Estimation of Smallholder Farmers' Demand for Certified Seed: Evidence from Wheat and Tef Seed Systems in Ethiopia

Abera Gemechu[1*], Bekele Gemechu[1], and Karta K. Kalsa[2]
[1]Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center, P.O. Box: 32, Bishoftu, Ethiopia; [2] Ethiopian Institute of Agricultural Research, P.O. Box 2003, Addis Ababa Ethiopia
**Corresponding author: Email: brgemechu@yahoo.com*

Abstract

Previous studies in Ethiopia have focused on the adoption of improved tef and wheat varieties and complementary inputs. However, there is a gap in research on the factors that influence the demand for certified seeds. This study aims to assess the factors that influence farmers' decisions to purchase certified seeds and the quantity of seeds purchased by tef and wheat farmers. Data were collected from 186 randomly selected sample farmers using a multistage sampling approach. A double hurdle model was used to analyze the data, considering that the decisions to participate in certified seed purchase and the quantity of seeds purchased are influenced by different factors. The study found that household size, tef farming experience, proximity to the cooperative office, age, and land size were significant factors in the likelihood of purchasing certified tef seeds. Additionally, education level, distance to the extension office, certified wheat seed price, and extension contacts influenced the decision to purchase certified wheat seeds. Moreover, education level, land size, certified tef and wheat seed price, and livestock ownership significantly influenced the quantity of certified tef and wheat seeds purchased. In conclusion, the study suggests that enhancing farmers' skills, ensuring local seed availability through collective actions, and implementing a seed price subsidy program.

Keywords: Certified seed demand; Smallholder farmers; Tef, wheat, Ethiopia

Introduction

Cereal crops, particularly tef and wheat, are vital to Ethiopia's economy, providing the majority of rural employment, contributing significantly to the agricultural GDP, and serving as the primary source of sustenance and income for the population (Fikre et al. 2020 ; Tadele and Hibistu, 2021; Mihretie et al. 2022).

Tef, a vital staple food crop in Ethiopia, is grown by over 7 million farm households across the country These households cultivate tef on more than 3 million hectares of land. Recently, tef has garnered global attention for being gluten-free and having a nutrient-rich composition, thus becoming a valuable source of income for Ethiopian farmers (CSA, 2022 ; IFPRI 2018). However, its productivity falls behind other cereal crops due to limited access to improved technologies, such as limited accessibility of improved seeds and the cost of improved tef seeds (Mihretie et al.

2022; Chanyalew et al. 2019; IFPRI, 2018). Efforts to improve tef production have led to the release of 58 new varieties since 1950, aiming to enhance productivity and sustainability (Birhanu et al. 2022; Kebede et al. 2022 ; Ethiopian Agricultural Authority, 2023).

Similarly, wheat is an important crop in Ethiopia's agricultural sector, with significant contributions to food security, income generation, and overall economic development (Anteneh and Asrat, 2020 ; CSA, 2022). The country is making strides in wheat production by focusing on irrigation methods in both lowland and highland areas. The government-led initiatives are expanding irrigated wheat production and promoting lowland wheat cultivation, leading to increased yields. Pilot programs for lowland wheat production, supported by organizations like CIMMYT and the EIAR, are showing promise. However, challenges such as drought, climate variability, rapid population growth, and urbanization remain. The main objectives of these initiatives are to boost agricultural productivity, ensure food security, and reduce reliance on wheat imports, with the goal of becoming a net exporter by 2025/2026 (Kedir, 2022 ; Nigus et al., 2022; CIMMYT,2023).

The seed sector in Ethiopia faces challenges in ensuring the availability of high-quality seeds, with only a small percentage of smallholder farmers using certified cereal seeds (EIAR, 2020 ; Yitayew et al., 2023). Addressing these challenges is crucial to improve the seed system and support smallholder farmers who rely on these crops for consumption and income (Yitayew et al. 2023). The demand for seeds is subject to fluctuations influenced by factors like weather conditions, price variations, and the amount of seed saved from the previous year (Stratton, 2015).

The demand for improved seeds fluctuates significantly throughout the year and between years, impacting agricultural productivity (Kaguongo et al., 2014). Access to quality seeds is crucial for smallholder farmers to increase their incomes and enhance agricultural productivity (Kalsa et al.2021; Kalsa 2019). Agricultural Policy documents like ADLI and GTPI/GTPII emphasize the importance of improving access to high-quality seeds for smallholder farmers in Ethiopia (NPC, 2018). Understanding the factors influencing farmers' demand for certified seeds is essential for developing a robust seed system in the country. This understanding can help in targeting production and marketing efforts effectively, leading to increased agricultural output (Ogola 2012 ; ATA, 2016).

The empirical evidence indicates that tef and wheat productivity is lower on farmers' land compared to research stations. This could be due to the continued use of low-yielding crop varieties by farmers. Small-scale farmers heavily reliant on subsistence agriculture could improve their welfare and food security by purchasing

certified seeds (FAO, 2020). However, the unavailability and high cost of certified seeds are key factors contributing to low agricultural productivity. As a result, farmers often resort to recycling grain as seed, further hindering the potential of certified seeds (ATA, 2016).

Several studies in Ethiopia have examined the adoption of improved tef and wheat seeds, along with the use of complementary inputs (e.g.,Yitayew et al., 2023 ; Abebaw and Haile, 2013; Anteneh and Asrat, 2020). However, there is a notable gap in research regarding the factors that influence the demand for certified seeds in the country, particularly for cereals like tef and wheat seeds. This lack of understanding among policymakers about the importance of certified seeds and their potential influence on cereal production highlights the need for further investigation in this area.

The demand for certified cereal seeds in Ethiopia is fuelled by the desire for enhanced agricultural productivity, food security, and economic advancement (Feyissa and Worku, 2023). Moreover, research findings indicate that the seed systems in Ethiopia are impacted by the interplay of government regulation and market forces, which in turn affects smallholder farmers' access to certified seeds. It is crucial to tackle these obstacles in order to improve farmers' adoption of high-quality seed varieties (Gebrehiwot et al. 2024). This literature highlights the importance of understanding the demand for certified seeds in order to unlock the country's potential in cereal crop production. By examining both price and non-price determinants of certified tef and wheat seeds demand, policymakers can develop effective seed policies and enhance crop production. This study aims to provide valuable insights for policymakers, agro-input suppliers, and seed producers to promote the use of certified seeds. The research questions formulated in the study are designed to achieve the objectives of identifying factors influencing certified seed demand and improving seed distribution at the farm level. Overall, the study emphasizes the significance of addressing the demand for certified seeds to maximize crop production and socioeconomic benefits.

Objectives of the study

The main objective of the study is to analyse the factors influencing the demand for certified tef and wheat seeds, as well as the preferred varieties when purchasing certified seeds of tef and wheat in the rural highlands of Ethiopia.

1. To assess the determinants of farmers' decisions to participate in the purchase of certified tef and wheat seeds in the central highlands of Oromia, Ethiopia;
2. To investigate the determinants of the quantity of certified tef and wheat seeds purchased by farmers in the central highlands of Oromia, Ethiopia.
3. To identify the tef and wheat varieties that are predominantly preferred by smallholder farmers in the central highlands of Oromia, Ethiopia.

Materials and Methods

Description of the study areas

The study was carried out in the Eastern and South Western Shewa Zones of the Oromia Regional State of Ethiopia in the 2021 crop season. These zones are renowned for their significant contribution to tef and wheat production within the country, as farmers have adopted improved practices for cultivating these crops (CSA, 2021). The rural highlands of Ethiopia, particularly the Gimbichu, Becho, Lume, and Adea districts of Oromia, were selected for their agroecological suitability for tef and wheat production (Figure 1).

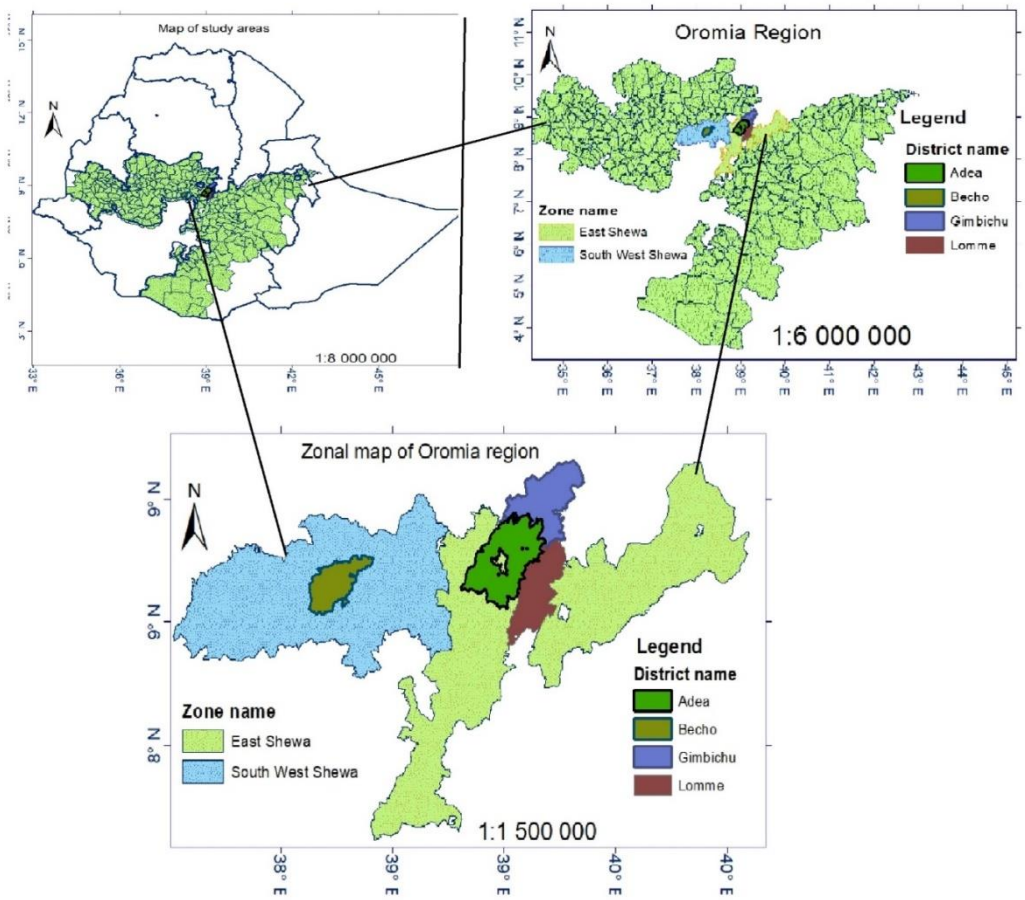

Figure 1. Study areas

Sampling procedure, sample size, and type of data

The study employed multi-stage procedures to collect primary data, starting with the purposive selection of two zones based on crop production potential. From these

zones, four districts were randomly sampled, and from those districts, nine kebeles were randomly selected. Finally, the researchers employed Cochran's sample size determination formula with a 95% confidence level (z = 1.96) to calculate an appropriate sample size with 95% precision and 15% variability in the population. The formula used was:

$$n = \frac{Z^2 pq}{e^2} = \frac{(1.96^2)(0.15)(0.85)}{0.05^2} = 196$$

Where, e represents precision, p denotes the assumed variability levels in the population, q represents one minus the level of variability in the population, n stands for the sample size, and Z indicates the standard normal distribution value. Consequently, the study required a sample size of 196. However, due to incomplete responses from 6 farmers and 4 elderly farmers who had difficulty understanding the interview, the total sample size used for data analysis was 186 respondents. A structured questionnaire was designed for primary data collection, and experienced enumerators were trained to facilitate the task. The study collected primary cross-sectional farm household data, including information on farmer characteristics, cereal farming practices, and environmental and institutional characteristics related to the households. To triangulate the primary data, secondary sources of data were also collected from MOA, CSA, published documents, and other relevant institutions.

Data analysis methods

Following the completion of data collection, the responses were coded and entered into the SPSS version 26 software program and converted into STATA 14 software for statistical analysis. Descriptive statistical analyses such as mean, percentages, and standard deviations were used to understand farm households' demographic characteristics, resource ownership, and institutional service, production characteristics and farm input use. The determinants of farm-level participation decision and quantity of certified tef and wheat seeds purchase were analysed using a double hurdle model.

Empirical model specification

This section presents an empirical model for estimating the factors influencing farm-level decisions on purchasing certified tef and wheat seeds in the central highlands of Ethiopia. The participation of farmers in certified seed purchase activities is expected to be influenced by socioeconomic factors, as well as the characteristics and demographics of the farmers. These factors are used to determine whether a specific farmer finds it desirable to engage in certified seed purchase for tef and wheat, and to what extent. The study aims to analyse the motivations behind farmers' participation in certified seed purchases. It is important to note that some farmers may choose not to participate in these activities, resulting in a portion of the dependent variable being zero.

Addressing the challenge of zero values in farm household investment data requires an approach that can handle both discrete and continuous components (Green *et al*. 2008). While probit or logit models can analyse factors influencing market participation decisions, they do not provide information on the level of participation in the market (e.g., Dedah *et al*. 2010 ; Aman *et al*. 2014; Adam and Alemu, 2015). However, these models fail to provide information about the level of participation in the market.

The Tobit model, also known as the censored regression model, is useful for analysing factors influencing joint decisions when dealing with dependent variables containing a substantial number of zero values. While it offers advantages over other models in determining both the probability and intensity of market participation, it also has limitations when the proportion of zero values is significant (Obayelu *et al*. 2016: Adam and Dawit 2015). Specifically, the Tobit model is specifically designed for truncated data with a continuous dependent variable that is censored, such as zero. Zeros are considered intentional choices rather than a lack of opportunity. However, the model assumes that the same factors influence both the decision to purchase certified seed and the total amount purchased, which could potentially lead to an underestimation of variability and interactions. Thus, this model is not suitable for our data since all farmers require certified seeds, intentional choice not to purchase certified is minimal, farmers most of the time lack economic capacity to purchase certified seeds, and the decision to participate and the amount to purchase may not be affected by the same factors.

The Heckman (2012) addressed the weaknesses of the Tobit model by introducing the two-stage estimating technique, also known as the Heckit model, which eliminates selection bias caused by zero observations and estimation on a chosen subsample. The approach involves performing a complete sample Probit estimation in the first stage and a corrected self-selection estimation in the second stage. It assumes different sets of independent variables and no zero observations in the second stage. Specifically, the Heckman Two-Stage Model is used to address sample selection bias in non-random samples with censored observations caused by self-selection. The model consists of two stages: first estimating the selection probability using covariates, and then adjusting the outcome regression by incorporating the inverse Mills ratio. Effective bias correction in this model requires correlated error terms. It is worth mentioning that this model is not appropriate for our data analysis as the data were randomly collected from farmers, and the model is specifically designed to handle sample selection issues arising from individuals self-selecting into an intervention.

The Double Hurdle model, an extension of the Tobit model introduced by Cragg (1971), incorporates a second hurdle that must be overcome before observing any positive values. This model is used to estimate the decision to purchase certified tef/wheat seed and the quantity purchased in our case, addressing the possibility of zero values in the second stage. It allows for the examination of the impact of various factors on both participation in certified seed purchase and the intensity of purchase. The Double Hurdle model focuses on decisions related to participation and the amount purchased, influenced by different factors. It consists of two equations: the Participation Equation for non-zero values and the Quantity Equation for the amount purchased. The model's flexibility allows for the use of different regressors for participation and purchase, overcoming the limitations of the Tobit model. The Double Hurdle model can handle situations where zeros arise from either abstention or the inability to make a purchase, providing a comprehensive analysis of the factors influencing decisions regarding the purchase of certified seeds. In empirical applications, the Double Hurdle model often offers a better fit and explanatory power compared to other models, especially when the causative factors for each hurdle differ significantly. Therefore, the Double Hurdle model was chosen for data analysis in this study. Additionally, our discussion with farmers during the household survey revealed that farmers made varying decisions when it came to the two different crops. Consequently, the independent decision-making for each crop necessitates the application of Double Hurdle models in our data analysis. According to Yen and Jones (1997) the specification of the double hurdle model can be expressed as:

Stage 1: certified seed purchase decision.

$$D_i^* = X_{1i}\ \beta_1 + \epsilon_i\ ; \epsilon_i \sim (0,1) \quad (1)$$

$$D_i = \begin{cases} 1 & if \quad D_i^* > 0 \\ 0 & otherwise \end{cases} \quad (2)$$

Where D_i^* is a latent variable indicating whether or not the individual participates in certified seed purchase during the production season β_1 is a vector of parameters to be estimated X_{1i} is a vector of observed independent covariates that explain an individual's decision; D_i is a binary variable that takes the value 1 for a farm household i of certified seed purchase and 0 otherwise. and ϵ_i is an unobserved error term capturing all other factors.

Stage 2: The intensity of certified seed purchase.

$$Z_i^* = X_{2i}\ \beta_2 + \omega_i \quad \omega_i \quad \sim N(0,\sigma^2) \quad (3)$$

$$Z_i = \begin{cases} 1 & if \quad D_i = 1 \quad Z_i^* > 0 \\ 0 & if\ D_i = 0 \end{cases} \quad (4)$$

Finally, the observed quantity of certified seed purchased is determined as:

$$Y_i = D_i \cdot Z_i \quad (5)$$

In this specification, a positive quantity of certified seed purchase Y_i is observed if D_i^* and $Z_i^* > 0$. This illustrates the double-hurdle element of the model. D_i^* is a

latent endogenous variable representing the decision to participate in the purchase of certified tef or wheat seed by farmers i, Z_i^* is a latent variable representing the quantity purchased by farmer *i*, Y_i is the observed quantity of certified tef or wheat seed purchased by farmer *i*, X_{1i} is a set of farmers characteristics that influence the farmers' decision to participate in certified tef and wheat seeds purchase decision, X_{2i} is a vector of socioeconomic and institutional characteristics of farmers that affect the quantity of certified tef or wheat seed purchase. $\beta 1$ and $\beta 2$ are vectors of the estimable parameter. In this formulation, (X_{1i}; X_{2i}) may contain the same common explanatory variables, although their corresponding effects on the two hurdle equations might be quite different. ϵ_i is normalized to 1 since the outcome of the first hurdle is binary. Both error terms, ϵ_i and ω_i are assumed to be normally and independently distributed, which implies that there is no relationship between the two stages of a decision and can be written as:

$$\begin{pmatrix}\epsilon_i \\ \omega_i\end{pmatrix} \sim N\left[\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}1 & 0\\0 & \sigma^2\end{pmatrix}\right] \quad (6)$$

As in the Tobit and Heck model cases, the independent double-hurdle model is estimated using maximum likelihood techniques with the log-likelihood given as follows,

$$\ln L = \sum_0 \ln\left[1 - \varphi(X_{1i}\ \beta_1)\varphi\left(\frac{X_{2i}\ \beta_2}{\sigma}\right)\right] + \sum_+ ln\left[\varphi(X_{1i}\ \beta_1)\varphi\frac{1}{\sigma}\left(\frac{Z_i - X_{2i}\ \beta_2}{\sigma}\right)\right] \quad (7)$$

The first term on the right-hand side represents the sum of zero observations in the sample. It suggests that both participation and level of participation decisions can be influenced by zero observations. The additional term in equation (7) contributes to the impact of potential zero values in the second stage decision in the double-hurdle model. The first term captures the possibility of observing zero values in the second stage decision, thus indicating that the second stage is represented similarly to a Tobit model. The second term on the right-hand side represents the sum of positive observations. This term expresses the conditional probability distribution and density function coming from the censoring rule and observed positive values (Fabiosa, 2006).

Results and Discussion

This section provides a detailed analysis of the descriptive and econometric findings, including a comparison between certified seed users and non-users, the most preferred varieties of tef and wheat by smallholder farmers, factors influencing the decision to purchase certified seeds, and the quantity of certified tef and wheat seed purchased.

Descriptive Statistics Results

The study shows that farmers in different districts have average ages ranging from 43 to 46 years, with an overall average of 44.51 years. The youngest participant was 21 years old, while the oldest was 79 years old. Most households purchasing tef and wheat seeds are in their active working age and financially capable of buying certified seeds. This implies that older farmers, who own significant rural land and can afford certified seeds, may restrict land availability for younger individuals in agriculture. This aligns with Tebeka et al. (2017) who highlighted the importance of the age of the household head in acquiring knowledge and experience related to seed quality, crucial for seed production or purchasing seeds from formal sources.

The study found that the majority of household heads (94.6%) in farming families are men, with only a small proportion being women. Additionally, the research highlights that male head predominantly makes purchases of certified wheat and tef seeds. This finding contradicts Kramer and Galiè (2020) who stated that research on enhancing seed systems should prioritize identifying innovations that not only reach but also equally benefit and empower both women and men. Therefore, efforts should be made to provide improved inputs, particularly certified wheat and tef seeds, to both women- and men-owned agricultural households to ensure their security and well-being.

The study indicates that 70% of the household heads in the sample completed elementary school (grades 1-8) and are able to read and write, with 24% being illiterate. Furthermore, 6% completed high school. Additionally, 14.3% completed high school. Education levels varied across different districts, impacting the percentages of illiteracy and school attendance. The research emphasized the importance of the education level of the farm household head in influencing their willingness and ability to purchase certified tef and wheat seed, with a statistically significant level ($P < 0.01$). This aligns with Bernard et al., (2010) who found a positive association between the education level of the head and the adoption of improved technologies.

The study found that household sizes varied across districts, with Gimbichu having the largest average size of 6 persons, followed by Becho (7), Lume (6), and Adea (5). Certified seed purchasers had larger household sizes, indicating that larger households are more likely to participate in certified seed purchases to increase productivity for consumption and selling purposes. Additionally, larger household sizes facilitate various farm operations when using certified seeds. The t-test results indicated a significant difference in household sizes between certified tef and wheat seed purchasers and non-purchasers, with ($p < 0.05$). The findings imply that households with larger sizes are more likely to engage in certified seed purchases, leading to increased quantities of certified tef and wheat seed purchases. This highlights the importance of household size

in influencing farmers' decisions regarding seed purchases and agricultural productivity. This result is consistent with the findings of (Yitayew et al. 2023). Table 1 presents household size per study districts.

Land is the primary factor of production for farmers. The results of the study indicate that the average landholding of farmers in Gimbichu, Becho, Lume, and Adea districts ranges from 1.06 to 1.5 hectares. Tef farmers who purchase certified seed have larger landholdings compared to non-certified tef seed users, and the same trend is observed for wheat seed purchasers. The t-test results show a significant ($P<0.05$) difference in landholding between certified and non-certified seed purchasers, indicating that landholding size influences the demand for certified seeds. This result is consistent with the findings of (Kifle et al. 2022). Young farmers are addressing land scarcity by sharing land with their parents and relatives after marriage, as well as gaining access to farmland through sharecropping and renting. In the study districts, the areas of land rented in and out during the cropping season were 1.12 hectares and 0.245 hectares respectively. Table 1 presents descriptive statistics of variables included in the model.

Table 1: Descriptive statistics of included in the double hurdle model

Variables	Unit	Seed purchase by farmers	
		Certified seed (129)	Non-certified seed (57)
Dependent Variable			
Mean certified tef seed purchased	Kg	25	0
The mean of certified wheat seed purchased	Kg	73.4	0
Certified tef seed purchase participation decision	Yes=1		
	No=0	1(30.7%)	0 (69.4%)
Certified wheat seed purchase participation decision	Yes=1		
	No=0	1 (31.7)	0 (68. 3%)
Independent Variables			
Age	Years	46.2	40.7
household size	AE	6.5	5.5
Land size (ha)	Ha	1.65	0.83
Experience in certified tef growing	Year	8.5	6.3
Certified tef seed price	Kg	23.40	28.80
Expected tef grain price per Qt	Qt	4096.8	4512.3
Livestock owned	TLU	10.40	7.26
Distance to cooperative offices	km	18.8	19.2
Distance to the extension office	km	24.9	30.4

Source: Survey data.

The quantity of certified tef seed purchased was about 9.8, 20.2, 36.4, and 31.2 kilograms in Gimbichu, Becho, Lume, and Adea districts, respectively. Similarly, the average quantity of certified wheat seed purchased by the farm household during the cropping season in Gimbichu, Becho, Lume, and Adea districts is about 91.9, 90, 118.4, and 61.25 kilograms, respectively. One-way-ANOVA test shows that there is a significant difference among the study districts in the quantity of certified tef seed purchased in kilograms per household at ($P<0.05$) level.

The ANOVA test also indicated that there is a significant mean difference in the quantity of wheat seed purchased in the study districts, specifically, the difference in the quantity of certified wheat seed purchased was observed between Adea and Gimbichu. The difference might be attributed to the agroecological difference between the districts. In general, the results show that certified tef and wheat seed purchasers significantly differ from non-certified tef and wheat seed purchasers in their socioeconomic characteristics.

Farmers' access to institutional services

The results reveal that the average distances of sample farmers from the nearest market, cooperative, and extension office vary across different districts. In Gimbichu district, the mean distances are 3, 2.7, and 5 kilometres, respectively. In Bacho district, the mean distances are approximately 2.2, 2, and 5.2 kilometres, while in Lume district they are 2.3, 2.25, and 9 kilometres, and in Adea district they are 2.2, 2, and 8 kilometres, respectively. A one-way ANOVA test demonstrated a significant difference among the districts in terms of their proximity to the nearest market, cooperative, and extension office, with a significance level of ($P<0.01$). These findings suggest that sample farmers located closer to these facilities are more likely to engage in certified seed purchases, benefiting from valuable advice provided by extension agents. This finding is consistent with the findings of Tebeka et al. (2020), which demonstrate that households located near the district town were anticipated to encounter reduced transaction costs when searching for a buyer of quality seed.

The study indicates that farmers are concerned about the limited availability and high prices of certified seeds, as well as the neglect of resource-poor farmers by agricultural extension agents. To address these issues, it is crucial for the government and development practitioners to support certified seed producers, provide subsidies to suppliers, and improve the quality of certified seeds to ensure better agricultural output for all farmers. Additionally, a significant proportion of farmers did not receive extension services or advice on the importance of purchasing certified tef and wheat seeds. More than half of tef and wheat producers lacked access to extension services for acquiring improved and certified seeds.

Additionally, farmers indicated during semi-structured interviews that extension workers tend to prioritize visits to wealthier farmers over poorer ones. Therefore, it is imperative to prioritize inclusive certified seed extension services to enhance the production and productivity of these crops.

The study shows that the majority of smallholder farmers (95.2%) buying certified tef and wheat seeds are part of farmers' cooperatives or unions. Surprisingly, a significant portion of these farmers have not received formal

training on how to produce these crops. This lack of training is concerning as it is essential for enhancing farmers' knowledge and skills in certified seed production, which are crucial for improving crop production and productivity.

The study reveals that approximately 59.7% of surveyed farmers obtained certified seeds from the Office of Agriculture, with 18.29% purchasing from seed producer cooperatives while 16.67% of the farmers exchanging seeds with neighbouring farmers. Despite the preference to purchase certified seeds from the Office of Agriculture, some farmers revealed that the quality requirements were not always met. Additionally, nearly all farmers purchased complementary inputs such as fertilizers and pesticides alongside certified tef and wheat seeds. The average application of urea and NPS for Bosset tef production was 102.2 kg/ha and 109.9 kg/ha, respectively, while for Quncho tef production, it was 127.6 kg NPS and 108.0 kg urea per hectare.

Most preferred tef varieties

The study revealed that Bosset, Quncho, Enatite, Magna, Dagim, Kora, Nigus, and Filagot are the most preferred tef varieties among farmers. Market demand, adaptability to harsh climates, injera-making quality, and potential yield are the key factors influencing farmers' preferences. Approximately, 28.7% of sampled farmers cultivate improved Bosset tef varieties, while 14.5% grow Quncho varieties. The average productivity of Bosset tef was 8.2 quintals per hectare during the survey period, lower than the yield in research fields. The one-way ANOVA test indicates a significant difference in variety preference among study districts at a level of ($P<0.05$), likely due to varying weather and soil conditions. This suggests the need to target specific areas for further expansion of new tef varieties based on local conditions. This finding is similar to the results of Semahegn et al., (2021). Figure 2 provides a visual representation of the preferred tef varieties by farmers.

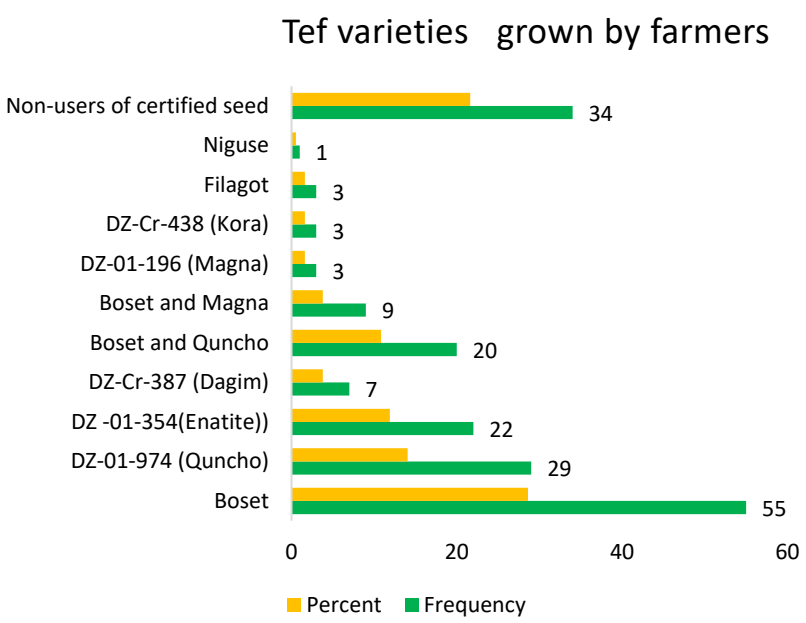

Fig. 2. Preferred tef varieties among farmers. Source: Survey data

Most preferred wheat varieties

Farmers in the study areas show a preference for specific wheat varieties, with Kakaba, Denda'a, Ogolcho, and Hidase being the most popular bread wheat varieties. The farmers have an average of 9 years of experience in purchasing bread wheat, indicating a level of familiarity with the crop. This preference may be attributed to the adaptability of bread wheat to different agroecological zones, as well as its disease and drought resistance, potential yield, and days to maturity. Additionally, Utuba and Mangudo are the commonly purchased improved durum wheat varieties in the study areas. This finding is similar to the results of (Semahegn et al., (2021). Sample farmers had 8 years of experience using improved durum wheat seed with a maximum experience of 21 years. However, the results of the study depict that the production of durum wheat is drastically decreasing. For example, the majority (81.08%) of farmers are not growing durum wheat due to improved seeds unavailability, and susceptibility of existing varieties to diseases. Figure 3 and 4 provide a visual representation of the preferred wheat varieties by farmers.

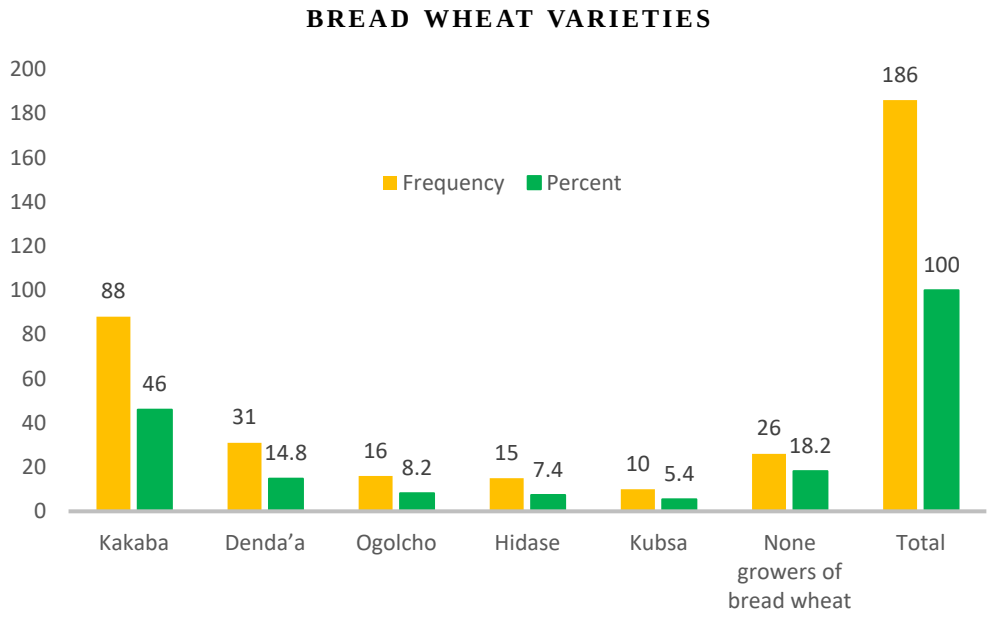

Fig. 3. Preferred bread wheat varieties. Source: Survey data, 2022.

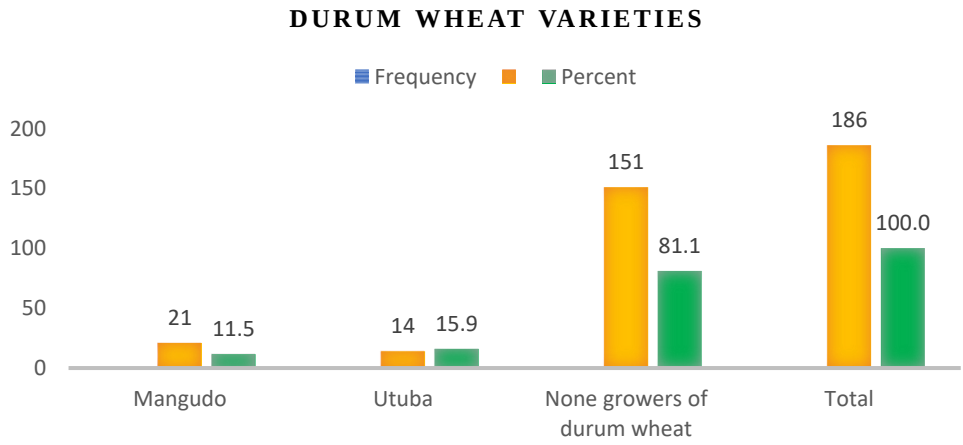

Fig. 4. Preferred durum wheat varieties. Sketch from survey data, 2022.

Trends in improved seed replacement and purchase

The study reveals that a significant percentage of farmers replace seeds by purchasing from certified suppliers for yield advantage, market preference, disease, and pest resistance. However, some farmers are deterred from replacing seeds regularly due to high costs and limited availability of better-quality seeds in certain districts. The trends of certified tef and wheat seed purchase to replace seed over the last three years is depicted in Table 2 and 3.

Table 2: Trends of certified tef purchase over the last three years

Seed type	2019		2020		2021	
	Frequency	%	Freq	%	Freq	%
Quncho	76	41.1	73.5	39.73	36	19.35
Dz-01-354 (Enatit)	33	17.8	36	19.46	20	10.75
Magna	13	7.0	5	2.70	2	1.08
Boset	19	10.3	34	18.38	76.5	41.14
Kora	7	3.8	3	1.62	3	1.61
Dagim	7	3.8	9	4.86	13	6.99
Local	19	10.3	6	3.24	5	2.7

Source: Survey data, 2022.

Table 3: Trends of certified wheat purchase over the last three years

Seed type	**2010/11**		**2011/12**		**2012/13**	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Ogolcho					10	5.5
Kubsa	32	17.7	20	10.8	10	5.4
Hidase	9	5.0	16	8.6	5	2.7
Danda'a	38	21.0	38	20.4	43	23.2
Kekeba	49	27.1	67	36.0	75	40.5
Digalu	4	2.2	4	2.2	1	0.5
Utuba	2	1.1	4	2.2	10	5.4
Manqudo	11	6.1	5	2.7	5	2.7
Cocrete	-	10.0	5.38	5.4	15	8.1

Source: : Survey data, 2022.

Econometrics results

Determinants of the probability and intensity of demand for certified tef seed

The section discusses the determinants of smallholder farmers' decision to purchase certified tef seeds and the quantity of purchase in kilograms. The double hurdle two-step approach was used to analyse this, assuming that the two error terms from the two hurdles are normally distributed and independent. The study found that the decision to purchase certified tef seeds and the quantity purchased were independent of each other among the sampled tef farmers. This indicates that factors influencing the decision to buy did not affect the amount purchased, as shown in Table 4.

Table 4: Cragg's double hurdle model estimates for certified tef seed purchase decision and quantity of purchase

	First hurdle (participation decision) Probit output			Second hurdle (quantity of certified tef seed purchase)		
Variable	Coef.	Z-stat	Marginal Effect	Coef.	Z-stat	Marginal Effect
Age of household head	0.088***	3.16	0.088	-0.15***	4.8	0.130
Education	0.057	1.45	0.058	0.14***	2.75	0.146
Household size	0.930**	1.99	0.094	0.17***	3.9	0.091
Sex of household head	-0.812	-1.60	-0.813	0.11	0.94	0.013
Tef farm experience	0.003*	1.80	0.037	0.74	1.11	0.689
Cultivated land size in hectares	0.354**	2.27	0.036	0.14***	2.73	0.113
Size of livestock (TLU)	0.270	1.23	0.280	0.25**	2.15	0.240
Training on certified tef seed	0.345	0.86	0.350	-2.90	0.71	-3.460
Distance to all weather road	-0.004	-0.77	-0.005	0.00	-1.08	-0.003
Distance to coop office	-0.022*	-1.89	-0.023	-0.00	1.53	-0.024
Member of farmer group	0.430	1.53	0.420	0.46***	2.67	0.046
Distance to the extension office	0.002	1.48	0.002	0.01***	3.04	0.009
Purchase price certified tef seed	-0.510	0.13	-0.051	-0.01*	-1.95	-0.020
Constant	1.160**	2.50	1.008*	0.42***	2.37	0.040
Sigma	3.840			23.84		

Asterisks indicate levels of significance: *** = 0.01, ** = 0.05 and * = 0.10
Source: : Survey data, 2022.

The study reveals that older household heads are more likely to participate in seed production or purchase certified tef seeds from formal sources, with age having a significant positive impact on these decisions. This is attributed to the accumulated resources of older household heads, as evidenced by the 0.88% increase in seed purchase decisions and the 0.13 kg increase in the quantity of seeds purchased for every one-unit and one-year increase in age, respectively.This finding is consistent with Tebeka et al. (2017), who found that the age of the head is vital for engaging in seed production or purchasing seeds from formal sources.

The study demonstrates a strong link between education level and the purchasing behaviour of certified tef seed among farmers, highlighting the importance of education in promoting the adoption of advanced agricultural practices. This finding is consistent with previous research, highlighting the importance of the household head's education level in utilizing advanced agricultural practices (Kifle *et al.* 2022). Educated farmers tend to be more open to new ideas and technologies, which enhances their decision-making abilities in farming practices. The estimation from double hurdle model indicates that a one-unit increase in the education level of the household head will increase the amount of certified tef seed purchased by 0.146 kg among tef farmers.

Results show that household size positively influenced the participation of sample farmers in seed purchase in the probit model at a significance level of less than ($P<0.05$); influenced the quantity of certified seed purchased at a significance level of less than ($P<0.01$) in the seed demand model. The findings align with the results

reported by Yitayew et al. (2023), demonstrating that the household size of the household head was statistically significant and had a positive correlation with the use of improved technologies. The study found that larger household sizes are linked to a higher probability of buying certified tef seed and purchasing larger quantities, indicating that households with greater food demand are more likely to invest in certified seeds, and larger families may have the capacity to effectively handle certified seed production. Conteh et al. (2015) argue that farming in most rural areas depends on family labor, and large family labor is associated with labor availability for the timely operation of farm activities that enhance productivity.

The study indicates that farmers with larger landholdings are more likely to participate in certified tef seed purchase activities and buy a greater quantity of certified tef seed compared to those with smaller landholdings. The size of cultivated land significantly influences farmers' decisions to participate and the quantity of certified seed purchased, with larger farm sizes leading to increased participation and purchase of certified tef seeds. The findings of the study corroborate Ohen and Ajah (2015) who found that households with more land can cultivate more of the crop and expand their production to ensure adequate household consumption and supply to the market.

The study shows that livestock ownership plays a crucial role in increasing the quantity of certified tef seeds purchased, as indicated by a significant coefficient of 0.25 for every one unit increase in tropical livestock units. This is due to livestock serving as a key source of draft power and income for households, allowing them to invest more in certified tef seeds. This study similar to the findings of Upton (2004).

The study shows that proximity to the cooperative office impacts the decision to purchase certified tef seed, with closer distance increasing the likelihood of participation in the decision-making process. Farmers near the office are more likely to purchase certified seed due to their familiarity with the cooperatives and easier access to cooperative officers. This finding is consistent with the findings of Tebeka et al. (2020) which validate that households situated close to the market were observed to reduce transaction costs when searching for a buyer of quality seed.

The study highlights that the distance to the extension office impacts the amount of certified tef seed purchased by farmers, with a significant negative correlation observed. Farmers further away from the extension office buy less certified seeds, indicating a need for improved access to extension services for better dissemination of agricultural information.This finding is aligned with the findings of Tebeka et al. (2020).

The study indicates that membership in farmers' cooperatives positively impacts the quantity of certified tef seed purchases, but not the likelihood of participation. The information and contact received through cooperatives play a significant role in influencing small-scale farmers' decisions to purchase certified seeds, with group members having a higher chance of making such purchases. This finding is consistent with the findings of Mulesa, (2021) who found that members of agricultural cooperatives positively and significantly influenced the quantity of certified tef seed purchase.

Determinants and Intensity of demand for certified wheat seed

This section presents insights into factors influencing farmers' decisions to purchase certified wheat seed and the quantity purchased. The marginal effects derived from the estimated model help understand how changes in independent variables impact the probability of purchase, highlighting the importance of these factors in decision-making. The results in Table 5 highlight the significant determinants influencing certified wheat seed purchase decisions and quantities in the East and Southwest Shewa zones of Oromia.

Table 5: Cragg's double hurdle model estimates for certified wheat seed purchase decision and the quantity of purchase

Variable	Certified wheat seed purchase decision (Probit output)			Certified wheat seed purchase quantity of output		
	Coef.	Z-stat	Marginal Effect	Coef.	Z-stat	Marginal Effect
Age of household head	0.02*	1.8	0.002	0.29	-1.5	-0.98
Sex household head	-0.82	-1.47	-0.09	0.46	0.9	0.45
Education level	2.86***	2.76	0.02	0.34***	2.9	0.050
Distance to the extension office	-.032**	2.4	-0.037	-0.31	1.18	-0.10
Distance cooperative office	0.004	1.04	.000	0.08	0.5	.076
The household size in AE	-0.10	-0.8	-0.012	0.54	-0.8	-0.05
Cultivated land size	0.26*	2.2	0.03	0.32**	2.23	0.06
Purchase price wheat seed	-0.01**	2.15	-0.01	-0.12***	5.6	-0.03
Extension contacts	0.86*	1.71	0.09	0.39	0.5	0.71
Access to training	0.42	0.30	0.06	0.51	0.2	0.16
Livestock ownership	0.69	1.41	0.06	0.79***	2.63	0.02
_cons	0.87*	1.97		0.46		
Sigma	0.203					

Asterisks indicate levels of significance: *** = 0.01, ** = 0.05 and * = 0.10
Source: Survey data, 2022.

The study revealed that the age of the farm household head plays a significant role in determining participation in certified wheat seed purchase, but does not have a significant impact on the quantity of certified wheat purchased. This finding is consistent with Tebeka et al. (2017)who found that the age of the head is vital for engaging in seed production or purchasing seeds from formal sources. The marginal effect indicates that a one-unit increase in the age of the household head increases the probability of certified tef seed purchase by 0.002.

The study revealed a strong positive correlation between the educational level of the household head and the decision to purchase certified wheat seed, as well as the quantity of seed purchased. This relationship was statistically significant at a level of $P<0.01$. The results are consistent with previous research Kifle et al. (2022), indicating that higher education levels lead to increased adoption of improved agricultural technologies. The marginal effect of household head education on the demand for certified wheat seed was calculated to be 0.02, meaning that for each additional year of education, there is a 0.02 increase in the likelihood of purchasing certified seed. Furthermore, an increase in the educational level of the household head was associated with a 0.34 increase in the quantity of certified seed purchased, all else being equal.

The study results show that an increase in distance to an extension office by a kilometer diminishes the probability of participation in the certified wheat seed purchase decision by 0.09 and decreases the quantity of certified seed purchase by 0. 39, ceteris paribus. This means that the distance to the extension service is negatively related to the probability of certified wheat seed purchase and the quantity of certified wheat seed purchase is statistically significant at a level of significance less than 0.05 ($P<0.05$).

The study found that the size of cultivated land significantly influenced a farmer's decision to purchase certified wheat seed, with larger land areas leading to a higher probability of purchasing certified seeds and buying a larger quantity. This aligns with previous research by Ohen and Ajah (2015), indicating that households with larger land holdings can produce more crops to meet both household needs and market demands. The results highlight the importance of considering land size when analysing farmers' seed purchasing behaviour and production levels. Moreover, the study found that the purchase price of certified wheat seed has a significant impact on farmers' decisions to buy and the quantity purchased. Specifically, a higher price of certified wheat seed makes it less likely for farmers to afford it. The research revealed that for every one Birr increase in the price of certified wheat seed, the probability of a wheat farmer purchasing it decreases by 0.01. This suggests that pricing plays a crucial role in farmers' decisions regarding certified wheat seed purchases.

Results show that as expected, livestock holdings were found to affect both the probability of purchasing certified wheat seed and the quantity of certified wheat seed purchased positively and significantly at less than ($P<0.05$) and ($P<0.01$) respectively. The marginal effect from the results suggests that the probability of making a certified wheat seed purchase decision increased by 0.06 as the number of livestock increased by one tropical unit and the quantity of certified seed purchased would increase by 0.79 as the number of livestock increased by one-unit tropical

livestock unit holding other factors constant. This finding is consistent with the findings of Semahegn et al. (2021).

The study shows that access to extension services has a positive influence on the likelihood of purchasing certified wheat. While it was found that access to extension services did not affect the quantity of certified wheat seed purchased, it did have a significant effect on the probability of participation. Farmers who were exposed to extension services regarding the benefits of using certified wheat showed a 0.09 increase in the probability of purchasing certified wheat seed. This suggests that regular contact with extension services plays a role in influencing farmers to buy certified wheat seed, especially as the frequency of extension agent contact with farmers increases. The findings of this study of corroborates the findings of Hassena (2017).

Conclusion and Recommendation

Conclusion

The research findings suggest that older farm households, higher education levels, larger household sizes, and larger landholdings are key factors contributing to increased purchases of certified tef and wheat seeds. Proximity to cooperative and extension services, membership in farmers' cooperatives, and an increase in livestock numbers also positively influence seed purchases. To improve seed marketing, focusing on supplying seeds closer to farming households can enhance accessibility and availability for smallholder farmers. Strengthening direct seed marketing strategies can lead to more efficient distribution and utilization of certified seeds. The study highlights the importance of quality-certified seeds, support for producers, seed price subsidies for resource-poor farmers, and inclusive extension programs to boost productivity and meet demand.

Recommendation

The recommendations based on the findings and conclusions are as follows:

Firstly, the government should focus on supporting disadvantaged rural households by implementing a subsidy system for seed prices to assist farmers with limited resources. Secondly, policies need to be established to improve the quality and accessibility of certified seeds, while reinforcing regulatory frameworks to build trust in farmers regarding certified seed schemes. Thirdly, certified seed suppliers should prioritize providing seeds closer to smallholder farmers to increase demand. Lastly, it is important to incentivize seed producer cooperatives and private seed suppliers to increase their involvement in producing certified self-pollinated seeds, and to provide training to smallholder farmers on the benefits of using certified seeds.

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