Factors Influencing Use of Improved Postharvest Storage Technologies among Small Scale Maize Farmers: a Case of Kilolo district, Tanzania

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Abstract

The study assessed factors influencing the use of improved postharvest storage technologies among small-scale maize farmers in Kilolo District, Tanzania. Data were collected from 260 maize farmers by using the questionnaire, Focus Group Discussions (FGD) and through personal observations. Descriptive statistics such as means, frequencies, percentage and a binary logistic regression model were computed. Formal education, access to credit, access to extension services, membership in farmer groups and distance from home to the market place were found to be the farmers' determinants of the use of improved postharvest storage technologies. The study recommends that extension agents should increase their contact with farmers, the government should look for possibilities to subsidize improved postharvest storage technologies with a high initial cost in order to enhance their use. Additionally, the Kilolo District Council and other development partners should encourage farmers to form groups for community food storage such as cereal banks and warehouse receipts system.

Keywords: Factors, postharvest storage technologies, small scale farmers, Kilolo District.

Introduction

Agriculture is the major economic activity for the majority of Tanzanians, employing about 75% of the labour force (United Republic of Tanzania-URT, 2016). The crop sub-sector, especially cereals have been identified and prioritized as a major source of food in Tanzania. More than half of cultivated land in Tanzania is allocated to cereal crop production (FAOSTAT, 2014). Of all staple and cash crops cultivated in Tanzania, maize is the major staple crop (USAID, 2010). For instance, it takes about 60% of cultivated food crops (URT, 2016). Maize production in Tanzania is dominated by small scale farmers who produce about 85% of total production (FAOSTAT, 2014). Maize is grown almost in all regions of Tanzania as a food crop; however, the Southern zone regions (Iringa, Rukwa, Ruvuma, Njombe, and Mbeya) are the largest maize producers in the country, accounting for over 45% of the total annual maize production (USAID, 2010). Furthermore, maize accounts for 31% of the total food production, constitutes more than 75% of cereal consumption and contributes about 34-36% of total average daily calorie intake in Tanzania (Zorya *et al.,* 2011).

Studies by the Alliance for Green Revolution Africa (AGRA) (2013) and FAOSTAT (2014), show that overall maize production in Tanzania has grown at an annual rate of 4.6% over the last 25 years. Furthermore, the total area under maize production has increased from 1,630 hectares in the 1990s to over 4,000 hectares in the 2010s (Barreiro, 2012). However, these developments have not resulted in ensuring food security and increasing income to small-scale farmers in Tanzania. For example, the Household Budgetary Survey of 2012 estimated that poverty and extreme poverty levels were at 28.2 and 9.7% respectively. Although they are far apart, both measures share two common implications: poverty levels are unacceptably high and the target of reducing poverty to 18% by 2015 as was envisaged in the Millennium Development Goals (MDGs) has not been realized (Barreiro, 2012). These two are very much linked with food shortages and food insecurity in general.

The problem of food shortage in developing countries could be overcome through the use of a variety of modern agricultural technologies (URT, 2012). Experience shows that the Tanzanian government efforts to improve the agriculture sector have resulted in increased food crop production including maize. Despite the increased maize production, periodic food shortages have been experienced. One of the reasons is that Post Harvest Losses (PHL) has remained high. The term PHL refer to measurable quantitative and qualitative food loss in the postharvest system (de Lucia and Assenato, 1994). PHL losses which occur between harvest and the moment of human consumption include on-farm losses, such as when the grain is threshed, winnowed and dried as well as losses that occur during transportation, storage and processing (World Bank, 2011). For many households, such losses threaten food, nutrition, and income security.

In Tanzania, PHL lies between 30-40% of the total annual crop production (URT, 2013), while in Kilolo District PHL in 2012 was between 25–30% and in 2015 was between 22–28% (RUDI, 2016). Poor post-harvest handling practices, poor infrastructure, weather variability, biotic factors such as insects, bacteria, pathogens, viruses, and fungi, often aggravate such losses that result in reducing the quality and quantity of the products (Shiferaw *et al.,* 2013). This impedes efforts to reduce poverty and improve food security.

Iringa is one of the biggest maize producers in the Southern zone of Tanzania. In Kilolo district, there are about 81,225 small scale maize producers and a total area of about 64,980 hectares are under maize production (Kilolo District Council-KDC, 2018). Despite the high production potential, farmers in the district have not been able to get out of poverty trap and they are still prone to food insecurity (URT, 2012). For instance, 33.6% of the population lives below the poverty line and the number of poor people per square kilometer is seven (Kuwawenaruwa *et al.,* 2015). In order to assure availability of food throughout the year, it is important for the farmers to have access and know how to appropriately use improved storage technologies. This will help to reduce PHL resulting from storage pests and pathogens and eventually lead to food availability and quality products for marketing during high demands (Kimenju *et al.,* 2009; Tefera *et al.,* 2011).

For years various initiatives have been taken by the government and partner institutions to improve crop storage in order to reduce PHL in Kilolo district. For example, in 2014 One Acre Fund programme implemented a two years project which targeted 200 farmers (Kilolo District Council, 2018) . The objective of the project was to supply inputs recommended for an acre for the target maize farmers and promoted the use of improved storage technologies. Similarly, Rural and Urban Development Initiative (RUDI), in the same year implemented a three years project which targeted 24 farmer groups. The main objective of the project was to introduce a warehouse receipts system and establish a demonstration plot for each group on the General Agricultural Practices (GAPs) for maize production. Furthermore, the Clinton Foundation in 2016 trained 30 groups of farmers on GAP, improved postharvest storage technologies and demonstrated the use of Purdue Improved Crop Storage (PICS), Metal Silo technologies for each group (ibid).

These initiatives made by the local government and partners were founded on the understanding that efforts to improve maize production and bring about the desired impacts should go hand in hand with building farmers' capacities on use of technologies and improving infrastructure to reduce PHL. Despite the efforts taken by different stakeholders to promote the use of improved postharvest storage technologies in Kilolo district, experience shows that the extent to which farmers are using improved storage technologies is still low and postharvest losses are still witnessed (22-28%) (Kilolo District Council, 2018). This study, therefore, was conducted to identify postharvest storage technologies commonly used by maize farmers, determine farmers' knowledge on the use of improved postharvest storage technologies, and to identify factors that determine farmers' use of improved postharvest storage technologies in the study area. Although postharvest losses occur during different processes from farm to fork, including, threshing/shelling, drying, storage and transportation, this study focused on postharvest losses of maize grains during storage after harvest, specifically the use of improved storage technologies.

Materials and Methods

Study area

This study was conducted in Kilolo District (Fig. 1), one of the four districts in Iringa Region, Tanzania. The district is located 7° and 8.3° South of equator and 34° and 37° East of Greenwich. The district lies on altitude of 1200 m - 2700 m above sea level (KDC, 2016). The District was selected first, due to its high potential for producing maize, as statistics show that the current maize production level is on an average at 2.5 tons/ha but postharvest loses stand at 22-28% (RUDI, 2016), and secondly because of existence of initiatives promoting the use of improved postharvest technologies.

Sampling procedure and sample size

The study adopted a multi-stage sampling technique as suggested by Verstraete and Meirvenne (2008). First, the district was purposively selected based on the reasons stated above. Secondly, Simple Randomly Sampling (rotary technique) was employed to select study villages. Thirdly, two hundred and sixty (260) respondents were randomly selected from the list of small scale maize farmers to form a study sample. Twelve key informants: One District Agriculture Agriculture, Irrigation and Cooperatives Officer (DAICO), three Subject Matter Specialists (SMS), four Extension Officers and four Ward Executive Officers (WEO) were selected for in-depth interviews and Focus Group Discussions.

Instrumentation and Data Collection Procedures

Data were collected in face-to-face interviews with respondents by using a semi-structured questionnaire and interview schedule which were all pre-tested before actual data collection for improvement. The survey instrument was designed specifically for farmers who are producing maize and using postharvest storage technologies to store their farm produces. In order to get detailed information, key informant interviews, as well as focus group discussions (FGD), were also conducted. These provided, among other things, information on factors influencing the use of improved postharvest storage technologies.

Data were collected in two phases from January to February 2018. Phase one involved reconnaissance survey to the study area while the second phase involved administering the questionnaire. During the reconnaissance survey, apart from the researchers' familiarization within the study area, several consultations and discussions with different people (including area leaders) were made as well as the identification of the study villages. Drawing the sample was also made. This was followed by the actual primary data collection through face-to-face interviews.

Data Analysis

The collected quantitative data were coded, edited and analyzed using the Statistical Package for Social Sciences (SPSS) version 16 Computer software. Descriptive statistics such as mean, standard deviation, frequency and percentages were computed. To identify determinants of the use of improved postharvest storage technologies among respondents, a binary logistic model was estimated using a Statistical Package for Social Sciences (SPSS) computer software. In total 10 independent variables were used for estimation as explained hereunder. These variables were selected on the basis of theoretical explanation and the results of various empirical studies.

The logistic model was as follows:

$$Logit(Y)=log(\pi/1-\pi i)=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+ \ldots\ldots\ldots\ldots\beta_{10}X_{10}$$

Where Y is a binary response variable, Y=1 if the trait is present in observation i and X= (x_1, x_2, x_3, x_4 and x_{10}) is a set of independent or

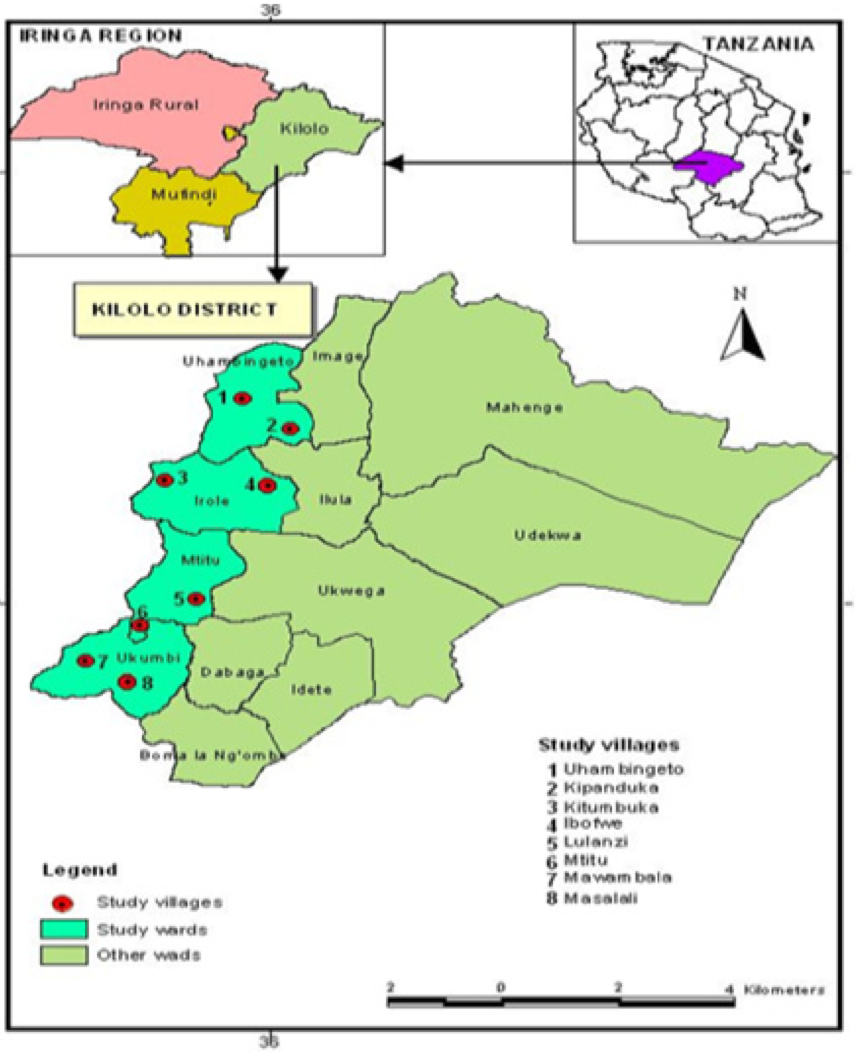

Figure 1: Map showing the study area

explanatory variables whereby
X1 = acquired formal education,
X2 = Access to credit,
X3 = access to extension services,
X4 = Farm size
X5 = Off farm income
X6 = Number of bags harvested,
X7 = maize variety used,
X8 = participation in training,
X9 = membership in farmers group and
X10 = distance from house to market place.

The dependent variable which was used with logit model is the use of improved postharvest storage technologies (meant that either a respondent is using one or more technologies were treated as they were using improved postharvest storage technologies) value of 1 for using improved postharvest storage technologies and value of 0 for not using improved postharvest storage technologies. The various goodness of fit measures were checked and validated which indicate that the model fits the data well. The likelihood ratio test statistics exceeds the Chi-square critical value at less than 1% probability level ($\rho \leq 0.002$). This implies that the hypothesis that all coefficients except the intercept is zero, was rejected.

Qualitative data were analyzed by the Content Analysis approach (Mayring, 2014).

In this technique, all elements of data set were examined to clarify concepts and constructs as well as the deconstruction of the textual data into manageable categories, patterns, themes and relationships.

Results and Discussion

Demographic characteristics of respondents

Findings (Table 1) indicate that most of the respondents (82.7%) were married, 76.9% were from male-headed households. About 87.6% were aged between 26-55 years, which is a productive age. Most of the respondents (66.5%) had primary school education, 13.1% had secondary education while only a small proportion (1.5%) attended post-secondary education. Further, the findings show that the majority (73.5%) cultivated one to four acres of land, which is an indication that the agricultural sector in the study area is generally dominated by small scale farmers. Similar findings reported by Mrutu *et al.* (2014) indicate that the agriculture sector in Tanzania is dominated by small scale farmers who cultivate less than five acres.

About 60% of all the sampled households had more than six individuals, which is slightly higher than the average household size in Tanzania. According to the National Bureau of Statistics, the average household size for Tanzania is five individuals (United republic of Tanzania - URT, 2012). More than three quarters (79.7%) of respondents earned less than 600,000/= Tanzanian shillings (Tshs) while only 6.5% earned above Tshs 800,000/= annually. Over three quarters (85.8%) grow maize for both consumption and sale. This means that maize is required to be stored in order to maintain its quality and quantity for consumption and sale. It is well established that efficient storage of agricultural produces is critical to maintain product quality while stored and when enters into the market (Tefera *et al.,* 2011).

Postharvest storage technologies commonly used by respondents

Findings in Fig. 2 show the common postharvest storage technologies used by small scale maize farmers in the study area. These include polythene bags (65.4%), storage chemicals (32.3%), traditional granaries (24.7%), PICS (18.2%), improved granaries (4.1%) and Metal Silo (2.2%). Generally, most of the respondents were using traditional storage technologies. The FGDs revealed that traditional storage technologies are poor in maintaining the quality and quantity of stored products as demonstrated below by one of the FGD participant in Kilimbwa village.

"We use traditional storage technologies to store our maize but they are let us down as most of the time our products are not vey safe" (FGD in Kilimbwa village, 20th July, 2018)

This finding is similar to what was reported by Gitonga *et al.* (2015) that most of the African communities still rely on unimproved storage technologies for food storage because are simple and inexpensive to construct. The

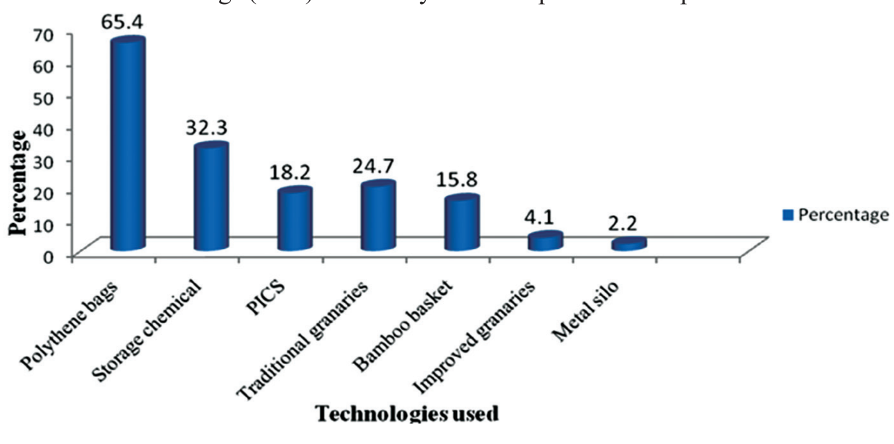

Figure 2: Postharvest storage technologies commonly used by respondents (N=260) (Multiple response)

Table 1: Respondents' socio-economic characteristics

Variable	N	%
Sex of household head		
Male	200	76.9
Female	60	23.1
Age of respondents		
26-35	57	21.9
36-45	114	43.8
46-55	57	21.9
>55	32	12.4
Education level		
Non-formal	49	18.8
Completed primary school	173	66.5
Completed secondary school	34	13.1
Post-secondary education	4	1.5
Marital status		
Single	23	8.8
Married	215	82.7
Separated	8	3.1
Divorced	8	3.1
Widow	6	2.3
Household size		
1-3	39	15.0
4-6	70	26.9
>6	151	58.1
The total area under cultivation in acres		
1-4	191	73.5
5-8	62	23.8
Above 8	7	2.7
Household income level Tshs (annual)		
<200 000	9	3.5
210 000 - 400 000	165	63.5
410 000 - 600 000	37	14.0
610 000 - 800 000	30	11.5
>800000	17	6.5
Household head access to credit		
Have access to credit	73	28.2
Have no access to credit	187	71.8
Purposes of growing maize		
Consumption	33	12.7
Sale	4	1.5
Consumption and sale	223	85.8

same authors pointed out that unimproved or traditional storage systems lead to substantial post-harvest losses. Also, through FGDs it was revealed that farmers who were using traditional storage technologies sold their products soon after harvesting. The FGDs further revealed that farmers remained with only a little amount of food and little seeds for the next season. The findings of this study are comparable to those of Gitonga *et al.* (2015) and Abass *et al.* (2014) who reported that traditional storage practices in African countries cannot guarantee protection against major storage pests of staple food crops like maize.

It is noted that 32.3% of respondents used storage chemicals. This proportion was higher compared to the improved postharvest storage technologies. This could be due to the fact that the cost of storage chemicals was perceived by respondents as relatively less and mostly available than other technologies in their areas. These findings are similar to those of ANSAF (2016) which found that large proportion of farmers (67.7%) in Dodoma and Manyara districts of Tanzania, used storage chemicals and knew that insecticides can protect their stored maize while only 28.3% used other improved storage technologies such as storage chemicals, hermetic bags and improved granaries.

Determinants of the use of improved postharvest storage technologies among respondents

Among the 10 variables included in the model, five were found to be statistically significant determinants of farmers' use of improved postharvest storage technologies at 5% level (Table 2) and are discussed as follows:

Acquired formal education

The results indicate that the respondents' attendance to formal education increased the chance of using improved postharvest storage technologies by 2.119 times when other factors are kept constant ($\rho \leq 0.042$). This means that when the respondents acquire formal education they are likely to use the improved storage technologies as compared to those without formal education.

This could be because they get information from various sources such as books, magazine and leaflets as they can read and write and have a chance of memorizing information concerned with improved storage technologies. The findings are similar with Maonga *et al.* (2013) in the adoption of Metal Silo in Malawi who found that formal education had a consistently positive relationship to the adoption of small Metal Silo technology. Similarly, Adegbola *et al.* (2010) in Benin found that the respondents who had formal education preferred to use improved postharvest storage technologies compared to their counterparts who did not have it. Similarly, Uaiene *et al.* (2009) in Mozambique found that completion of at least lower primary school implies a much higher propensity to adopt new technology than lower or zero levels of education.

Access to credit

Findings show that access to credit increases the odds of using improved postharvest storage technologies by 1.343 times when other factors are kept constant ($\rho \leq 0.027$). This means that the respondents in the study area who had access to credit were more likely to use the improved postharvest storage technologies and other improved agricultural technologies as compared to their counterparts with no access to credit. The findings of this study are similar to those of Venance *et al.* (2016), Letaa *et al.* (2014) and Akudugu *et al.* (2012) who found that farmers who had access to formal credit were likely to adopt the improved technologies. The credit helps farmers to have the means to purchase agricultural inputs that facilitate a farmer to adopt new technologies. As attested by Okurut *et al.* (2004), credit is an important instrument for improving the welfare of the poor directly through consumption smoothening that reduces their vulnerability to short-term income. It also enhances productive capacity of the poor through financing investment in their human and physical capital. In the study area, only 28.2% of respondents had access to credit the main limiting factor being lack of valuable assets that could be used as collateral for loan security as usually demanded by the creditors.

Access to extension services

Access to agricultural extension messages has a positive influence on technology uptake by farmers. Findings show that access to extension services in the study area increased the farmers' chances to use improved postharvest storage technologies by 3.086 times when other factors are kept constant ($\rho \leq 0.031$). This means that respondents that have regular contact with extension agents are more likely to use improved storage and other improved agricultural technologies than their fellow counterparts who have no regular contact with extension agents. These findings are similar to those of Uaiene *et al.* (2009) in Mozambique who found that contact with extension agents had a positive effect on uptake of Metal Silos based on the innovation-diffusion theory. Since extension agents have two main roles that are educational and communication, it means that access to extension services enable access to information. In addition, Maonga *et al.* (2013) who conducted a study on the influence of extension services on Metal Silos adoption found that the probability of adopting small Metal Silo technology was 44.5% higher for smallholder farmers with access to agricultural extension services than those without access. Barungi *et al.* (2013) found that the probability of adopting Napier grass in Uganda was 25.6% higher for farmers with access to extension services than for those without access to extension services. This implies that extension agents should increase their contact with farmers in order to enhance farmer's uptake of recommended technologies including improved postharvest storage technologies.

Membership in farmers' organization

Findings show that membership in farmer group/organization increased farmers' use of improved postharvest storage technologies by 2.229 times when other factors are kept constant ($\rho \leq 0.016$). This implies that farmers in the study area who are members of groups like self-help groups, VICOBA, SACCOS and AMCOS are more likely to become users of improved storage and other improved production technologies than their counterparts' nonmembers. Probably farmers' groups provide social capital that enables access to credit that facilitate technologies adoption and use. Also maybe membership in farmers groups enabled farmers to access a platform to discuss issues concerning the use of improved storage technologies and associated benefits. The findings are congruent with those of Wekesa *et al.* (2003) and Owach *et al.* (2017) who found that membership in an organization, such as farmer association, could lead to better access of information related to the adoption of improved storage systems through training, discussion and sharing of experiences.

Distance from home of respondents to the market place

Distance from the home of respondents to the market place was found to have a significant negative association with the use of improved storage technologies. It is indicated in Table 2 that a unit increase in distance to the marketplace leads to a decrease in the chance to use improved storage technologies by 0.534 times at $p<0.05$ when other factors are kept constant. The possible reason could be that respondents who are closer to the market place are more exposed to some of the information about storage technologies such as the use of PICS and also they easily access the technologies. Long-distance to the market place which is atypical of the situation in the study area may further limit the use of improved technologies. This result is consistent with those of Adegbola *et al.* (2010) and Idrissa *et al.* (2012) who in their studies found that there was an association between the distance to the market place and adoption of modern technology. On the other hand, farmers that are close to sources of improved technologies take advantage of their closeness and tend to adopt the innovations compared to those who stay far away from the sources of the technologies. Poor road networks in the study area coupled with difficult terrain make movement difficult that inhibits communication and accessibility of farmers to technologies such as PICS and Metal Silos.

Conclusions and Recommendations

Acquired formal education, access to credit, extension services distance from home to market and membership in farmers groups are the critical factors influencing the use of improved postharvest storage technologies among small scale maize farmers in the study area. In addition, the high initial cost of technologies, low level of knowledge on how to use them among small-scale maize and low maize storage technologies. Similarly, farmers should be imparted with knowledge and skills on how to use these technologies. This can be achieved through mass media and group group-based extension approaches as well as building farmers' organizational capacities.

Table 2: Results for logistic regression analysis

Variable	Coefficient	S.E	Wald	df	ρ-value	Exponent (β)	95.0% C.I for EXP(B)	
							Lower	Upper
Acquired formal education	0.751	0.375	4.124	1	0.042*	2.119	1.026	4.160
Access to credit	0.295	0.561	1.865	1	0.027*	1.343	1.809	3.276
Access to extension services	1.127	1.328	7.990	1	0.031*	3.086	1.208	4.752
Farm size	1.073	2.001	12.951	1	0.110	2.924	2.050	8.404
Off farm income	1.140	1.339	2.412	1	0.058	3.127	2.788	12.673
Number bags harvested	-2.833	0.320	6.806	1	0.109	0.059	0. 032	1.413
Variety	-1.528	1.313	2.723	1	0.092	0.217	0.112	2.037
Training	1.576	0.438	4.642	1	0.063	4.835	3.725	16.274
Membership in group	0.802	0.296	7.397	1	0.016*	2.229	1.283	3.798
Distance from market place	-0.627	0.449	1.947	1	0.033*	0.534	0.219	1.517
Constant	-1.334	1.585	1.327	1	0.567	0.261		
Model chi-square value	42.293							
Log-likelihood	-260.003							
Prob>Chi^2	0.002							
Pseudo R^2	0.6152							

returns from the maize enterprise were the main reasons for the low use of improved storage technologies such as PICS, Metal Silos and Improved Granaries. The study recommends that the government continue investing in formal education, improve market infrastructures and look into the possibilities of subsidizing improved postharvest storage technologies such as Metal Silo, improved granaries and PICS. In addition, agricultural extension agents should increase their contacts with farmers and educate them on the importance of the use of improved

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