World Journal of Agricultural Science and Technology
2025, Vol. 3, No. 2, pp. 24-31
https://doi.org/10.11648/j.wjast.20250302.11

Research Article

Adoption of Improved Potato Varieties in Ezha District Southern, Ethiopia

Amsalech Yirga*

Department of Agricultural Economics, Ethiopian Institute of Agricultural Research (EIAR), Chiro National Sorghum Research and Training Center, Chiro, Ethiopia

Abstract

The improvement of potato yield and overall production is significantly dependent on the integration of advanced technologies, particularly the use of enhanced potato varieties. Nevertheless, the uptake of these improved varieties in developing nations, such as Ethiopia, is constrained by a range of factors, including socio-economic, demographic, and institutional challenges. To investigate this matter, the study was conducted in Ezha District, located in southern Ethiopia. This research utilized a three-stage sampling technique and gathered primary data through interviews, focus group discussions, and key informant interviews, also sourcing secondary data from various references. The analysis of the data showed that the adoption rate of improved potato varieties was 48.4%, while the intensity of adoption was 55.01%. Based on the probit regression model, it was found that factors such as level of education, size of land and livestock, frequency of extension contact, and membership in a cooperative had a positive impact on farmers' decisions to adopt improved potato varieties. Conversely, the distance to the farmer's training center and the nearest market had a negative influence. As a result, suggested that stakeholders, including the local community, District Agriculture Office, and research institutes, should promote improved potato varieties in the study area to enhance potato yield and production.

Keywords

Improved Potato Varieties, Determinants, Probit Model

1. Introduction

Potato (Solanum tuberosum L.) is a crucial root and tuber crop precisely grown in more than 125 countries worldwide. It is a short-cycle crop that is well-suited for double cropping, making it a popular choice for farmers [1]. In terms of production, it is the fourth-most important food crop globally [2] and the most important from vegetable crops. Over the past two decades, potato production and harvested areas have more than doubled in Africa, making it a vital food security crop in the high altitude and variable rainfall of Sub-Saharan Africa. Over 150 years potatoes have been cultivated in Ethiopia, it provide food and income to over 2.3 million households across the country [3].

Potatoes are a multifunctional crop that can be grown in a different agro ecology [4]. It is used to address seasonal food shortages during other food crops are depleted through storage. So far, the importance of potatoes is increasing due to urbanization and by introduction of potato processed products such as French fries (crisps) and potato crisps and their

*Corresponding author: amsalyirg2019@gmail.com (Amsalech Yirga)

Received: 9 April 2025; **Accepted:** 4 May 2025; **Published:** 6 June 2025

impact on demand; as a food source, it also plays a major role in the national economy [5].

Ezha is one of the Districts that grow potato extensively for economic and social benefits in Southern part Ethiopia. In fact, productivity of the crop is low due to multidimensional factors such as, an inadequate supply of disease-resistant and high-yielding varieties, limited knowledge of agronomic and crop protection management technologies, and poor post-harvest handling [6]. As a matter of fact, implementation of agricultural technology like improved varieties plays a crucial role in enhancing agricultural productivity, attaining food self-sufficiency, alleviating poverty, and mitigating land degradation [7]. In addition to it increase farmers' income, maintain food security, contribute to economic development, and improving their capacities to maximize their benefit [8].

Improved varieties (IVs) have better yield [9] and more resistant to late blight [10], virus and bacterial wilt [11]. As a matter fact, research centers, universities, and private enterprises in Ethiopia have introduced over 36 improved potato varieties [12]. However, many Ethiopian farmers remain hesitant to adopt these improved potato varieties for cultivation. As matter of fact, the productivity of potatoes in Ethiopia is considerably lower than that of other nations, attributed to several challenges including the prevalence of diseases, lack of access to improved seed varieties, insufficient storage infrastructure, and an antiquated production system [13]. Moreover, Farmers are not adopting advanced technologies as anticipated, primarily due to the prohibitive costs of seeds, inadequate availability of fertilizers and pesticides, a lack of credit facilities, and limited awareness. Still, the integration of enhanced agricultural technology is essential for improving the living conditions of the rural poor. In fact, improved potato varieties currently grown in the study area include Belete, Jalene, and Gudene. Notably, there has been no prior research conducted in this region concerning the acceptance of new potato varieties or the barriers that impede the adoption of improved potato varieties. Therefore, this study was commenced to investigate the determinants factors that affecting the adoption of enhanced potato varieties and to analyze the rate and extent of their implementation within the study area.

2. Materials and Methods

2.1. The Study Area

The research was carried out in the Ezha District, which is situated in the Gurage Zone of Southern Ethiopia Regional State of Ethiopia. Ezha is one of the sixteen Districts in the Guraghe zone. It is positioned 180 km gone to Addis Ababa, in the southwest route along the main road to Wolkite. The District's geographical coordinates are between 8°50'-9°15' N and 38°25'-38°45' E. According to the 2007 census report by the CSA, the population of Ezha District was 84,905, with 40,261 males and 44,644 females. The District altitude ranges from 1895 to 3200 m.a.s.l. The area experiences a bimodal distribution of rainfall, with short rains occurring from February to May and heavy rains from June to September. The average annual rainfall is approximately 950-1100 mm. the minimum and maximum temperatures range from 7.5°C to 28°C, respectively.

2.2. Data Types, Source and Method of Data Collection

A cross-sectional study design was utilized in the research. The data collection techniques employed for this study encompassed household surveys, focus group discussions, and key informant interviews in Ezha District during the production year of 2021/22. For this study data were collected in both qualitative and quantitative forms. Qualitative data was obtained through focus group discussions and key informant interviews. Conversely, primary quantitative data was gathered using an arranged questionnaire format through 7.5 CSPRO software and a computer-assisted personal interview (CAPI). This data includes factors related to demographics, socio-economics, and institutions, as well as the farmers' responses to the adoption of improved potato varieties rate and extent. Additionally, field observations were conducted to gather information about potato production on a farm station. Secondary data was obtained from the District Finance and Economic Development Office and the Central Statistical Agency of Ethiopia.

2.3. Sampling and Sample Size Determination Techniques

The sample household was selected using three-stage sampling technique. In the initial stage, Ezha District was purposefully chosen out of the 16 Districts in Guraghe Zone due to its high potential for potato production. Ezha District consists of 29 rural Kebeles out of which six were identified as potential potato producers. In order to be included in the study, three Kebeles were selected randomly from this group in the second stage. Thirdly, from three kebeles choose farmers randomly using possibility proportionate to size sampling approach taking into account the size of each selected Kebele. This resulted in a total sample household of 250. The sample size for the three Kebeles was determined at a 0.05 (5%) level of precision using a simplified formula provided by Yemane (1967).

$$n = \frac{N}{1+N(e^2)} = 250 \quad (1)$$

Where n is required sample, N the total number of households for the three Kebeles and e is degree of confidence.

$$ni = \frac{Ni(n)}{\sum Ni} \quad (2)$$

Where ni = sample from the i^{th} kebele, Ni is total population in the i^{th} kebele., ΣNi is the summation of population in three selected kebeles and n is sample size of the study.

2.4. Method of Data Analysis

Both descriptive and econometric method used to analysis the collected data. Descriptive statistics such as percentages, means, and standard deviations were utilized to analyze the explanatory variables. While, inferential statistics, specifically t-test and χ2-test, were employed to determine if there were significant differences among households that adopted improved potatoes varieties in terms of continuous and categorical variables. Narrative and interpretation analyses were used to analyze qualitative data gathered from FGDs and KIIs. The collected data was analyzed using Excel 2010 and Stata V.15 software.

2.5. Probit Regression Model

The decision of a farmer to participate in the cultivation of improved potato varieties is a dependent variable that can be represented as a binary variable taking a value of either one or zero, indicating whether the household is an adopter or not. According to [14] the participation decisions of households can be determined using either logit or probit models, as the results of both models are similar. Probit regression model used for this study, to evaluate the factors influencing farmers' decisions to adopt improved potato varieties, following the estimation procedures of Long [15]. The probit model considers the error term distribution and realistic probabilities [16] But according to the probit model, there is an unobserved continuous variable Y* that influences the value of the response variable Y, whereas the response variable Y assumes values of 0 and 1 for non-adopters and adopters, respectively [17]. Therefore, Y* is expressed as:

$$Y^* = \beta X i + \varepsilon \quad (3)$$

Where: ε~ N (0, 1). Then, Y can be viewed as an indicator of whether this latent variable is Positive, such that Y = 1 (Y* > 0), that is, 1 if Y* > 0 i.e. (ε <$\beta X i$), and 0, Otherwise * that determines the value of Y.

3. Results and Discussions

3.1. Descriptive Analysis

The male-headed respondents were about 90.8% while, the remaining 9.20% were female-headed. About 92.56% adopters of improved potato varieties were male headed household and the remaining households were non-adopters. Out of the female-headed households, 7.44 % were adopters and the rest were non-adopters. The result shows that, there is no a statistically significant association between the adoption of IPVS and the sex of the household head. Access to credit, cooperative membership, participation in demonstration and off-farm activities were the variables that significantly related with participation in improved potato varieties.

Many farmers obtain additional income by participating in off-farm activities. The result of the study revealed that 51.60% of sample households were participate in off-farm activities. There was a significant associated between off-farm activities and adoption of improved potato varieties at a 10 % probability level (p = 0.05) (Table 1). In addition to, this the assertion is supported by FGD and KII. From the adopters, about 78.51% were members of the cooperative. The results of chi-square analysis indicated that members of cooperatives had a significant relationship with adoption of improved potato varieties at a 1% significant level (p = 0.000). These households' participants in cooperative to have access of improved seed, credit, training, information and experience sharing among them. Thus, they encourage to adopting improved potato varieties. Concerning credit access, only 32.8% of households got credit access; similarly, 38.84% and 27.13% of the improved potato varieties adopters and non-adopters, respectively got credit access. The result of chi-square test (p = 0.049) showed that there was a significant associated between credit access and adoption of improved potato at 5% significant level. The study found that improved potato varieties adopters were higher among participants in demonstration (27.27%) than non-participants (16.27%). The results revealed that, there was a significant relationship between adoption of improved potato varieties and participant in demonstration at 5% significant level (p = 0.035).

Table 1. *Descriptive results of dummy independent variable.*

Variables	Total HH		Adopter		Non-adopter		X^2 test	P value
	N	(%)	N	(%)	N	(%)		
Sex HHH								
Female	23	9.20	9	7.44	14	10.85	0.87	0.351
Male	227	90.8	112	92.56	115	89.15.		

Variables	Total HH		Adopter		Non-adopter		X^2 test	P value
	N	(%)	N	(%)	N	(%)		
Participation of demonstration								
Yes	54	21.60	33	27.27	21	16.28	4.45	0.035**
No	196	78.40	88	72.73	108	83.72		
Credit access								
Yes	82	32.8	47	38.84	35	42.68	3.88	0.049**
No	168	67.20	74	61.11	94	55.05		
Cooperative membership								
Yes	153	61.21	95	78.51	58	44.96	29.59	0.000***
No	97	38.80	26	21.49	80	55.03		
Off-farm Participation								
Yes	129	51.60	70	57.85	59	45.74	3.66	0.05*
No	121	48.40	51	42.15	70	54.26		

Based on the survey findings, it was observed that the average educational attainment of individuals who adopted improved potato varieties was 6.61 years of schooling, whereas for non-adopters, was 4.82 years. The t-test analysis revealed a statistically significant mean difference at a 1% level of significance (p = 0.000). These results suggest that adopters tend to have a higher level of education compared to households with lower educational backgrounds. Consequently, it can be concluded that farmers who embrace improved potato varieties generally possess a higher educational level than those with a lower educational level. It was hypothesized that farmers who have more experience in potato production would possess better knowledge.

The size of a family is a crucial factor in determining the labor force available to a household, which in turn affects the likelihood of adopting improved potato varieties (as shown in Table 2). The t-test result indicated that there is a significant mean difference in household size between adopters and non-adopters of improved potato varieties, with a significance level of 1% (p = 0.0001). Farmers who adopted improved potato varieties, the distance of nearest market was 28.52 minutes, which is less than the average of 35.03 minutes for non-adopters. Therefore, the distance of nearest market had a significant mean difference between adopters and non-adopters of improved potato varieties at a 1% significance level (p = 0.0004) as shown in Table 2. This discovery is advantageous as it facilitates more convenient access to the nearest input market, which is essential for the adoption and effective use of enhanced agricultural inputs. The insights obtained from focus group discussions (FGD) and key informant interviews (KI) further corroborate this assertion, indicating that households located nearer to the market benefit from greater utilization of farm inputs and advanced agricultural techniques.

The average walking distance to a farmer's training center for households that have adopted improved potato varieties was found to be 28.04 minutes, while non-adopters had to walk for 39.14 minutes on average. This indicates that non-adopters had to travel a longer distance to access the farm training center compared to adopters. The t-test revealed a statistically significant disparity in the average walking time between adopters and non-adopters, with a significance level of 1% (p = 0.000).

Land is a vital resource for economic activities, particularly in rural and agricultural sectors. The size of farms plays a significant role in households' decisions to adopt new technologies. Those who adopted improved practices averaging 1.71 hectares, while non-adopters averaged 1.19 hectares of land owned. The results of the t-test revealed a statistically significant difference in land holding sizes between adopters and non-adopters at a 1% significance level (p = 0.000) Table 2. In the study area the mean livestock holding among the farmers was recorded at 3.20 Tropical Livestock Units (TLU). Within this sample, adopters exhibited a higher average of 3.39 TLU, whereas non-adopters had a lower average of 2.83 TLU, as presented in Table 2 a statistically significant difference at the 1% level (p = 0.000). Furthermore, farmers who maintained more frequent interactions with extension agents demonstrated a greater propensity to adopt new technologies compared to their counterparts with less frequent contact. Specifically, adopters experienced an average of 14.32 interactions with extension agents annually, in contrast to non-adopters, who averaged 8.08 interactions per year. Between the two groups regarding their engagement with extension agents statistically significant difference, with a probability

level of 1% (p = 0.000) confirmed the t-test analysis.

Table 2. Descriptive results of continuous independent variable.

Variable	Total HH (N = 250)		Adopter (n=121)		Non-adopter (n=129)		T-test	p-value
	Mean	SD	Mean	SD	Mean	SD		
Educat level of hhh	5.69	3.14	6.61	3.19	4.82	2.83	4.71	0.000***
Experience of hhh	25.35	11.83	25.53	11.3	25.17	12.36	0.23	0.811
Family size	4.05	1.59	4.54	1.72	3.60	1.31	4.38	0.000***
Distance to FTC	33.77	16.79	28.04	13.73	39.14	17.65	-5.52	0.000***
Dis.to nearest market	31.88	14.69	28.52	10.55	35.03	17.17	-3.61	0.000***
Land owned	1.44	0.58	1.71	0.57	1.19	0.47	7.81	0.000***
Livestock holding	3.20	1.31	3.39	1.29	2.83	1.22	4.75	0.000***
Frequency of extension. Contact	10.86	11.97	14.32	10.70	7.62	8.08	5.59	0.000***

*** Represents statistically significant difference at 1 % significant level.
Source: survey data, 2023

Adoption Status of Improved Potato Varieties

The farmers grow different types of both local and improved varieties in the study area. Farmers have been growing improved varieties since the 2022 production year as revealed by focus group discussions and key formats. The sampled households were almost producing potato through rain-fed. The smallholders in the study area have adopted three officially released varieties by the Ethiopian Institute of Agriculture Research (EIAR). These improved potato varieties were Belete, Jalene and Gudene. Whereas, from local varieties, Cercher, Asefo, Embamashe, and Eroga were grown. From the respondents (250) farmers, 121 (48.4%) used improved varieties whereas 129 (51.6%) did not use improved varieties showed the survey result. The outcome revealed that from the total adopters, 65 (53.72%) planted Gudene, which was the most widely adopted and marketable than other varieties, about 37 (30.58%) planted Belete and 19 (15.70%) planted Jalene varieties (Table 3).

In the Ezha District, participant farmers allocated 0.083 ha to1 ha of land for improved potato varieties. In the case of participants, they allocated different sizes of land for improved varieties based on their perception. Accordingly, Gudene has occupied about 38.46 ha, Belete 17.18 ha and Jalne 6.68 ha of land on average. Gudene was the first and most widely adopted variety, occupying more of land on average (Table 3). Because it is in high demand, sells at premium prices, and it has a longer shelf life than other improved varieties. Because of this situation in the area, the farmers used it as food security for a longer time than other varieties. In proportion of area assigned for enhanced potato varieties (intensity) among adopters' households was 55.01%, whereas an average of 44.99% was allocated for local varieties.

Table 3. Adoption status of improved potato variety in the study area.

Name of varieties	Number of farmers	Prcent	Area in hectare	Percent
Gudene	65	53.72	38.46	61.71
Belete	37	30.58	17.18	27.57
Jalene	19	15.7	6.68	10.71
Total	121	100	62.32	100

Source: Survey, 2023

3.2. Econometric Model Results

Factors Affecting Utilization of Improved Potato Varieties

The study utilized a probit regression model to analyze the factors that influence households' adoption of improved potato varieties. The findings, which are presented in Table 4, reveal the results of the model. The dependent variable in the probit model is the probability of adopting improved potato varieties. The model includes a total of thirteen variables, Out of all the independent variables, seven variables were found to significantly affect the adoption decisions of improved potato varieties. These variables include livestock

owned, land ownership, education status of the household head, membership in a potato seed producer cooperative, frequency of extension contact, distance to the nearest market, and distance to the nearest farmer training center.

The educational status of the household head has a significant and positive impact on the adoption of improved potato varieties, with a significance level of 10% (0.069). This could be attributed to the fact that more educated farmers have better access to information and more aware of new technologies, leading to a higher likelihood of adopting improved potato varieties. These results are consistent with the studies conducted by [18-20]. However, the results of the study contradict by [22]. The study findings also demonstrate a strong and statistically significant correlation among the size of land holdings and the likelihood of farmers adopting improved potato varieties. This association is significant at 1% level (0.008). This result suggest that farmers with higher land holdings are more inclined to adopt improved potato varieties compared to those with smaller land holdings. These findings are consistent with earlier studies conducted by [21, 22, 6].

The outcome suggests that with each additional tropical livestock unit, households are 5.2% more inclined to embrace enhanced potato varieties, could be recognized to the fact that households with a larger number of livestock experience a reduced capital constraint when it comes to purchasing agricultural inputs, and they besides exhibit a more risk-taking behavior in utilizing technologies such as improved varieties. Additionally, organic fertilizer obtained from livestock is utilized for crop cultivation this is leading to minimize the cost of inorganic fertilizer. These findings align with the research conducted by [23-25]. The extension agent plays a vital role in promoting innovation by facilitating the exchange of ideas, experiences, resource information, skills, and knowledge among farmers, thereby aiding in their livelihood improvement. The presence of this variable had a positive and significant impact on the adoption of improved potato varieties with a probability level of 10% (0.079). This suggests that farmers who have more contact with extension agents are more likely to adopt this technology compared to those with limited contact. Furthermore, farmers who maintain frequent communication with extension agents exhibit a higher likelihood of embracing improved potato varieties. These findings are consistent with the studies conducted by [26, 27].

Membership in a cooperative has been found to have a positive and significant impact on the adoption of improved potato varieties, with a significance level of 10% (p = 0.08). The involvement of farmers in a cooperative is crucial for accessing and disseminating new information and technologies. This is likely membership in social organizations increases farmers' awareness of technologies, as they have easy access to information and can establish strong networks that facilitate access to credit and essential agricultural inputs such as improved seeds. Interestingly, this finding contradict the results of previous studies conducted by [28-30] furthermore, the distance to a farmer's training center, measured in minutes of walking, was found to negatively affect the adoption of improved potato varieties. This variable was statistically significant at a 5% level (P = 0.022). The training center serves as a vital source of information and a platform for demonstrating and disseminating technologies to farmers. This finding aligns with the study conducted by [31].

Moreover, the distance to the closest market and the adoption of enhanced potato varieties have a negative relationship at a probability level of 5% (0.02). This suggests that when markets are located far from farmers' destinations, the probability of using improved potato varieties decreases. When farmers are closer to the market, they can take advantage of potato technology by accessing market information, purchasing agricultural inputs, and selling their products with lower transaction costs. The result was in consistent with the findings of [32, 33].

Table 4. *Determinates of adoption improved potato varieties probit model result.*

Variable	Coefficient	Std. error	Marginal effect (dy/dx)
Sex of household head	-0.471	0.343	-0.184
Education status of HHH	0.056*	0.034	0.022
Experience	0.005	0.008	0.002
Family size	0.069	0.065	0.027
Distance to FTC	-0.014**	0.006	-0.005
Distance to nearest market	-0.015**	0.006	-0.006
Land size	0.547***	0.206	0.218
Tropical livestock	0.131*	0.073	0.052
Extension contact	0.021*	0.012	0.008
Credit. access	-0.234	0.258	-0.092
Off far participation	-0.085	0.224	-0.034
Cooperative member	0.384*	0.219	0.151
Demonstration participation	-0.096	0.237	-0.038
Constant	-0.943	0.553	
LR ch^2	92.58		
Prob > chi2	0.0000		
Pseudo R2	0.2673		

4. Conclusions and Recommendation

The adoption of agricultural technology plays a crucial role in enhancing agricultural productivity, attaining food self-sufficiency, alleviating poverty, and mitigating land degradation. This research aims to investigate the factors that influencing the decision-making process and the extent to which farmer households adopt improved potato varieties, based on a sample of 250 households. The Probit model was employed to analyze the determinants of farmers' decisions to adopt these improved potato varieties. The study's findings indicate that the rate and intensity of adoption of enhanced potato varieties was 48.4% and 55.01% respectively in the research area. The probit model result reveal that educational attainment, ownership of livestock, possession of land, cooperative membership, and frequency of extension contacts play positive and crucial roles in potato production, greatly influencing farmers' decision to adopt improved potato varieties. Nevertheless, the distance of market and farmers training center were decreases the degree of adoption. This can be attributed to limited knowledge about potato technology and exposure to input market participation, and skills to implement new agricultural technologies, such as improved potato varieties. Thus, it is imperative for the relevant organization to focus on incentivizing individuals who have already adopted improved potato varieties to continue doing while, ensuring that non-adopters have access to these improved varieties in order to encourage their in adoption.

Abbreviations

EIAR	Ethiopia Institute of Agriculture Research
FGDs	Focus group Discussions
KIIs	Key Format Interviews
Hhh	House Hold Head
IPVS	Improve Potato Varieties
TLU	Tropical Livestock Unit

Author Contributions

Amsalech Yirga is the sole author. The author read and approved the final manuscript.

Acknowledgments

The author acknowledged the Ethiopian Institute of Agricultural Research (EIAR) for funding the project. Furthermore, the author declared the Chiro National Sorghum Training and Research Centre for providing all necessary inputs.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Yigezu, Y. A., C. Y.Tizale And A. Aw-Hassan. 2015. Modeling farmers' adoption decisions of multiple crop technologies The case of barley and potatoes in Ethiopia. 1008: 2016-80 241.

[2] Faostat, F. A. O. 2019. Food and Agriculture Organization of the United Nations-Statistic Division https://www. Fao. Org/faost at/en/# data. QC.

[3] Seifu, F., E.Betewulign. 2017. Evaluation of released and local potato (*Solanum tuberosum L.*) Varieties for growth performance. Journal of Agronomy. Asian Network for Scientific Information 16(1): 40-44.

[4] Burke, J. J. 2017. Growing the potato crop Vita equity house upper Ormond quay Dublin, *7*.

[5] Singh, B. P. And Rana, R. K. 2015. Potato for food and nutritional security in India. Indian Council of Agricutural Research.

[6] Ketema, M., D. Kebede, N. Dechassa and F.Hundessa. 2016. Determinants of adoption of potato production technology package by smallholder farmers: evidences from Eastern Ethiopia. Review of Agricultural and Applied Economics *(RAAE)*. 19(395-2016-24364): 61-68.

[7] Nigussie, D., K. Mengistu, D. Haile, K.Wole, A.Tamiru, B. Olkaba, A. Solomon and T.Samuel. 2012 Participatory Rural Appraisal (PRA) for Gurawa. Haramaya, Kombolcha, and Habro Districts (Woredas) of East and West Hararghe Zones in Ethiopia.

[8] Solomon and T.Samuel. 2012. Adoption Rate and Trends in Adoption of Conservation Agriculture in Ethiopia. Oxfam.

[9] Anis, G., H. Hassa, A. El-Sherif. H.Saneoka and A. EL Sabagh. 2019.Evaluation of new promising rice hybrid and its parental lines for floral, agronomic traits and genetic purity assessment. *Pak. J. Agric. Sci* 56: 567-576.

[10] Chakraborty, S., A. V. Tiedemann. and P. S.Teng. 2000. Climate change potential impact on plant diseases *Environmental pollution*. Elsevier 108(3): 317-326.

[11] Song, H. H., H. S. Lee, J. H. Jeong, H.S.Park and C. Lee, 2008. Diversity in beauvericin and enniatins H, I, and MK1688 by Fusarium oxysporum isolated from potato. *International journal of food microbiology*. Elsevier 122(3): 296-301.

[12] Thiele, G. 1999. Informal potato seed systems in the Andes Why are they important and what should we do with them?', World development. Elsevier 27(1): 83-99.

[13] Woldegiorgis, G. 2013. Potato variety development strategies and methodologies in Ethiopia *S*eed potato tuber production and dissemination: experiences, challenges and prospects.

[14] Gebru, H., A. Mohammed, N. Dechassa and D. Belew 2017. Assessment of production practices of smallholder potato (Solanum tuberosum L.) Ethiopia Agriculture and Food Security. Biomed Central, 6(1): 1-11.

[15] Greene, W. 2004. 'Convenient estimators for the panel probit model Further results *Empirical Economics*. Springer 29(1): 21-47.

[16] Williams, R. 2016. Understanding and interpreting generalized ordered logit models The Journal of Mathematical Sociology. Taylor and Francis 40(1): 7-20.

[17] Agwu, N. M., E.E.Nwankwo And C.I.Anyanwu. 2014. Determinants of agricultural labour participation among youths in Abia State Nigeria *International Journal of Food and Agricultural Economics (IJFAEC)* 2(1128-2016-92018): 157-164.

[18] Sebopetji, T.O., And A. Belete. 2009. An application of probit analysis to factors affecting small-scale farmers decision to take credit: a case study of the Greater Letaba Local Municipality in South Africa. African journal of agricultural research. Academic Journals 4(8): 718-723.

[19] Zeru, M. 2018. Adoption of improved potato varieties by smallholder farmers: the case of chilga District, north gonder zone, amhara region, Ethiopia.M.Sc Thesis. University of Haramaya, Ethiopia. 68 p.

[20] Bati, B. And M. Aman 2017. Determinants of adoption of improved potato varieties by smallholder farmers in shashemene district, west arsi zone, oromia national regional state, Ethiopia. M.Sc Thesis. University of Haramaya, Ethiopia. 78p.

[21] Bagheri, A. 2015.Determinants of adoption of mini-tuber seed Potato: A case in Ardabil Province of Iran International Journal of Agricultural Management and Development *(IJAMAD)*, 5(1047-2017-1625): 263-270.

[22] Tesfaye, A., G.Woldegiorgis, W. Kaguongo, B. Lemaga and D. Nigussie. 2013. Adoption and impact of potato production technologies in Oromiya and Amhara Regions.'

[23] Yirga, C. And D.Alemu, 2016. Adoption of crop technologies among Smallholder Farmers in Ethiopia Implications for Research and Development. Eth. J. Agric. Sci. EIAR 50th Year Jubilee Anniversary Special, (1-16).

[24] Teshome, B. 2018. Determinants of Adoption of Improved Jalenea Potato Variety.M.Sc Thesis University, Ethiopia. 65 p.

[25] Tsion, T. E. 2022. 'Impact of Improved Potato Varieties Adoption on Household Resilience to Food Insecurity.M.Sc Thesis. University Jimma, Ethiopia. 80 p.

[26] Teklemariam, T. M. 2014. The impact of International Potato Center's nutrition project on smallholder farmers' income and adoption of improved potato varieties.M.Sc Thesis.

[27] Wabwile, V. K., Ingasia, O. A. And Langat, J. K. 2016. *Effect of the improved sweet potato varieties on household food security: empirical evidence from Kenya*. (No. 310-2016-5492).

[28] Ahmed, M. H. 2015. Adoption of multiple agricultural technologies in maize production of the Central Rift Valley of Ethiopia. *Studies in Agricultural Economics* 117(1316-2016-102848): 162-168.

[29] Tufa, A. And T.Tefera. 2016. Determinants of improved barley adoption intensity International journal of agricultural economics. Science Publishing Group 1(3): 78-83.

[30] Ketema, M. And D. Kebede. 2017. Adoption intensity of inorganic fertilizers in maize production: empirical evidence from smallholder farmers in eastern Ethiopia *Journal of Agricultural Science* 9(5): 124-132.

[31] Sileshi, M., R. Kadigi, K. Mutabazi and S. Sieber. 2019. Determinants for adoption of physical soil and water conservation measures by smallholder farmers in Ethiopia. *International soil and water conservation research*. Elsevier 7(4): 354-361.

[32] Abreham, G. And Y.Sete. 2019. Adoption of Improved Potato VarietyThe Case of Dabatworeda Ethiopia. *Indian Journal of Economics and Development* 7(6): 123-137.

[33] Feleke, A., Regasa, G. And Muche, M. 2019. 'Factors influencing adoption of improved potato (Belete) variety: evidence from Ethiopian smallholder farmers'. Estonian Academic Agricultural Society.