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Determinants of Smallholder Farmers Adoption for Improved Finger Millet Varieties in West Hararghe Zone, Oromia National Regional State, Ethiopia

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Abstract: ***Finger millet is one of among the important crop produced in Ethiopia. It has been grown for many years for its nutritive and food security values. For this different improved finger millet varieties with its packages were promoted and disseminated. However, factors that limit adoption decision and intensity of improved finger millet varieties were not conducted in study area. Thus, the purposes of this study were to examine determinants of adoption of improved finger millet in West Hararghe zone, Oromia region. For this study both primary and secondary data were used. Primary data were collected from 143 households (87 adopters and 56 non-adopters) and supported by secondary data. To address the aforementioned objectives descriptive statistics and econometric models (Double hurdle) were employed. The probit results of Double hurdle (DH) model indicated that the likelihood of adopting decision of improved finger millet was positively and significantly affected by land size owned, fear of risk on improved varieties, participation on demonstration, access to extension service and participation on demonstration. The second stage of the double hurdle model revealed that household size, access to extension service and fertilizer application for finger millet were positively and significantly affects the adoption intensity of improved finger millet technologies. While, access to credit negatively and significantly affects the adoption intensity of improved finger millet technologies. The findings generally suggest the need to create a chance of participation on demonstration and field day for farmers; access for extension service and strength application of fertilizer for finger millet production.***

Key words: ***Adoption, Double hurdle model, Finger millet***

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INTRODUCTION

The adoption of agricultural innovations is crucial to increase incomes and food output in developing countries to meet the needs of the continuing growing population [23]. Adoption is degree of use of new technology in long run equilibrium when the farmer has full information about new technology and its potential [11]. They further divided adoption into individual (farm level) adoption and aggregate adoption. Final adoption at the individual farmer's level can be defined as the degree of use of new technology in long run equilibrium when the farmer has full information about new technology and it's potential. Aggregate adoption is a process of spread of new technology within a region. Aggregate adoptions are measured by aggregate level of use of specific new technology within a given geographical area or within a given population. The rate of adoption is defined as the percentage of farmers who have adopted a given technology and intensity of adoption is the number of hectares planted with improved seed or the amount of input applied per hectare (Ibid).

Millets are the most important cereals of the semi-arid zones of the world. For millions of people in Africa and Asia they are staple crops. Among millet crops, finger millet figures prominently; it ranks fourth in importance after sorghum, pearl millet and foxtail millet [31]. In recent years, a strand of literature and strategies has emerged that promote particularly underutilized cereal crops including finger millet. It is argued that these could make an important contribution to food and nutritional security as well as to income generation to resource-poor farmers living in low productivity areas like the semi-arid climates of Sub Saharan Africa for several reasons [22]. Besides, they tend to be more resilient to poor or unpredictable agro-ecological conditions than commonly produced cereals such as maize, wheat, and rice [25].

In Ethiopia, finger millet is the 6th important crop after teff, wheat, maize, sorghum and barley. It comprises about 5 percent of the total land devoted to cereals [32]. The crop is mainly grown in the northern, north western and western parts of the country, especially during the main rainy season. The national annual production area of finger millet in 2017/18 cropping season is estimated at around 456,057.31 hectares, with a total production of 10.3 million quintals [26]. In Oromia national regional state, finger millet is produced in different zones but it is widely grown in West Wollega. The annual finger millet production area coverage in 2017/18 cropping season is estimated at 93,831.88 hectares, with a total production of 2.1 million quintals in this region.

In West Hararghe zone, finger millet has been grown for many years for its nutritive and food security values. It is produced by smallholder farmers who have continuously grown low yielding unimproved finger millet varieties. It has consequently food insecurity persistently experienced in the zone and contributed significantly to the low food production. For this, Mechara Agricultural Research Center was introduced, promoted and scaled up improved finger millet varieties (Boneya, Tadesse, Tessema and Meba) and improved agronomic practices in the zone since 2004 E.C. Besides, different stakeholders like Melkassa Agricultural Research Center; and zone and districts Agricultural Offices also have been disseminated improved finger millet varieties in the study area. Despite the efforts made so far, the dissemination and adoption of this technology among the smallholder farmers, similar study was not conducted in the study area which was forming the basis for this study.

It is due to various technical and socio-economic constraints including limited supply of improved seeds varieties, less adoption of modern agricultural technology, high prices of fertilizers and inadequate credit facilities for purchase of agricultural inputs are the major socio-economic constraints [10]; [9] and [4]. Additionally, there is no empirical evidence on the determinants of adoption decisions for these improved finger millet varieties. Therefore, this study aimed at investigating factors that influence the farmers' decisions to affect these improved varieties in the study area.

Objectives

- To assess the adoption status of improved finger millet varieties in West Hararghe zone,
- To identify factors affecting smallholder farmers' decision and intensity of adoption of improved finger millet varieties in the study area.

Methodology

This section outlines the research procedure used in the study. It covers description of study area, sampling procedure and sample size, data collection and data analysis used in the study.

Description of study area

This study was conducted in three districts (Daro Lebu, Habro and Gemechis) of West Hararghe Zone of Oromia National Regional State, Ethiopia. Daro Lebu district is one of the 15th districts of West Hararghe zone. It is located at 434 km South-east of Addis Ababa and 115 km from Chiro, the zonal capital town of West Hararghe Zone. The district is found from 1350 to 2450 meters above sea level. The district has three agro-ecological zones. These are 10% high land, 34% midland, and the rest 56% lowland. The minimum and maximum annual rainfalls are 900 and 1000 mm with an average of 963 mm. The minimum and maximum temperature of 14°C and 26°C with the average temperature is 16°C [6].

Habro district is one of the 15 districts of West Hararghe Zone of Oromia National Regional State, Ethiopia. It is located at 404 km South-east of Addis Ababa and 75 km from Chiro, the zonal capital town of West Hararghe Zone. The district is found from 1600 to 2400 meters above sea level. The district has three agro-ecological zones. These are 15% high land, 80% midland, and the rest 5% lowland. The district received mean annual rainfalls of 966.7 mm. The minimum and maximum temperature of 13.4°C and 26.8°C with the average temperature is 19.97°C [16].

Gemechis district is one of the 15 districts of West Hararghe Zone of Oromia National Regional State, Ethiopia. It is located at 343 km South-east of Addis Ababa and 17km from Chiro, the zonal capital town of West Hararghe Zone. The district is found from1300 to 3400 meters above sea level. The district has three agro-ecological zones. These are 26.9% high land, 35.5% midland, and the rest 37.6% lowland. The minimum and maximum annual rainfalls are 650 and 1200 mm with an average of 850 mm. The minimum and maximum temperature of 15°C and 30°C with the average temperature is 22°C [12].

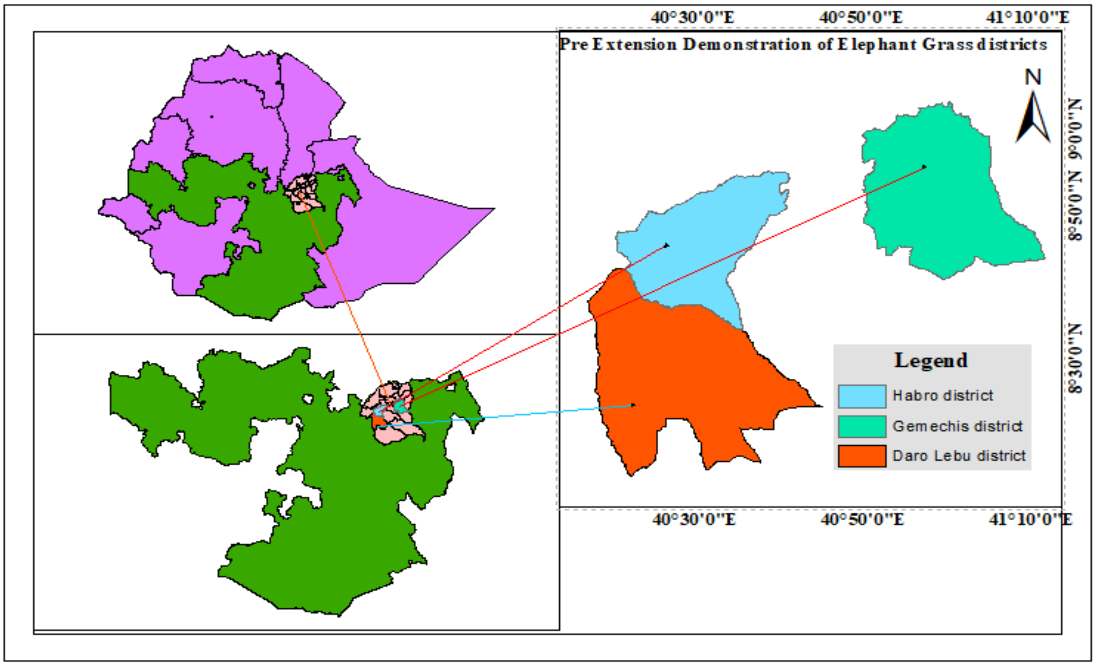

Figure 1: Map of the study areas
Source: Own design from ArcGIS data, 2022

Sampling frame and sample size

In this study a multi-stage sampling techniques were employed. Firstly, three districts (Daro Lebu, Habro and Gemechis) were selected purposively based on the intervention of improved finger millet varieties. Secondly, two kebeles from each district were selected randomly among the kebeles in which the intervention of improved finger millet varieties was undertaken. Finally, appropriate sample size of representative households producing those improved finger millet varieties were selected randomly by considering probability proportional to population size. For the drawn sample respondents, the simplified formula provided by [27] was employed in determining the required sample size at 91.65% confidence level and level of precision (e) = 8.35%.

$$n = \frac{N}{1+N(e^2)} = \frac{112{,}887}{1+112{,}887(0.0835^2)} = 143 \quad \text{...... (1)}$$

Where *n* is the sample size, N is the population size (total agricultural households of the three districts), and e-is the level of precision.

Table 1: Summary of sample respondents across districts

District	Kebele	Sample size taken	
		Frequency	Percent
Daro Lebu	Kotora	20	13.99
	Gelma Jeju	25	17.48
Habro	G/Goba	30	20.98
	Gadisa	31	21.68
Gemechis	K/Segariya	26	18.18
	W/Defo	11	7.69
Total		**143**	**100**

Sources: Own computation

Data Types, Sources and Method of Data Collection

This study used the two data types: qualitative and quantitative data. It was employed from both primary and secondary data sources. Secondary data source was collected from published and unpublished documents of district Agricultural Office to support the primary data. The primary data was collected from the selected representative sample households through direct interview. Data collected from primary sources were collected using structured questionnaire administered through personal interviews.

Method of Data Analysis

Descriptive statistics

The collected data was analyzed with STATA 16. Both descriptive statistics (such as mean, standard deviation, frequency and percentage) and econometric model (Double hurdle model) were employed to meet the specific objectives of the study. Furthermore, test statistics such as t-test for continuous and discrete variables to compare means; and chi-square (χ2) test for dummy variables were employed among adopters and non-adopters of improved finger millet technologies.

Econometric Analysis

A smallholder farmer faces two hurdles while deciding on improved finger millet varieties. The first is to decide whether to cultivate improved finger millet varieties. The second hurdle is related to the intensity of adoption. The most important underlying assumption of the model is that these two decisions are made in two different stages. Therefore, the first dependent variable in this model was dichotomous consisting of two outcomes, yes or no. The second dependent variable of this model was the adoption index which was continuous variable ranges 0 to 1.

The different econometric model could be used to identify factors that affect producers‟ decision to participate in cultivating improved finger millet varieties (yes/no); and also identify the determinants of the adoption intensity. Those include Tobit, Heckman's twostage models, and Double hurdle models.

According to [19], the double hurdle (DH) model is a useful and proper approach to analyze technology adoption in assumption of many Ethiopian farmers' faces constraints of accessing inputs. Hence, double-hurdle model was used instead of Tobit and Heckman's model.

In addition, the specifications of the empirical model used to identify these factors the Double-hurdle models widely discussed in different adoption studies [19]; [29]; [21]; [30]. The double-hurdle model was used to analyze factors influencing smallholder farmers' adoption decision, and the adoption intensity. Based on the specification by [5], the two hurdles for a farmer can be written as:

$$d_i = \alpha Z_i + v_i \qquad (2)$$

$$y_i^* = \beta x_i + \varepsilon_i \qquad (3)$$

Where,

$$d_i = 1 \text{ if } d_i^* > 0, \text{ and is } 0 \text{ if } d_i^* \le 0$$

d_i is the observable variable describing a farm's decision to adopt, y_i^* is the latent variable describing intensity of adoption, and d_i and y_i are their observed counterparts, respectively. Also, z_i is the vector of variables explaining whether farmer participants in producing improved finger millet, x_i is a vector of variables explaining intensity of adoption, and v_i and ε_i are the error terms.

The two error terms of the model were jointly normal and correlated,

$$(v_i, \quad e_i) \sim N(0, \Sigma) \qquad (4)$$

The likelihood function for the double hurdle model is:

$$L = \prod_0 \left[1 - F_2\left(Z_i\alpha, \frac{X_i\beta}{\alpha}, \rho\right)\right] \prod_+ \Phi\left(\frac{Z_i\alpha + \rho/\sigma(y - X_i\beta)}{\sqrt{1-\rho^2}}\right)\frac{1}{\sigma}\phi\left(\frac{y - x_i\beta}{\sigma}\right) \qquad (5)$$

Where, Φ and ϕ are the standard normal cumulative distribution function and density function, respectively.

Before running the specified model, the explanatory variables were checked for the existence of severe multicollinearity problems using the Variance Inflation Factor (VIF). According to [15], the threshold value of the VIF is 10 and that a highly positive value of the VIF indicates existence of severe multicollinearity. However, in this study there was no serious multicollinearity problem (VIF = 1.22) among explanatory variables. However, the tests of the Breusch-Pagan/Cook-Weisberg test showed the existence of heteroscedasticity problems in the dependent variable (Prob > chi2 = 0.0028).

Besides, to check as the double hurdle model was fit (appropriate) than Heckman two stages, specification tests were done. Heckman two-step procedure was tested against the Double hurdle model using inverse mills ratio (IMR). The study result revealed IMR was insignificant at 5% probability level. Therefore, Double hurdle model was appropriate and employed for the study.

Estimation of the adoption index

Before analyzing the determinants of adoption decision, it is important to assess the level of the adoption for each farm household. Accordingly, farmers who were not growing an improved finger millet variety were considered as non-adopters, while farmers who were growing at least one improved finger millet variety focusing on 2020/21 production season were considered as adopters. Among improved agronomic practices only four practices (improved variety, seed rate, portion of land allocated for improved finger millet and fertilizer application) are currently practiced by finger millet producer in the study area. The other practices (spacing, number of plough, chemical application and harvesting time) were excluded because of absence and difficulty in getting reliable information from farmers. In this study, adoption index was used to measure the extent of adoption at the time of the survey for multiple practices (package). Accordingly, the adoption index for each respondent farmer, which shows to what extent the respondent household, has adopted the technology packages were calculated using the following formula:

$$AI_i = \frac{\frac{AH_i}{AT_i} + \frac{FA_i}{RFA_i} + \frac{SR_i}{RSR_i}}{NP} \quad (6)$$

Where, AI_i= Adoption index; AH_i = Area under improved variety of finger millet of the ith farmer; AT_i = Total area allocated for finger millet production of the ith farmer; FA_i = fertilizer application for finger millet production of ith farmer; RFA_i = fertilizer application for finger millet production; SR_i = Seed rate of finger millet ith farmer used and RSR_i = Recommended seed rate of finger millet.

Thus, the adoption index is a continuous dependent variable calculated using the formula presented above with a value ranging from 0 – 1. Zero indicates no adoption and 1 indicates full adoption; an adoption index score between 0 and 1 indicates partial adoption. Improved finger millet production involves the use of different package practices. These include use of improved variety, seeding rate, fertilizer application and land allocated. Significant improvement in production and productivity depends on the extent to which a household has practiced the recommended improved agronomic practices. The level of adoption of improved finger millet production practices by farmers may vary depending on demographic and socioeconomic variables, institutional and environmental factors in which the household operates. The sample households' index scores were categorized into four adopter groupings namely non-adopter (0), low (0.01 – 0.33), medium (0.34 – 0.66) and high (0.67 – 1) adopter.

Table 2: Summary and description of explanatory variables

Variables	Measurement	Expected sign
Dependent variable		
Adoption decision	Dummy	
Adoption index	Continuous variable	
Explanatory variables		
Age of Household head	Years	+
Household size	Number	+
Land size owned	Timad	+
Livestock owned	Tropical livestock unit	+
Sex	Dummy	±
Education status	Categorical	+
Fertilizer application	Dummy	+
Fear of risk on improved varieties	Dummy	_
Access to market information	Dummy	+
Access to extension services	Dummy	+
Participation on demonstration and field day	Dummy	+
Access to credit	Dummy	+

Results and Discussions

This section presents descriptive and econometrics results of the study.

Socio Economics Characteristics of Finger Millet Producer Farmers

In this study adopters were referred as those farmers cropped improved finger millet varieties for at least one year. While, non-adopters were referred as those farmers never used improved finger millet varieties forever. According to Figure (1) below, from the total sample respondents 60% were adopters of improved finger millet technologies; while the rests were non adopters.

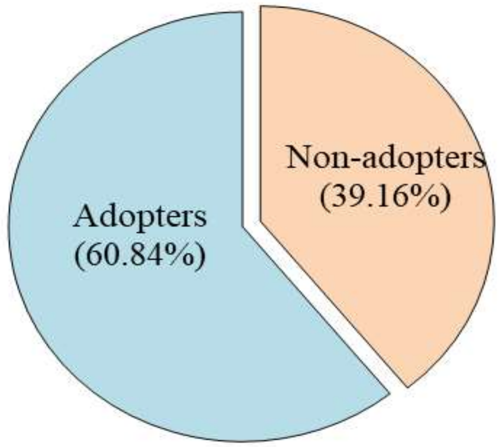

Figure 2: Status of sampled finger millet producer farmers

In study area, household size was on average 6. As indicated on Table (2) below, F-value indicated that there is no statistical difference between the two groups (adopters and non-adopters). It implied that there was no household size difference in between adopters and non-adopters (Table 2).

Table 3. Socio-economic characteristics of respondents (Continuous variables)

Items	Adopter		Non-adopter		Overall		F
	Mean	SD	Mean	SD	Mean	SD	
Household size (No)	5.8	2.4	5.9	2.1	5.9	2.3	0.36
Age (year)	39	10	41	11	40	10	1.16
Land size (ha)	0.75	0.46	0.48	0.28	0.65	0.42	1.78**
Livestock (tlu)	2.56	2.05	2.02	1.43	2.35	1.85	1.08

Source: Survey result, 2022

Land size had a great role in agricultural production and productivity. Households in the study area had on average 0.65 hectare with standard deviation of 0.42 hectares of farm size. There is a statistical significance difference in between adopters and non-adopters at 5% significance level. Adopter farmers had larger farm size (0.75ha) than non-adopter farmers (0.48ha).

Livestock is assets that guard farm household against shocks and agricultural related risks such as crop failure. In study area, on average households had 2.35 tropical livestock unit. Even if livestock owned is no statistical difference between adopter and non-adopter; there is numerical difference that means adopter had 2.56 tlu and non-adopter had 2.02 tlu.

Demographic and Institutional Service Characteristics of Respondents

According to the study result of Table (3) below, majority of the sampled households were male household heads which was around 97% while the rest were female headed households. Among adopter and non-adopter 96% and 98% were male headed households, respectively. However, there was no statistical difference among adopter and non-adopter in sex of households.

Education may directly affect application of new agricultural technologies and its adoption. In study areas in education status, most of the interviewed farmers (74.83%) were followed at least 1 year school formal education, 6.29% were not followed formal education but they could read and write; while 18.88% were illiterate. Among adopter 18.18%, 7.95% and 73.86% were illiterate, read and write and formal education, respectively (Table 3). While, non-adopter 20%, 3.64% and 76.36% were illiterate, read and write and formal education, respectively.

In finger millet production, both organic (manure, compost) and inorganic fertilizer is recommended as it should be applied. Out of the total respondents, three fourth (75.52%) were applied inorganic fertilizer (Urea and/ NPS) for finger millet production. But, one fourth (24.48%) of respondents were not used inorganic fertilizer for finger millet production. There are different reasons why farmers did not applied inorganic fertilizer for finger millet production. The main reason why households did not applied fertilizer was lack of capital, expensiveness and farmers perception of not applied for finger millet.

Table 4. Demographic and institutional service characteristics of respondents

Items		Adopter (%)	Non-adopter (%)	Overall (%)	Ch^2
Sex of household head	Male	96.59	98.18	97.20	0.315
	Female	3.41	1.82	2.80	
Education status	Illiterate	18.18	20.00	18.88	
	Read and write	7.95	3.64	6.29	1.090
	Formal education	73.86	76.36	74.83	
Fertilizer application for finger millet	Yes	86.36	58.18	75.52	14.542***
	No	13.64	41.82	24.48	
Access to extension service	Yes	61.36	38.18	52.45	7.293***
	No	38.64	61.82	47.55	
Access to market information	Yes	56.82	47.27	53.15	5.51
	No	43.18	52.73	46.85	
Fear of risk on improved varieties	Yes	55.17	21.43	41.96	15.929***
	No	44.83	78.57	58.04	
Participation on demo & field days	Yes	40.91	14.55	30.77	11.043***
	No	59.09	85.45	69.23	
Access to credit	Yes	10.23	16.36	12.59	1.158
	No	89.77	83.64	87.41	

Source: Survey result, 2022

According to the survey result, out of the total sample respondents 52.45% were get extension service access and the rest were not get access to extension services. From adopter farmers 61.36% were got extension service access and the rest were not got. Out of the non-adopter farmers only 38.18% were got extension service access. There were statistical significant differences in access to extension services among the two groups at 1% significance level.

Market information is important for enhancing finger millet producers to adopt packages of improved finger millet technologies. However, only 53.15% of sample households were access to finger millet market information and 46.85 percent of sample households did not have access to market information. According to the survey result 56.82% of adopter households and 47.27% of non-adopter households get market information. They were getting market information from different sources, mainly from market observations, neighbors and radio. The chi-square result revealed that there is no significant statistical difference between adopters and non-adopters in access to market information.

Among finger millet producers in study area, 41.96% were fear risks to cultivate improved finger millet varieties. This is a reason of wilting problems except Tesema variety, pests' occurrence (birds attach) and untimely availability of its improved seeds. Among adopter categories 55.17% had fearing of risks within land shortage owned during cultivating even if they are adopters. While among non-adopters 21.43% were did not fear to cultivate improved finger millet varieties. However, due to untimely availability of improved seed, expensiveness and no need have improved variety. The chi square test showed that there is a statistical significant difference between the two groups at 1% significance level (Table 3).

Farmers who participated in on demonstration & field days are believed to have to access more information on improved technology packages as compared to other farmers. Accordingly, survey result shows that overall only about 30% of the respondents were participated on demonstration and/ field day. There is a statistical significance difference in between adopters and non-adopters at 1% significance level. Adopter farmers were more participated (40.91%) than non-adopter farmers (14.55%) on demonstration & field days. In study area, few of the sampled respondents (12.59%) get credit access, while the remaining 87.41% did not get. Available credit itself is mainly for only for fattening and trades rather for crop production. On credit access there is no significant differences between adopters and non-adopters.

Finger Millet Technologies

Agronomic Practices

The agronomic practice of improved finger millet production technology package contains improved seed, sowing method, seed rate, fertilizer application, land preparation, sowing date, weeding, pest prevention, threshing method, storage system and others. However, all the packages were not included in this study to calculate the adoption index because it is difficult to get reliable data for some packages (i.e., sowing date and harvesting).

In study area, all producers were conducted weeding managements of finger millet production. Majority of households (on average 90%) were weeding more than one times; while only 10% were weeding only one time.

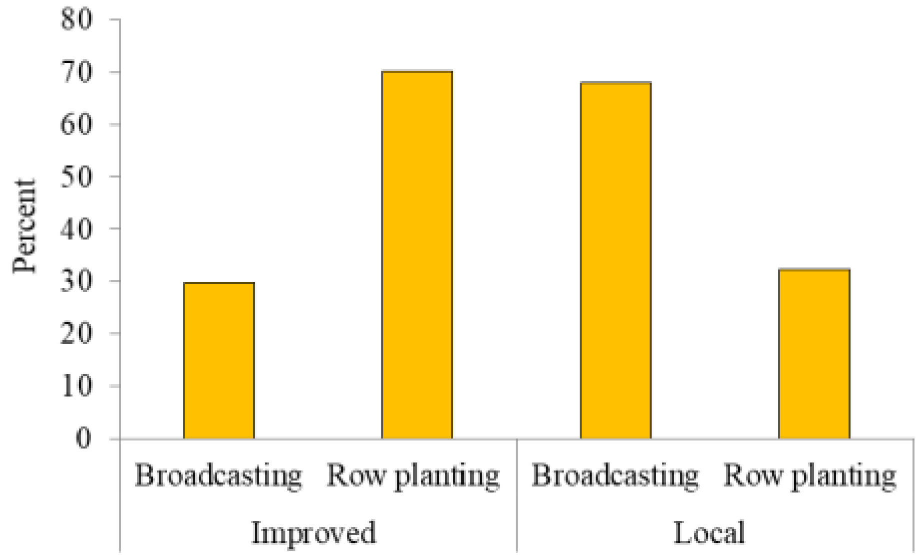

Figure 3: Sowing methods of finger millet in study area

According to figure (3) above, majority of farmers used improved finger millet varieties were sowing in row planting method. However, majority of farmers not used improved finger millet varieties (local) were sowing in broadcasting.

Being the crop is drought tolerant it is popular crops for both home consumption and market sales. In study area smallholder farmers primarily they produce finger millet for home consumption. Besides, the surpluses from home consumption were applied for market by some farmers. Among interviewed farmers some farmers were increasing area allocated for finger millet from year to year. As a reason of finger millet were productive crops, long store ability and drought tolerance of crop. But, few farmers in reverse decreasing area allocating for finger millet due to maize cluster, giving priority for other crops and small amounts is sufficient for home consumption

.

Table 5: Cropping system of finger millet in study area

Cropping system	Frequency	Intercropped With	Frequency
Sole	102		
Both	2	Maize	36
Intercropping	39	Sorghum	3
		Chat	2
Total	**143**		**41**

Source: Survey result, 2022

In study area, majority of farmers (71.33%) were sowed finger millet in sole cropping system. The rest percent were intercropped with other crops mainly with maize, sorghum and in chat (Table 5).

Improved finger millet varieties

Table 6: Mean yield and traits of farmers used varieties

No	Varieties	N	**Mean** (qt/timad)	Traits
1	Boneya	12	4	Red seed color & flower
2	Tadese	29	7.88	White seed color & flower
3	Tesema	36	6.2	Red seed color & white flower
4	Meba	2	8.25	Red flower
5	Tesema & Tadese	8	9.71	-

Source: Survey result, 2022

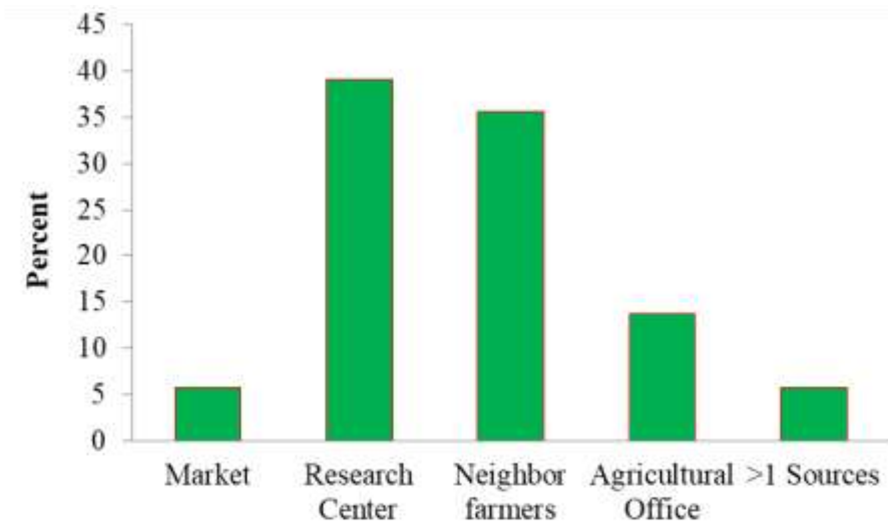

Figure 4: Sources of improved finger millet varieties

Research center and neighbor farmers (who transfer the received improved seed for other farmers) were the two major sources of improved finger millet varieties in study area. In this case research center played a lion share in provision of improved finger millet varieties for farmers. While, it followed by agricultural office and purchase from the market.

Adoption intensity of finger millet packages of technologies

Table 7: Categories of adopter farmers on finger millet packages of technologies

No	Technologies	Category (Yes)	
		Frequency	Percent
1	Using improved varieties	87	100
2	Recommended seed rate used (10-15kg/ha)	19	21.84
3	Fertilizer application	74	85.06
4	Sowing method (row planting)	61	70.11

Source: Survey result, 2022

According to [28], planting finger millet at the lowest seed rate (10kg/ha) at 30 cm row spacing gave the optimum grain yield of finger millet. Other studies indicated that planting finger millet at 15kg/ha seed rate at 40 cm row spacing gave the optimum finger millet grain yield [13]. Therefore, 10-15kg/ha seed rate is taken as a standard in calculation of adoption index.

Table 8: Status of adoption categories of smallholder farmers

No	Adoption categories	Index score Categories	Frequency	Percent
1	Non-adopters	0	56	39.16
2	Low adopters	0.01–0.33	8	5.60
3	Medium adopters	0.34–0.66	24	16.78
4	High adopters	0.67–1.00	55	38.46
Total			**143**	**100**

Source: Survey result, 2022

The actual adoption categories were categorized into four groups such as non-adopter, low adopter, medium adopter, and high adopter based on the adoption index. The index score is 0.00, 0.01–0.33, 0.34–0.66, and 0.67–1.00, which represents none, low, medium, and high adopters, respectively. Similar studies, [2], [18], [24], and others), used similar techniques. Therefore, more than half of the interviewed farmers were found under categories of medium and high adopters.

The main reasons for not adopting of improved finger millet varieties indicated in table above is due to expensiveness of seed, no need and fear of risks in 60.53%, 16.89% and 22.58% of respondents, respectively. Besides, disease, pests and shattering of the improved varieties issues caused farmers mistrusts on the technology and leads to not adopting it.

Table 9: Adoption categories of smallholder farmers across district

No	Adoption categories	Daro Lebu		Habro		Gemechis	
		Freq	%	Freq	%	Freq	%
1	Non-adopters	21	46.67	13	21.31	22	59.46
2	Low adopters	1	2.22	1	1.64	7	18.92
3	Medium adopters	5	11.11	13	21.31	5	13.51
4	High adopters	18	40	34	55.74	3	8.11
Total		**45**	**100**	**61**	**100**	**37**	**100**

Source: Survey result, 2022

Among the study districts, large numbers of high adopters were found in Habro district. The reason is that Habro is firstly ranked district in finger millet production potential and there are large numbers of finger millet producers. That is also the reason the proportion of sample size taken among the district is differ. While Gemechis district less potential in finger millet production than Habro and Daro Lebu districts.

Econometric Results

In this section factors affecting adoption decision of improved finger millet varieties and adoption intensity are presented and discussed.

Factors affecting adoption decision of finger millet Varieties

The first stage of the double hurdle model shows that land size owned, fear of risk on improved varieties, participation on demonstration, access to extension service and participation on demonstration were positively and significantly affects the probability of adoption decision of improved finger millet varieties.

As expected, land size households owned was statistically significant at 10% probability level and had a positive effect on the household adoption decision on packages of improved finger millet varieties. As one hectare increment of land sizes the probability of the decision to adopt improved finger millet varieties increase by 25.65% keeping all other variables constant. The study result is coinciding with [1]. This result also agrees with

the findings of [7] which reported that production of crops like wheat is better relatively on large size of land than on small plots of land in economic gain.
Fear of risk on improved varieties was positively and significantly affects the probability of adoption of improved finger millet varieties at 1% probability of significance level. The probability of adopting improved finger millet varieties is 36.67% greater for farmers those do not fear risks to produce improved finger millet varieties than those fear its risks to produce keeping other variables constant. The study results agree with the study results of Sussie and Bosena (2020) which revealed that farmers' perception of a new specific technology on its future benefit and cost influences their
adoption decisions.

Table 10: Results of Double hurdle model estimation of adoption decision and level of adoption in improved finger millet technologies

Variables	Probability of adoption			Adoption intensity		
	Coefficient	**Std. Err.**	**Dy/dx**	**Coefficient**	**Std. Err.**	**Dy/dx**
Age of household head	-0.0208	0.0133	-.0077	-0.0028	0.0019	-.0028
Education status	-0.2242	0.1781	-.0827	-0.0073	0.0241	-.0073
Household size	-0.0870	0.0754	-.0321	0.0257***	0.0089	.0257
Land size owned	0.6958*	0.4018	.2565	-0.0308	0.0429	-.0308
Livestock owned (TLU)	-0.0041	0.0796	-.0015	-0.0136	0.0087	-.0136
Fear of risk on improved varieties	1.0714***	0.2795	.3667	-0.0087	0.0358	-.0087
Access to credit	-0.4355	0.3733	-.1678	-0.0976*	0.0557	-.0976
Participation on demonstration	0.6741**	0.3077	.2309	0.0281	0.0397	.0281
Access to extension service	0.4390*	0.2594	.1614	0.1218***	0.0393	.1218
Fertilizer application for finger millet	0.9669***	0.3485	.3673	0.3024***	0.0569	.3024
Access to market information	-0.3447	0.2847	-.1260	0.0171	0.0395	.0171
Sex of household head	0.1207	0.7388	.0454	0.0831	0.0954	.0831
Constant	0.3733	1.0904		0.2854*	0.1423	
Sigma	0.1515***	0.0117	Number of obs	143	Log likelihood	-69.507019
Pseudo R2	0.2739		LR chi2(12)	52.45 (0.0000)	Truncated obs.	56

*, ** & *** represents significance at 10%, 5% and 1% respectively.

Source: Survey result, 2022

Finger millet responds well to fertilizer application to give good yield. Fertilizer application for finger millet was positively and significantly affects the probability of adoption of improved finger millet varieties at 1% probability of significance level. The study results indicate that the probability to adopting decision of improved finger millet varieties is 36.73% greater for farmers applying inorganic fertilizer for finger millet production than those not applying inorganic fertilizer holding all other variables at their means. This is in line with the result of [3], who reported that fertilizer application decision was concurrent in decision to adopt improved bread wheat varieties.

Access to extension service was positively and significantly affects the probability of adoption decision of improved finger millet varieties at 10% probability of significance level. The study results revealed that the probability of adopting improved finger millet varieties is 16.14% greater for farmers get access of extension service than do not get access keeping other variables constant. The results are similar with [20] findings indicated that farmers who had frequent extension visit are more likely to adopt improved bread wheat technologies. The results also agree with [24].
Technological change was the basis for increasing agricultural productivity and promoting agricultural development. Participation on demonstration was positively and significantly affects the probability of adoption decision of improved finger millet varieties at 5% probability of significance level. As farmer participate on demonstration and/ field day they would aware of the technologies and get knowledge of how to use which leads to technology adoption. The study result showed that the probability of adopting improved finger millet varieties is 23.09% greater for farmers get chances of participation on demonstration and/ field day than do not get chance keeping other variables constant. The results are coincides with the results of [24].

Determinants of adoption intensity of improved finger technologies

The second stage of the double hurdle model shows that household size, access to credit, access to extension service and fertilizer application for finger millet were significantly affects the adoption intensity of improved finger millet technologies.

Household size was positively and significantly affects adoption intensity of improved finger millet technologies at a 1% level of significance. The result of truncated part of Double hurdle indicates that an increase of household size in a number increases intensity of adoption by 2.57% keeping the effect of the other variables constant. That is a reason of in study area most farmers produced finger millet for home consumption and the crop is high demand for food. In labor labor-intensive activity like teff production a household with high working labor force are allocate more hectares of land in a position to manage the activity [24]. The current findings also concur with past findings of [20].

Access to credit was negatively and significantly affects adoption intensity of improved finger millet technologies at a 10% level of significance. The marginal effect implied that households whose access to credit can reduce adoption intensity of improved finger millet technologies by 9.76% than those who do not have access to credit, other things remaining constant. A reason majority of finger millet producer farmers in study area did not search/ need credit because of religions case and fear of interest. While the left were lacks its access. This result is agreed with the study result conducted by [20] and [14].

Access to extension service was positively and significantly affects adoption intensity of improved finger millet technologies at a 1% level of significance. This implied that keeping other explanatory variables at their mean level, as a farmer being access to extension service the adoption intensity of improved finger millet technologies increases by 12.18% (Table 8). This result is consistence with other adoption studies by [2] and [17].

Fertilizer application for finger millet was positively and significantly affects adoption intensity of improved finger millet technologies at a 1% level of significance. The marginal effect result indicated that when all other variables are at constant, as farmers applied fertilizer for finger millet their adoption intensity of improved finger millet technologies increases by 30.24% than those not applied fertilizer for finger millet. This result is agreed with the study result conducted by [8] which reported as organic fertilizer as positively affected the productivity of Teff.

Conclusions and Recommendations

The study was initiated to identify adoption status and factors affecting the probability of adoption and intensity use of improved finger millet varieties. Finger millet is one of the important cereal crops which are staple crops for millions of people. It was conducted in three districts of West Hararghe zone. Descriptive and econometric (Double hurdle) model were used to analyze the collected data.

Descriptive results of the study revealed that, there exists a significant variation among adopters and non-adopters in relation to fear of risks on improved varieties, household size, participation on demonstration and field days, access to extension services and fertilizer application for finger millet. Improved finger millet varieties such as Tesema, Tedesa, Boneya and Meba predominantly grown in the study area. About more than three fifth of finger millet producer farmers were adopter of improved finger millet varieties in study area.

The first hurdle result indicated that land size owned, fear of risk on improved varieties, participation on demonstration, access to extension service and fertilizer application on finger millet significantly affects the adoption decision of improved finger millet varieties producer farmers. The second hurdle result indicated that household size, access to credit, access to extension service and fertilizer application for finger millet were significantly affects the intensity of adoption of farmers those produced improved finger millet varieties.

Based on the findings of this study the following recommendations were forwarded:

- It is crucial to give special attention of fertilizer application for finger millet production by farmers because around half of non-adopters were not applied fertilizer for finger millets. Farmers ought to be used fertilizer (either organic or in organic) for finger millet productions.
- Participation on demonstration and field days were an important factor in finger millet technology adoption. Therefore, research centers, universities and agricultural office should have to be creates and strengthens experience sharing program for farmers to enhance the adoption of improved finger millet varieties.
- Access to extension positively and significantly affects the adoption decision and intensity of finger millet technologies. Thus, development agents and extension experts of agricultural office need to give attention on awareness creation for farmers on recommended seed rates of finger millet, avoiding farmers' risks fearing on improved varieties and existence of interest free credits.
- Land size household owned had the greatest impact on increasing adoption decisions of finger millet technologies. However, there is no possibility of expansion of cultivation land to increase adoption decision of smallholder farmers in the study area. Therefore, further research required to see the crop compatibility for intercrops on the available cultivated land.

References

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[1] Akwalu, V.M., Mbogori, S.N., Obare, G.A. and Njehia, B.K., 2020. Factors Influencing Farmer's Willingness to Adopt Pearl Millet Production in Tigania West District, Kenya. International journal of innovative research and development; 9(1):201-206.

[2] Atrsaw Anteneh, Girmachew Siraw, and Negussie Siyum. 2022. Adoption Status and Perception of Farmers on Improved Tef Technology Packages: Evidence from East Gojjam Zone, Ethiopia. Hindawi Advances in Agriculture; https://doi.org/10.1155/2022/6121071

[3] Bedilu Demissie, Adem Kedir, Hussien H. Komicha, Sisay Asefa, 2021. Determinants of adopting improved bread wheat varieties in Arsi Highland, Oromia Region, Ethiopia: A Double-Hurdle Approach. *Cogent Economics & Finance*; 9:1-23.

[4] Chandio AA, Jiang Y. and Magsi H. 2016. Agricultural sub-sectors performance: An analysis of sector-wise share in agriculture GDP of Pakistan. *Int J Econ Finance* 8: 156.

[5] Cragg, J. 1971. Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods, Econometrica, 39(1): 829 – 844.

[6] Daro Lebu Agricultural Office (DLAO). 2021. Annual Report of 2020 of Daro Lebu Agriculture District Office. Daro Lebu district, West Hararghe Zone.

[7] Degefu Kebede, Mengistu Ketema, Nigussie Dechassa and Feyisa Hundessa, 2017. Determinants of Adoption of Wheat Production Technology Package by Smallholder Farmers: Evidences from Eastern Ethiopia. *Turkish Journal of Agriculture - Food Science and Technology.*

[8] Demelash Abewa, Hayimero Edmealem and Mulusew Kassa. 2020. Prevalence and Associated Factors of Agricultural Technology Adoption and Teff Productivity in Basso Liben District, East Gojjame Zone, North west Ethiopia. https://doi.org/10.1101/2020.10.28.358770

[9] Farooq A, Ishaq M, Yaqoob S. 2007. Varietal adoption effect on wheat crop production in irrigated areas of NWFP. Sarhad J Agric 23: 481–485.

[10] Fatima, H, Khan, MA. 2015. Influence of wheat varieties on technical efficiency and production of wheat crop in Pakistan (in selected area of Punjab). Sarhad J Agric 31: 114–122.

[11] Feder, L., Just, R.E. and Zilberman, O. 1985. Adoption of Agricultural Innovation in Developing Countries:" A Survey" Economic Development and Cultural Change, 32(2): 255- 297

[12] Gemechis Agricultural Office (GAO). 2021. Annual Report of 2020 of Gemechis Agriculture District Office. Gemechis district, West Hararghe Zone.

[13] Getahun Dereje, Tigist Adisu and Bekele Anbessa, 2016. nfluence of Row Spacing and Seed Rate on Yield and Yield Components of Finger Millet at Assosa Zone in Benshagul Gumuze Region of Ethiopia. *Journal of Biology, Agriculture and Healthcare*; 6(5):42-45.

[14] Girma Gezimu, Hiroshi Isodab, Dil Bahadur Rahutc, Yuichiro Amekawad and Hisako Nomura. 2019. Gender differences in the adoption of agricultural technology: The case of improved maize varieties in southern Ethiopia. Women's Studies International Forum; 76:1-11.

[15] Greene, J.C. 1997. Evaluation as Advocacy, Evaluation Practice. 18: 25-35.

[16] Habro Agricultural Office (HAO). 2021. Annual Report of 2020 of Habro Agriculture District Office. Habro district, West Hararghe Zone.

[17] Jerop, R., Dannenberg, P., Owuor, G., Mshenga, P., Kimurto, P., Willkomm, M. and Hartmann, G. 2018. Factors affecting the adoption of agricultural innovations on underutilized cereals: The case of finger millet among smallholder farmers in Kenya. *African Journal of Agricultural Research*; 13(36): 1888-1900.

[18] Jima Degaga, Gosa Alemu and Birhanu Angasu. 2020. Factors affecting adoption of improved haricot bean (Phaseolus Vulagris L) technology in West Hararghe zone of Oromia region, Ethiopia: A Heckman two-step approach. *TropicalAgriculture*; 97(4):253-267.

[19] Negussie Siyum, Almaz Giziew and Azanaw Abebe. 2021. Factors influencing Adoption of improved bread wheat technologies: a double hurdle approach in Northern Ethiopia. : https://doi.org/10.21203/rs.3.rs-275768/v1

[20] Negussie Siyum, Almaz Giziew and Azanaw Abebe. 2022. Factors influencing adoption of improved bread wheat technologies in Ethiopia: empirical evidence from Meket district. Heliyo, 1-11.

[21] Nigus Gurmis. 2018. Market Chain Analysis of Teff: The Case of Merhabete District, North Shewa Zone, Amhara National Regional State of Ethiopia. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

[22] Padulosi S, Thompson J, Rudebjer P. 2013. Fighting poverty, hunger and malnutrition with neglected and underutilized species: Needs, challenges and the way forward. Biodiversity International https://cgspace.cgiarorg/bitstream/handle/10568/68927.

[23] Pingali PL. 2012. Green Revolution: Impacts, limits, and the path ahead. Proceedings of the National Academy of Sciences 109(31):12302-12308.

[24] Susie Teshome and Bosena Tegegne, 2020. Determinants of Adoption of Improved Teff Varieties by Smallholder Farmers: The Case of Kobo District, North Wollo Zone, Amhara Region, Ethiopia. *International Journal of Agricultural Economics*; 5(4): 114-122

[25] Tadele Z. and Assefa K. 2012. Increasing food production in Africa by boosting the productivity of understudied crops. Agronomy 2(4):240-283.

[26] CSA (Central Statistical Authority). 2018. Central Statistical Authority: Report on Area and Production of Major Crops. Volume I.

[27] Yamane, T. 1967. Statistics, An Introductory Analysis 2nd Edition. New York.

[28] Yayeh Bitew and Fekremariam Asargew, 2014. Determination of Seed Rate and Inter Row Spacing for

Finger Millet Production (Eleusine Coracana Gaertn.) in North Western Ethiopia. *International Journal of Research & Review*; 1(4):1-7.
[29] Yonas Kassahun, Mengistu Ketema and Zekarias Shumeta. 2020. Determinants of Participation Decision and Levels of Participation in Small Ruminants Market. Sustainable Agriculture Research, 9(1):56-66.
[30] Achandi, E.L. and Mujawamariya, G. 2016. Market Participation by Smallholder Rice Farmers in Tanzania: A Double Hurdle Analysis. Studies in Agricultural Economics, 118(1): 112-115.
[31] GCDT (Global Crop Diversity Trust). 2012. Global strategy for the ex situ conservation of finger millet and its wild relatives. Global Crop Diversity Trust, Rome, Italy.
[32] Molla F. 2012. Participatory evaluation and selection of improved finger millet varieties in North Western Ethiopia. International Research Journal of Plant Science, 3(7): 141-146.