duque & Blair, 2022).

In Tanzania, coffee remains a cornerstone of the agricultural sector, cultivated in regions such as Mbeya, Ruvuma, Songwe, Kilimanjaro, Kigoma, and Kagera. The crop serves as a key cash commodity, directly supporting the livelihoods of approximately 450,000 Tanzanians engaged in coffee farming and related activities (Tanzania Coffee Board, 2021; TaCRI, 2022; World Bank, 2015). On a global scale, coffee dominates agricultural trade by volume, with over 131 million 60-kg bags traded in 2020 and an annual consumption rate of approximately 400 billion cups (ICO, 2021; Perfecto et al., 2005). The industry provides livelihoods to an estimated 60 million people across coffee-producing countries (Rapsomanikis, 2015).

Beyond its contribution to foreign exchange, coffee supports the livelihoods of millions of farmers who depend on its production for income (Dávila et al., 2023; Mbunduki, 2024). Aggregate income, defined as the total earnings from the production process minus intermediate costs, directly impacts farmers' ability to sustain agricultural activities and improve their quality of life (Solis Rosales & Cruz Romero, 2020; Tesfaye & Mahlet, 2019). Farmers' income is tied to various factors, including crop productivity, selling price, available cultivation area, and management practices (Galeas & Álvaro, 2014; Jamaldin, 2024). Effective resource management, particularly seed selection, is a crucial aspect of ensuring sustainable coffee production and long-term economic benefits (Muleta, 2017; Anteneh, 2023).

Despite its importance, coffee production faces numerous challenges, including poor seed selection, inadequate management practices, and climate variability (Kitonga & Njagi, 2019; Magrach & Ghazoul, 2015). Seed selection, in particular, remains a critical yet under-researched factor influencing coffee productivity and farmers' livelihoods. A lack of access to improved seed varieties and the absence of a structured certification and distribution system exacerbate production inefficiencies (Chen & Tsegaye, 2020; Kufa et al., 2011; Läderach et al., 2013).

The Kagera region, known for its agricultural potential, is one of the prominent coffee-producing areas in Tanzania. Coffee plays a dual role as a cash crop and a source of household income for many farmers in the region (Mwakalobo & Shively, 2020; Kitole et al., 2023). However, productivity levels have been inconsistent, primarily due to inadequate seed quality and poor agricultural practices (Mangula et al., 2019; Deepika & Jyotishi, 2021). Despite efforts to enhance productivity, coffee farmers in Kagera often lack access to improved seed varieties, which limits their potential to achieve higher yields and improved income (Nguyen & Ha, 2015; Myeni et al., 2023).

Studies suggest that disease management is also a persistent challenge for coffee farmers. For example, dieback disease significantly reduces coffee productivity in regions like Sidama, Gedeo,

and Wolayta (Tadesse et al., 2020; Waller et al., 2007). In Kagera, similar challenges exist, compounded by poor soil fertility, inadequate extension services, and lack of awareness about advanced farming techniques (Dimoso & Kitole, 2021; Jamaldin, 2024). Furthermore, climate variability, including rising temperatures, intensifies the risk of pests and diseases, adding to the vulnerabilities faced by farmers (Ward & Masters, 2007; Ramirez-Villegas et al., 2012).

While coffee is a vital economic crop, there remains a substantial gap in understanding the role of seed selection in influencing coffee productivity and farmers' livelihoods, particularly in regions like Kagera. Unlike other crops, coffee production in Tanzania lacks a robust seed production and distribution system. There is no established national coffee seed certification scheme, leaving farmers reliant on informal and often low-quality seed sources (Taye, 2013; Moat et al., 2017; Kilimo Trust, 2020). Moreover, limited research has explored the socioeconomic implications of poor seed selection on farmers' income and productivity, creating a critical need for targeted interventions and policy reforms (Bunn et al., 2015; Bealu, 2021).

This study aims to examine the influence of seed selection on coffee productivity and its subsequent impact on the livelihoods of farmers in the Kagera region. By identifying the challenges and gaps in the current seed selection processes, this research seeks to provide insights into improving agricultural practices and boosting the economic well-being of coffee farmers. Addressing these gaps will contribute to enhancing coffee production, ensuring sustainable livelihoods, and strengthening the region's position in the global coffee trade.

2. Empirical review

The coffee production process is a complex series of agricultural activities that begins with seed selection and continues through planting, fertilization, weed and pest control, and other management practices. These activities are critical to ensuring sustainable agriculture, enhancing productivity, and improving coffee quality (Ministry of Agriculture and Livestock, 2020). Proper characterization of production processes helps identify potential growth opportunities and diagnose challenges. Such assessments enable the design of targeted strategies to address issues, thereby improving farm-level efficiency and profitability.

Deepika and Jyotishi (2021) analyzed the risks faced by small-scale coffee growers in the Kodagu district of Karnataka, India, identifying farm-level, marketing, and policy-related risks. Farm risks include threats to yield due to rising input costs, lack of irrigation, and limited extension services. Marketing risks are driven by price volatility and supply chain dependency on buyers, while policy risks stem from taxation and regulatory challenges. The study emphasized the need for crop diversification as a risk mitigation strategy, a move supported by the Coffee Board, Spice Board, and horticulture departments. However, coordination among these institutions has been minimal, hindering efforts to encourage diversification. A unified approach could better address farmers' challenges holistically, promoting resilience in coffee farming systems.

Anteneh (2023) conducted a study on coffee seed production and supply in Ethiopia, revealing that access to improved coffee seeds significantly boosts production and productivity. Despite the potential benefits, the study found that the supply of improved seeds fell short of farmers' growing demand. Factors such as the unavailability of seed stock, long storage times reducing germination rates, and poor seed distribution systems contributed to this shortfall. Farmers often relied on informal seed exchanges, which were inadequate for meeting production goals. The study called

for innovative and alternative seed systems involving farmer groups and enhanced extension services to address these challenges.

Coffee production has a direct impact on farmers' livelihoods, especially in regions where it serves as a primary source of income. Galeas and Álvaro (2014) argued that income derived from coffee farming is a determinant of rural households' quality of life, influencing their ability to reinvest in farming activities. Proper seed selection and access to improved seed varieties play a vital role in enhancing productivity, which in turn contributes to higher incomes. However, challenges such as lack of awareness about improved seeds and the absence of certification systems hinder progress.

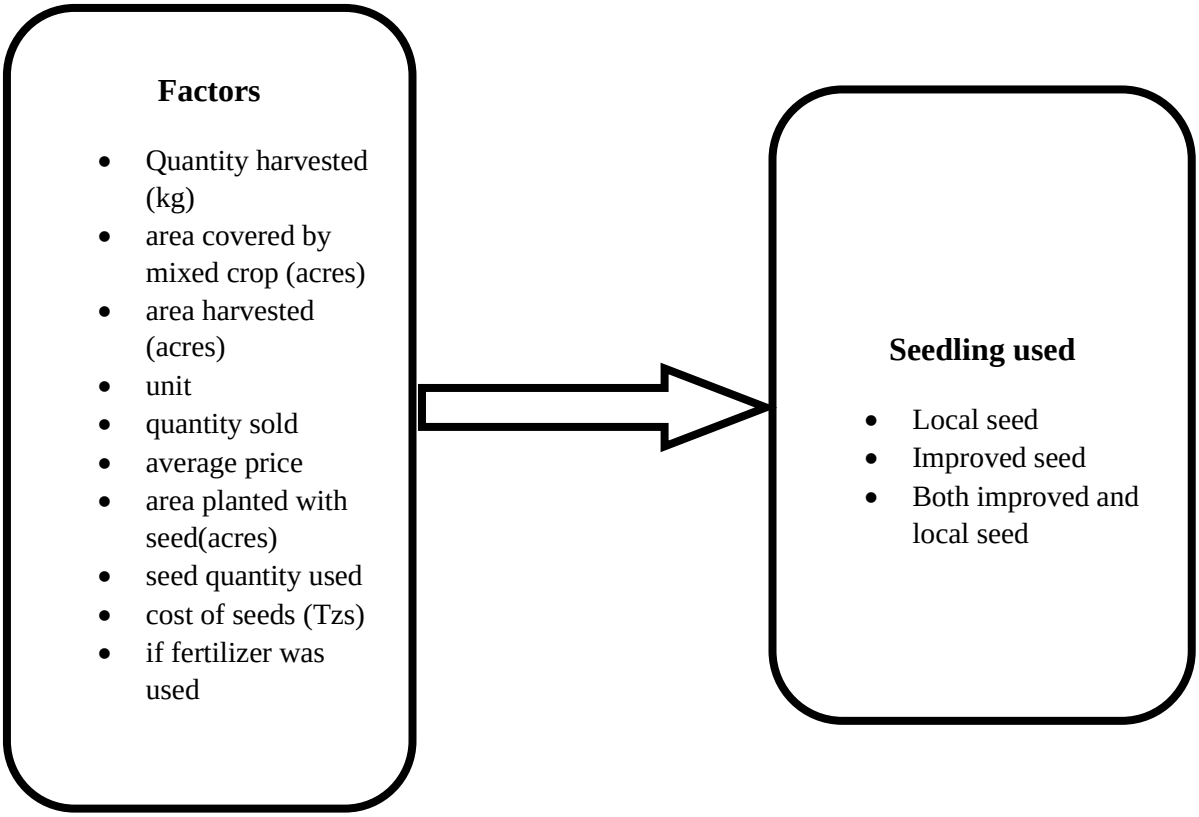
Taye (2013) highlighted the absence of a national coffee seed certification scheme in many coffee-producing countries, including Tanzania. This gap undermines farmers' access to high-quality seeds, which are essential for achieving sustainable yields. Seed selection influences multiple aspects of coffee production, including disease resistance, yield potential, and crop quality. Addressing this challenge requires the establishment of robust seed certification programs and strengthening the role of public and private stakeholders in seed production and distribution.

Ward and Masters (2007) demonstrated the profound impact of climatic changes on coffee farming, particularly regarding pest and disease dynamics. Rising temperatures accelerate insect development and reproduction, increasing the prevalence of agricultural pests. Additionally, poor management practices, such as low soil fertility and inadequate disease control, further exacerbate these issues. Tadesse et al. (2020) identified dieback disease as a significant threat to coffee productivity in Ethiopia, with farmers relying on limited and often ineffective methods to combat it. This highlights the need for improved extension services to educate farmers about integrated pest management and other sustainable practices.

The reviewed literature underscores the centrality of seed selection in shaping coffee productivity and farmer livelihoods. Studies such as Anteneh (2023) and Taye (2013) emphasize the critical role of improved seed varieties, while Deepika and Jyotishi (2021) highlight the importance of addressing farm and market-level risks holistically. Despite these insights, there remains a gap in the integration of seed certification systems and coordinated institutional support to farmers. Moreover, the combined challenges of climate variability, disease management, and poor access to improved seeds call for innovative solutions that enhance resilience and productivity.

This empirical review demonstrates the need for comprehensive strategies to address seed selection and supply issues, particularly in regions like Kagera. Integrating improved seed systems with extension services and fostering institutional collaboration can mitigate risks and boost productivity. Future research should explore the socioeconomic benefits of establishing certification schemes and alternative seed systems to meet farmers' growing demands.

Figure 1: conceptual frame work



Source: Author construction, 2024

3. Methodology

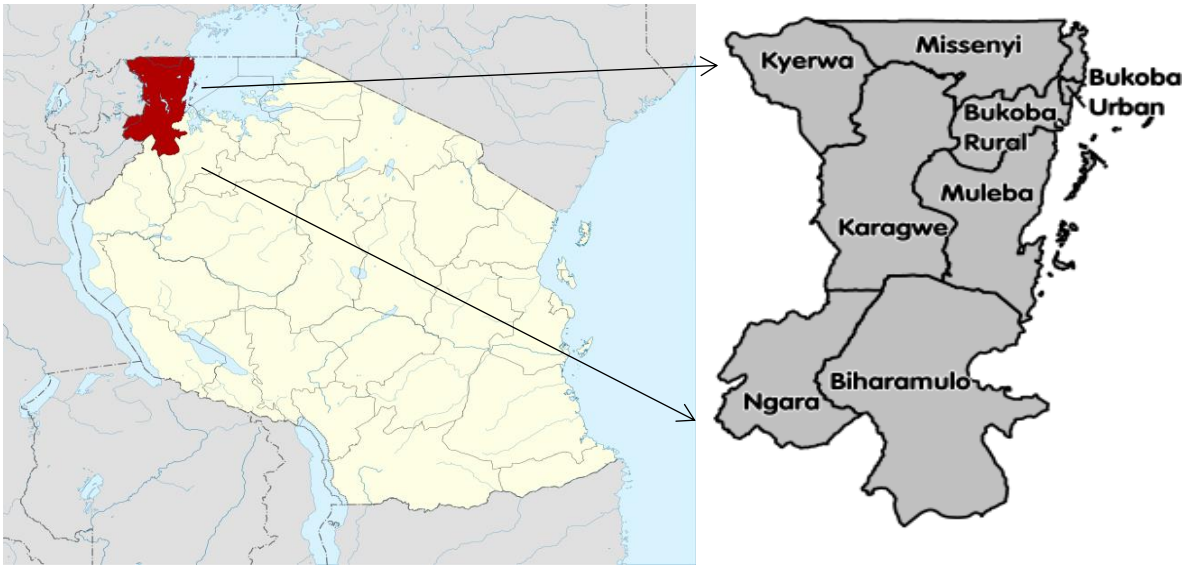
This study utilized secondary data from reports from the Coffee Board and panel survey data of 2019/2020 from National bureau of statistics (NBS) to investigate the influence of seed use and selection on coffee production and farmers' livelihoods in the Kagera region. The research employed a sample of 594 respondents ensuring appropriate representation and robustness in the analysis variables influencing coffee farmers and government initiatives using

Kagera region is located in the northwestern part of Tanzania, boarded by Uganda to the north, Rwanda and Burundi to west and Lake Victoria to east. The region lies between latitude latitudes 1º 00' and 2o 45' south, longitudes 30º 25' and 32o 40' east. This includes large part of the water of Lake Victoria. The landmass lies between 30º 25' and 31o 48' longitudes east. It covers a total land area of 40,838 sq.km.(National Bureau of Statistics 2018 and Jamaldin 2024).Kagera region features diverse topography including highlands, plateaus and valley which creates various microclimates suitable for coffee cultivation. Region experiences a bimodal rainfall pattern with the main rainy season from March to May and a shorter rain season from October to December.

Annual rainfall ranges from 5000mm in the western parts 2000mm along Lake Victoria coast. the average temperature ranges from 15ºC to 30ºC, providing an ideal environment for coffee growth Administrative districts Kagera comprises several districts, each contributing to its agricultural

output starting with Bukoba urban, Bukoba rural, Muleba, Karagwe, Ngara, Biharamulo kyerwa Missenyi. The majority of the population in the Kagera region about 90% are farmers the region's major cash crop include coffee, tea, cotton tobacco and vanilla and the food crop are bananas, beans, maize, groundnuts, and cassava. Both district vary in specific climatic conditions and agricultural practices influencing coffee production across the region

Figure 2. Map of Kagera region



Source: Kagera Region (2024)

3.2 Analytical model

The study employed a multinomial logistic regression model to analyze the effects of independent variables on the dependent variable, which in this case is the seed selection on coffee production in kagera region. This statistical model is particularly useful when dealing with multiple discrete alternatives. It facilitated the identification and quantification of the factors influencing farmer's decisions regarding different types of seed selection and use. This approach is similar to studies conducted by Mangula et al. (2019), Kitole et al. (2023), and Dimoso & Andrew (2021).

The multinomial logit model was chosen due to its capability to utilize the cumulative distribution function of the logistic distribution, making it well-suited for analyzing categorical dependent variables with more than two possible outcomes. It is a robust and effective tool frequently used in studies involving multiple-choice scenarios (Kitole et al., 2023; Kitole and Sesabo, 2022). The model allows for a clear understanding of the relationship between independent variables and the likelihood of selecting specific seed types. The multinomial logit equation applied to explain the influence of seed selection on coffee production and farmers' livelihood in Kagera region is expressed as:

$$log\left[\frac{\pi_j(x_i)}{\pi_k(x_i)}\right] = \alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots . . + \beta_{pj}x_{pi}$$

Whereas $j = 1,2, \ldots . . k$

Additionally, the reduced form of the equation is expressed as:

$$\log\left(\pi_j(x_i)\right) = \frac{\exp\left(\alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots . . + \beta_{pj}x_{pi}\right)}{1 + \sum_{j=1}^{k-1} \exp\left(\alpha_{0i} + \beta_{ij}x_{1i} + \beta_{2j}x_{2i} + \cdots \ldots \ldots . . + \beta_{pj}x_{pi}\right)}$$

For $j = 1,2, \ldots, (k-1)$, and the parameters α and β will be estimated by the use of maximum likelihood. This Model was Chosen because the dependent variable has more than two unordered categories: local seed, improved seed and both local and improved seed was preferred due to its straightforward computational process and its enhanced predictive capability in contrast to the Multinomial probit Model (Mhagama, and Heriel, 2023). On the other hand, variables that have been used in this study have been presented at Table 1.

Table 1. Description of variables used in the study

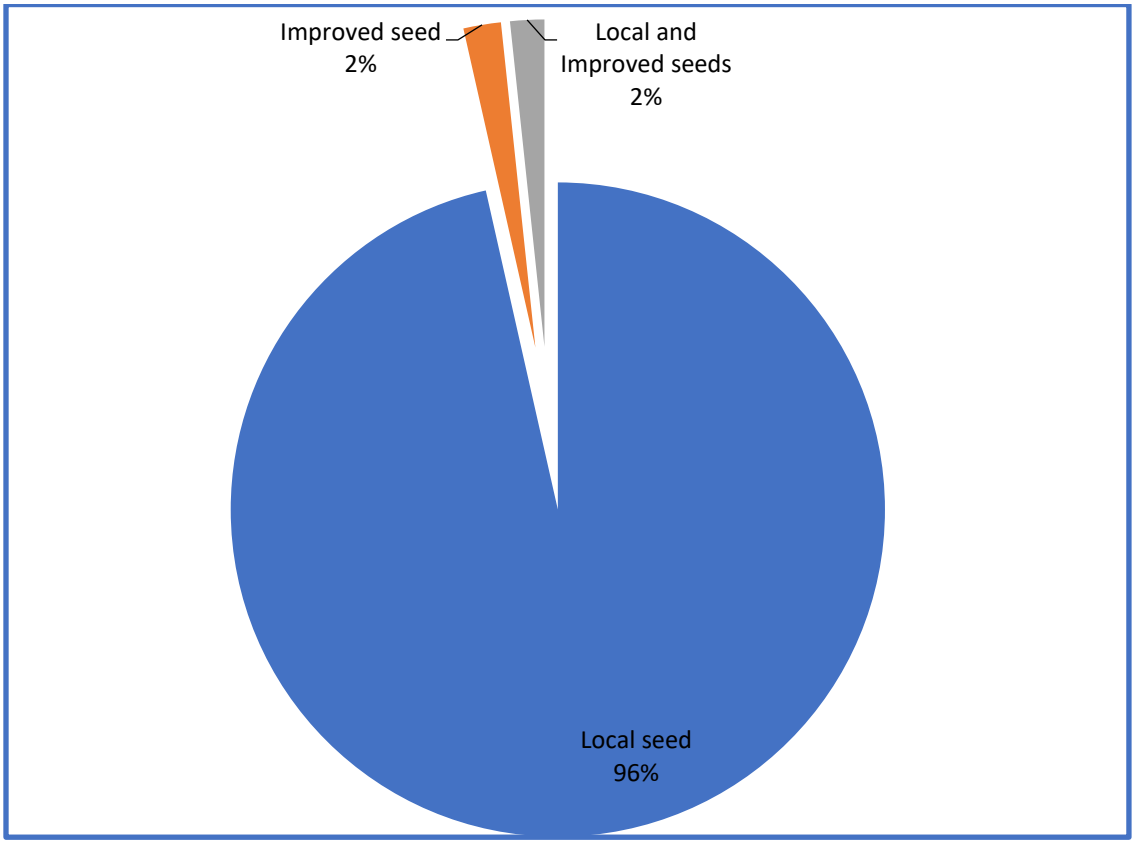
Variables	Measurements
Seedling used	Categories of Seedling used **(**Local seed**,** Improved seed**,** Both improved and local seed)
Quantity harvested (kg)	Quantity in kilogram (Kg)
area covered by mixed crop (acres)	Area covered in (acres)
area harvested (acres)	Area harvested in (acres)
Unit	Kilogram, Bunches
quantity sold	Quantity sold in (Kg)
average price	Average price in Tzs (Tanzanian shilling)
area planted with seed(acres)	Area planted seed in (acres)
seed quantity used	seed quantity used (kg)
cost of seeds (Tzs)	cost of seeds (Tzs) Tanzanian shillings
if fertilizer was used	If the fertilizer was used 1=Yes 2=No

Source: Author computations

4. Findings

The figure illustrates the types of seeds used by coffee farmers in the study area. The data indicates that 96% of farmers rely on local seeds, while only 2% use improved seeds and an additional 2% utilize a both local and improved seeds

Figure 3 distributions of seed types used by coffee farmers in Kagera region



The distribution suggests that the majority of farmers in the Kagera region heavily depend on traditional seeds varieties, potentially due to factors such as accessibility, affordability, or a lack of awareness about the benefits of improved seeds. The limited adoption of improved of improved seeds could constraints productivity as these seeds are often designed to deliver higher yield and better resistance to pest and diseases. This findings underscores the needs for targeted intervention to promote improved seed usage to enhance coffee production and farmers' livelihoods

Table 2 Multinomial logit on seed used on coffee production among farmers in Kagera region

Variables	Type of seed selected Improved seed	Both local and Improved seeds
Quantity harvested (kg)	0.0048486	-0.011458
	-0.0035434	0.0098335)
area covered by mixed crop (acres)	-0.080723	0.0757061
	-1.109614	-1.115487
area harvested (acres)	-3.045797	-4.885214
	-2.146164	(2.67577)*
Unit of measurement		
Bunch	-11.6374	-10.68263
	-1820.184	-1685.163
Kilogram	-2.246696	-0.909488
	(1.33221)*	-1.357479
quantity sold	-0.002837	-0.004565
	-0.0033856	-0.0046365
average price	0.0002576	-0.000403
	-0.0010713	-0.0018428
area planted with seed(acres)	1.930591	2.014692
	(0.9061263)**	-1.58943
seed quantity used	-0.003562	0.0005024
	-0.0044277	-0.0050035
cost of seeds (Tzs)	0.0000262	0.0000577
	-0.0000265	(0.0000181)***
if fertilizer was used		
No	-3.398338	-3.527741
	(1.09915)**	(1.384413)**

Standard errors in parentheses.
****p < 0.01, **p < 0.05, *p < 0.1.*

The coefficient for the quantity harvested for improved seeds is positive (0.0048) but statistically insignificant, suggesting a minimal relationship between coffee quantity harvested and the likelihood of adopting improved seeds. Similarly, the coefficient for both seed types is -0.0115 and statistically insignificant. These findings indicate that the volume of coffee harvested does not significantly influence farmers' decisions to adopt improved seeds or mixed seed types. Factors such as seed availability, cost, or farmers' knowledge about seed benefits might play a more critical role than the sheer quantity of the harvest.

For improved seeds, the coefficient is -0.0807, and for both seed types, it is 0.0757, neither of which are statistically significant. This suggests that the area under mixed crop cultivation does not have a meaningful influence on seed selection. Farmers may prioritize other considerations, such as financial constraints or input costs, rather than the extent of mixed cropping.

The coefficient for area harvested is -3.0458 for improved seeds and -4.8852 for both seed types, both statistically significant at the 10% level ($p < 0.1$). This implies that larger-scale farmers are

less likely to adopt improved seeds or mixed seed types. Possible reasons include resource constraints, logistical challenges, or the perception that larger plots make improved seeds less cost-effective. This result highlights the importance of targeted interventions, such as subsidies or technical support, to improve access to and adoption of improved seeds among large-scale farmers.

For improved seeds, the coefficient for bunch units is -11.6374, while for kilograms it is -2.2467, with the latter significant at the 10% level. These results suggest that farms using kilograms as a unit of measurement are less likely to adopt improved seeds. This could reflect differences in farming practices, crop management, or the market orientation of these farms.

The coefficient for the quantity sold is -0.0028 for improved seeds and -0.0046 for both seed types, both statistically insignificant. This indicates no meaningful relationship between the quantity of coffee sold and the likelihood of adopting improved seeds. Market dynamics, such as demand or profitability, might outweigh considerations of seed adoption when deciding the amount to sell. The coefficient for the average price of coffee is 0.00026, which is statistically insignificant. This suggests that the price farmers receive for their coffee does not significantly influence their choice of improved seeds. Instead, farmers may focus on production costs, availability, and affordability of inputs when selecting seeds.

The coefficient for the area planted with seeds is positive (1.9306 for improved seeds and 2.0147 for both seed types), with statistical significance at the 5% level ($p < 0.05$). This indicates that as the area planted increases, farmers are more likely to adopt improved seeds or a combination of both types. Larger planting areas may incentivize farmers to invest in higher-yielding seeds to maximize returns. This finding underscores the potential to scale up the adoption of improved seeds through targeted support and incentives.

The coefficients for seed quantity used (-0.0036 for improved seeds and 0.0005 for both seed types) are statistically insignificant, indicating no significant relationship between the amount of seed used and the likelihood of adopting improved seeds. This could be attributed to a lack of awareness about optimal seed usage or constraints in the availability of improved seeds in the region.

The coefficient for seed cost is 0.0000262 for improved seeds, significant at the 1% level ($p < 0.01$). This shows a positive relationship between higher seed costs and the adoption of improved seeds. Farmers investing in higher-cost seeds are likely prioritizing the perceived benefits of improved seed performance, such as better yields or disease resistance. Promoting the value proposition of improved seeds, including their return on investment, could encourage broader adoption.

The coefficients for "no fertilizer use" are negative (-3.3983 for improved seeds and -3.5277 for both seed types), both statistically significant at the 5% level ($p < 0.05$). This indicates that farmers who do not use fertilizer are less likely to adopt improved seeds or mixed seed types. Fertilizer use often complements improved seeds to enhance productivity, suggesting that efforts to promote seed adoption should also address constraints in fertilizer access and usage.

The results highlight several critical factors influencing the adoption of improved seeds among coffee farmers. While factors like the area planted with seeds and seed cost significantly encourage adoption, larger-scale farmers and those not using fertilizer face barriers. Addressing these

challenges through targeted interventions, such as improving seed availability, affordability, and complementary input access (e.g., fertilizers), can enhance adoption rates. Emphasizing the economic value and productivity benefits of improved seeds is essential for promoting their use across diverse farming scales.

5. Discussion

The findings of this study shed light on the factors influencing the adoption of improved seeds among coffee farmers, offering insights into the interplay of land size, seed cost, fertilizer use, and measurement practices in seed selection. The study revealed a statistically significant negative relationship between the area harvested and the likelihood of adopting improved seeds or a combination of both seed types. This suggests that as the size of harvested areas increases, farmers are less likely to adopt improved seeds, possibly due to the higher costs and logistical challenges associated with using improved seeds on larger scales. These findings align with the studies of Anteneh (2023) and Kufa et al. (2011), which highlighted that the limited availability of high-quality seeds and the absence of a formal coffee seed system remain significant barriers to seed adoption. Such challenges are further exacerbated by resource constraints faced by larger-scale farmers, underlining the need for policies and systems that enhance the accessibility of improved seeds across varying farm sizes.

A statistically significant positive relationship was found between the area planted with seeds and the adoption of improved seeds. This indicates that larger planting areas incentivize farmers to adopt improved seeds to maximize productivity and returns. These findings echo those of Myeni et al. (2023), who emphasized that expanding crop adaptability and planting high-yield varieties over larger areas can increase yields per unit and reduce the yield gap. This underscores the potential for scaling up improved seed adoption through targeted incentives, such as subsidies or support programs, particularly for farmers managing larger planting areas.

Seed cost emerged as a significant factor influencing improved seed adoption, with higher costs positively associated with the likelihood of adoption. This suggests that farmers willing to invest in higher-cost seeds are motivated by the expected benefits, such as improved yield performance or resistance to disease. The findings are consistent with Rahman and Connor (2022) and Tadesse et al. (2020), who concluded that improved seeds represent a high-potential return investment, particularly in regions dominated by smallholder farming. To further encourage adoption, it is crucial to emphasize the value and return on investment of improved seeds through farmer education and extension services, alongside strategies to make seeds more affordable.

A significant negative relationship was observed between the use of fertilizers and the likelihood of adopting improved seeds or combining improved and traditional seed types. Farmers who do not use fertilizers are less likely to adopt improved seed varieties, likely because fertilizers often complement improved seeds to achieve optimal yields. These findings differ from those of Coffea (2024), which suggested that organic and inorganic fertilizers provide sufficient nutrients for coffee growth. The discrepancy underscores the importance of ensuring that farmers have access to both fertilizers and improved seeds, as the effectiveness of one often depends on the availability of the other.

The findings indicate that the unit of measurement significantly influences the adoption of improved seeds. Farms using kilograms as the unit of measurement are less likely to adopt

improved seeds, possibly due to the higher costs associated with bulk seed purchases. This aligns with the studies of Kufa et al. (2011) and Anteneh (2023), which highlighted that kilograms are often associated with higher costs, making them less accessible to resource-constrained farmers. In contrast, bunch units, representing more traditional and accessible practices, may facilitate adoption among smallholder farmers. This finding suggests the need for tailored strategies to address financial barriers and ensure that improved seeds are affordable for all farmers, regardless of their preferred unit of measurement.

The findings emphasize that while larger planting areas and willingness to invest in higher-cost seeds positively influence the adoption of improved seeds, barriers such as limited seed accessibility, high costs, and inadequate fertilizer use persist. Addressing these challenges requires a multifaceted approach, including improving the formal seed system, reducing the cost of improved seeds, and ensuring that complementary inputs like fertilizers are readily available. Such strategies can enhance productivity and promote the widespread adoption of improved seeds, ultimately benefiting both smallholder and large-scale farmers.

6. Conclusion

The study highlights critical factors influencing seed selection among farmers and livelihood in the Kagera region. Larger-scale farmers are less likely to adopt improved seeds due to resource constraints and limited availability of high-quality seeds, consistent with prior studies. Conversely, farmers with larger areas planted are more likely to adopt improved seeds, demonstrating the potential to scale adoption with incentives. High seed costs positively influence improved seed adoption, suggesting that farmers value the benefits of investing in better-performing seeds. Fertilizer use showed a negative relationship with improved seed adoption, indicating a need for integrated input support. Lastly, units of measurement, such as bunches, were associated with higher adoption rates compared to kilograms, which often reflect bulk costs and deter resource-constrained farmers.

Strengthen Seed Supply Systems, to address the limited availability of high-quality improved seeds; government with collaboration with coffee stakeholders has to focus on establishing formal seed systems for coffee production. This could involve setting up certified seed production centers, encouraging private sector participation in seed distribution, and creating partnerships with research institutions to develop and disseminate improved seed varieties. A formal system ensures quality control, consistent supply, and affordability, which are critical for smallholder farmers. This approach will reduce dependence on informal and often unreliable seed sources also building rural seed distribution centers and improving road networks can ensure that improved seeds are accessible to even the most remote farming communities. Efficient distribution channels can also help reduce the overall cost of seeds, making them more affordable for farmers.

Promote Affordable Seed Packages, providing improved seeds in smaller, affordable units, such as bunches, can make them accessible to resource-constrained farmers who may find bulk purchases in kilograms unaffordable. This can be implemented through initiatives like farmer cooperatives or government-subsidized seed programs. Additionally, ensuring clear labeling and instructions on small packages can empower farmers to make informed decisions and encourage widespread adoption.

Integrated Input Support, since fertilizer use plays a significant role in the performance of improved seeds, integrated input support programs are crucial. Policymakers have to design schemes that bundle fertilizers and improved seeds, potentially at subsidized rates or through credit facilities. For example, farmers could access a package of seeds and fertilizers with deferred payment plans, allowing them to offset the costs after harvest. Training programs could also focus on demonstrating the complementary benefits of fertilizers and improved seeds to maximize yields.

Incentivize Large-Scale Farmers; Larger-scale farmers often face logistical and financial challenges in adopting improved seeds. Governments and stakeholders can introduce targeted incentives, such as tax breaks on agricultural inputs, interest-free loans, or grants for large-scale farmers willing to transition to improved seed varieties. These farmers can also be integrated into programs that facilitate bulk purchases at discounted rates, reducing costs and addressing supply chain inefficiencies. Furthermore, establishing farmer networks for resource sharing and collaborative learning could ease logistical challenges.

Develop Subsidy and Credit Programs for Improved Seeds, government has to create targeted financial support programs to reduce the initial cost burden of adopting improved seeds. Subsidies could focus on reducing the price of seeds for smallholder farmers, while credit programs could offer flexible repayment terms that align with harvest cycles. Partnering with microfinance institutions or agricultural banks can ensure the accessibility of such programs even in remote areas.

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