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FACTORS OF ADOPTION OF MAIZE POST HARVEST TECHNOLOGIES AMONG FARMER COOPERATIVE MEMBERS, KIREHE DISTRICT, RWANDA

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Abstract

This study was conducted to find out factors that influence adoption of maize postharvest technologies by maize cooperative members in Kirehe District, Rwanda. Semi-structured questionnaire and Key Informant Interview were used to collect data from 385 respondents selected randomly. Majority of farmers were mature, married, with less education, land lords, primarily involved in farming for food and market, had limited training and coaching, had good farming experience, and acquired an average number of 3 other assets. Farmers' access to electricity was very limited with a percentage of 10.7%. The average farm distance from the road was 361.5 meters. Maize was mainly sold through collection centers. It was revealed that majority of farmers are major adopters of cemented drying ground (77.1%), mechanical shelling machine (90.1%), mechanical winnowing machine (45%) and concrete silos (96.8%). Electrical shelling machine, electrical winnowing machine, metallic silos were not adopted. It was found that that there is significant influence of personal factors in terms of age on electrical shelling machine, and on sieve (b=-.360, P=.023; b=.68, P=006**); education on cemented drying ground, drying shade, sheeting, mechanical shelling machine, shelling with hands, house floor sacks (b=2.38, P=005**; b=-1.532, P=.037*; b=-.813, P=.042*; b=1.73, P=.013*; b=-.848, b=.018*; b=1.07, P=.005**; b=-.86, P=.007**); size of family on shelling with hands (b=.952, P=.010**); farming experience* *on winnowing machines and sieves for winnow, number of asset on concrete silos. Institutional factor, access to information influences adoption of electrical and mechanical shelling machine.*

Keywords: Adoption, Post-harvest, Technology, Farmer Cooperative

INTRODUCTION

Postharvest technologies are very important in proper handling of food products right from the farm to the consumer. For maize, they include drying, shelling, winnowing, processing, and storage technologies. Adoption of these technologies does not only reduce food losses but also exert a certain effect on food security (Kitinoja, 2015).

Globally, one third of food to be consumed by humans gets lost and wasted throughout food supply chain, just from the farm down to the final household consumer. In industrialized countries, significant food loss happen early in the food supply chain, whereas in developing countries food is mostly lost throughout the early and middle stages of the food supply chain (FAO, 2011).

In several developing countries, 30% of harvested grain is lost due to inadequate postharvest handling and storage (Hodges and Tanya, 2012). Low level of adoption of postharvest technologies has led to significant loss of maize and other food products in Bangladesh in 1990s and led to the reduction of national income, food insecurity and serious socio-economic problems like rise of prices on the market amongst many others (Mohammad, 2010). In sub-Saharan Africa, loss of food stuffs represents 23% as indicated by World Resource Institute (2013) in Global Knowledge Initiative (2014). 16336.

Food security, a situation where people, at all times, have physical and economic access to enough, safe and nourishing food cannot be attained if food loss is high due to low level of adoption of postharvest technologies FAO (2011). Trying to raise the level of adoption of postharvest technologies, scholars took interest in the factors that could influence it. According to Bokusheva et al (2012), the major determinants of adoption of postharvest technologies are personal factors such as (age, marital status, education, farming experience, quantity of produce, primary purpose of cultivation, farm income, asset ownership, etc). Nanyeenya (1997) in his studies on adoption added institutional factors like membership in a cooperative society, awareness and access to relevant information, infrastructure and transportation facilities, marketing systems, government policies and regulations.

Strategies for diminishing postharvest losses do not only address quantitative losses of food but also reduces quality losses such as loss of caloric and nutritive value, edibility and suitability (Kader, 2005). Postharvest technologies when adequately utilized in storage, drying, threshing, processing and conservation of grains and tubers reduces losses of food products then making food products more available to traders and consumers. Bokusheva et al (2012) reveal that in four Central American countries (El Salvador, Guatemala, Honduras and Nicaragua) adopters of postharvest technologies, particularly metallic silos have had considerably greater achievements in food security and welfare from 2005 to 2009.

To attain similar achievements in Rwanda, efforts in postharvest have been centered on staple crops mainly maize. The eastern province ranks the first in terms of quantities of maize grown nationwide, with Kirehe District ranking the first. Maize is the second crop in terms of share of land under cultivation with 22% after beans. From season A 2012 to season A 2013 maize cultivated area had increased by 24%, which led to 24% increase in productivity (Minagri, 2013). Though there has been significant increase in productivity, Kelly.et al (2002) reported that postharvest technologies were still mainly traditional and labor intensive. The Postharvest Handling and Storage Task Force (PHHS) of Ministry of Agriculture and Animal Resource (MINAGRI) implemented a set of activities to boost the level of adoption of technologies. This led to tremendous achievements, where the Postharvest Handling and Storage Taskforce (2013) reported losses of maize to have reduced from 32% to 9.24% for season A, in 2013 (Kayiranga, 2013). Much as significant reduction of food loss has been registered at national level, there is no documented evidence on what has been the level of adoption and personal and institutional factors responsible for this adoption.

METHODOLOGY

The study triangulated the research designs by employing a mixed research design (quantitative and qualitative); utilizing correlational, descriptive, and cross-sectional research designs. Descriptive research design was appropriate for assessing the factors associated with the adoption and the level of adoption, while qualitative research design using key informant interview was used to explore the factors that influence the level of adoption. Correlational research design using statistical inference was most appropriate in establishing whether personal and institutional factors influence the adoption of technologies.

The study population was 5504 from 12 cooperative operating in Kirehe District, eastern province. Simple random sampling and purposive sampling techniques were used in this study to select a representative sample of 385. Simple random sampling was used to get a representative sample from the main population, whereas purposive sampling technique was used to select one farmer cooperative representative to make a total of 12 key informants.

Data collection was through two pre-tested and validated gathering tools namely semi-structured questionnaire and validated Key Informants Interview (KII). SPSS 20.0 Version software was used to analyze both descriptive such as mean, frequency counts, range and standard deviation; and inferential statistics of which; simple linear regression. Level of significance alpha was set at 0.05 upon which the null hypotheses were tested for significance.

RESULTS AND DISCUSSION

Socio-demographic information

The personal factors of sampled farmers include the age, gender, marital status, education attained, training, access to coaching services, farming experience, farm size, land tenure, primary occupation, primary purpose of cultivation, asset owned, membership in cooperative, and access to relevant information.

Table 1: Socio-demographic information

Variable	**Frequency**	**%**
Age (Mean=43; SD=8.1; Range=)		
36-65	305	81.8
Marital status		
Married	361	96.8
Family size (Mean=6; SD=1.89; Range=11)		
7>	165	44.2
Education (Mean= 5.84; SD=1.96; Range=1.2		
1-6	267	71.6

The findings of the study revealed that average age is 43. The standard deviation (SD) 8.4 indicates that there is a wide deviation from the mean. The range of 37 years shows a relatively big distance of age between the lowest and the highest. The reason is the fact that agriculture is the main activity for both the old and the young people whose education and access to other opportunities are limited in the rural areas.

Regarding marital status, majority of respondents (96.8%), were married. The reason is that many couples find it mandatory to engage in farming for securing their families in terms of food and for making money and this is coupled with the fact that agriculture is the mainstay of rural economy. The findings of this study reveal that majority of respondents (71.6) attained primary education only. The average family size is 6.3.

Personal factors: Training, coaching, Access to Information, market information

The average number of times farmers attended training is 4.59. Trainings on postharvest technologies is quite important to determine adoption of any postharvest technologies.

The average number that farmers benefited coaching services for the last five years is 1.78 and the standard deviation which is greater than 1 indicates that the values are widely dispersed from the mean. As the study revealed, farmers' access to relevant information is critical, and this challenge could be an indication that there is weakness on the side of agriculture research institutions and organizations in provision of coaching services.

Key Informants of this study revealed different reasons for not benefiting coaching. Mainly extension officers are few and based at district. They find it too hard to provide services because of a very large geographical area to cover, with limited resources to reach a good number of maize farmers.

Table 2: Personal factors

Variable	**Frequency**	**%**
Number of trainings (Mean=4.59; SD=2.76; Range=19		
1-5	217	67.4
Number for coaching (Mean=1.78; SD=1.25; Range=11)		
1-2	132	35.3
Access to Postharvest Info [No: Times/Month]		
Broadcast Media (Mean=2.3; SD=1.6; Range=9)		
1-3	123	33
Print Media (Mean=2.2; SD=1.8; Range=8)		
1-3	23	6.1
Access to Market Information [no: times/week]		
ICT (Mean=.43; SD=1.63; Range=7)		
7-9	21	5.6
Radio (Mean=.68, SD=1.97, Range=7)		
7>	31	8.3
Print Media (Mean=.335, SD=1.345; Range=7)		
1-3	30	8

None of the respondents reported to have accessed information on postharvest technologies through ICT. Access to information on postharvest technologies is limited. The average number of times the information was accessed through broadcast media per month is 2.3, and 2.2 through print media per month. This study revealed that access to market information through ICT, broadcast media, and print media was low in the study area. Key respondents revealed that majority of respondents, access market information mainly through cooperatives. As was revealed by this study, majority of respondents attained primary education. Their limited access to information in general and market information in particular must be a function of their limited education. When one is least educated, his perception of importance of use of information is low. Given this low level of education, it is obvious that computer literacy and knowledge to manipulate electronic devices constitute another limitation.

Personal factors: farming experience, land tenureship, primary purpose of cultivation, asset owned and experience in cooperative

This study revealed that the average farming experience is 5.63 years. A few farmers are young, while a greater proportion of farmers, 72.6% reported that their experience has ranged between 5 and 9.

Table 3: Personal Characteristics of Respondents

Variable	Frequency	%
Farmers’ experience (Mean=5.8; SD=3.6; Range=6)		
5-9	271	72.6
Land tenure status		
Own land (Mean=93.3; SD=16.5; Range=70)		
100	309	82.8
Tenant (Mean=6.7; SD=16.6; Range=70)		
41-70	33	8.8
Primary purpose of cultivation		
Cash	11	2.9
Food and cash	362	97.1
Asset owned (Mean=3.8; SD=1.4; Range=7)		
4-8	287	76.8
Number of years in coop (Mean=5; SD=1.3; Range=7)		
5-6	222	60.6

Table 3 reveals that farmers involved in growing of maize do it under two types of land tenurial status. Majority of them (82.8%) grow 100% of maize they produce on their own land, which means they are land lords and have not rented land for growing maize. 93% of maize is grown on own land, whereas only 7% is grown on tenant land. The average proportion of produce grown on own land is 93.3%.

The average number of asset owned in this study is 3.8 and a relatively high standard deviation indicates that there is a wide disparity of values from the mean. The reason could be that respondents are of different age, different experience, have actually differing sizes of land, all which eventually affect the number of asset owned.

The Key informants revealed that farmers own farm equipment, buildings for commercial activities, houses for rent, transportation means like motorcycles, bicycles, car, and other farms. Regarding experience in a cooperative, the average number of years of membership in cooperative is 5.

According to this study, cooperative members in the study area had reasons of joining cooperatives valuing their membership. A relatively high overall mean (3.69) indicates that respondents strongly agreed with all the stated reasons for joining cooperatives which include value addition, linking to markets, and improving farming methods.

Table 4: Personal Characteristics of Respondents

Reason for joining cooperative	Mean	Description
Add value to farm products	3.8016	Strongly Agree
Improve farming methods	3.6810	Strongly Agree
Market linkage	3.6156	Strongly Agree
OVERALL MEAN	3.69	Strongly

Legend: 3.25-4.00: strongly agree; 2.50-3.24: agree; 1.75-2.49: disagree; 1.00-1.74 strongly disagree

Description of Institutional Factors

The institutional factors include infrastructure postharvest facilities (drying and storage), access to electricity, road access, perceived technical efficacy and cost-effectiveness, and marketing system. Findings revealed that majority of respondents (87.1%), reported that storage facility available for them was warehouse and 57.9% reported that accessible postharvest infrastructure facility for drying is cemented drying grounds. These are owned by cooperatives and cooperatively used by farmers. KI revealed that the ministry of agriculture had constructed warehouses, cemented drying grounds, and drying shades for maize farmers' cooperatives.

This study showed that majority of respondents (89.3%) is not connected to the power grid. Only 10.7% reported that they are connected to electricity, which indicates a low level of access to electricity by maize smallholder farmers..

As regard distance of the farm from the road, majority of respondents' farms (77.5%) are located between 1 and 500 meters from access road. The average number of meters to access road is 361.5, and a relatively very high standard deviation indicates a wide disparity of values from the mean. As key informants reported, that government has made heavy investment in road access construction in a bit to facilitate farmers' access to local and municipal markets.

According to the study, majority of respondents (84.5%) reported that they sold their maize through cooperatives. According to the key informants, the cooperative links to markets and sell in bulk to big customers, including the government, wholesalers, major processors, etc. Selling through cooperative guarantees farmers' access to market for their products and their farming activities can be more profitable.

Table 5: Institutional Factors

Infrastructure facilities	**Frequency**	**%**
Storage facilities		
Concrete silos	326	87.4
Metallic silos	4	1.1
Own house	43	11.5
Drying facilities		
Cemented drying ground	216	57.9
Drying shades	157	42.1
Access to electricity		
Connected to the power grid	35	9.4
Farm distance from road (Mean=361.5, SD=507, Range=2499)		
1:1-500[	290	77.8
Selling of maize		
Selling through cooperatives	315	84.5
Perceived Technical Efficiency		
Highly efficient	368	98.7
Perceived Cost Effectiveness		
Lowly cost effective	340	91.2
Fairly cost effective	33	8.8

Majority of respondents (98.7%) reported that use of postharvest technologies is efficient in that it reduces food loss and enhances farmers' access to market. As earlier presented, majority of farmers reported that they sell their maize through the cooperative. The use of technologies in postharvest that they benefit in cooperatives helps them in value addition, and market access among many other benefits.

However, majority of respondents (91.25%) reported that postharvest technologies are not cost effective. This is in agreement with the information provided by key respondents. They reported that technologies are expensive and mostly beyond the capacity of individual farmers. This could be the reason why technologies are subsidized by the government and managed at the level of cooperatives and local government entities.

Adoption of Postharvest Technologies

This study revealed the level of adoption of postharvest technologies by maize smallholder farmers in Kirehe District. The technologies included those used in maize drying, shelling, winnowing, and storage. To measure the level of adoption, the research classified cooperative members in four categories namely non-adopters, low level adopters, medium adopters, and majors adopters. Classification in these different levels was based on the proportion of maize handled using a specific postharvest technology. There were four scales of measuring adoption as follows:

1: 0%: Non adopters: Those who have never used any technology

2: 1-30: Low level adopters: Those who handled 1-30 % of maize using a technology

3: 31-60: Medium Adopters: Those who handled 31-60% of maize using a technology

4: 61-100: Major/High level adopters: Those who handled 61-100% of maize using a technology.

Adoption of Drying Technologies

The technologies adopted in the study area for maize drying are cemented drying ground, drying shades and sheeting. Cemented drying grounds, and drying shades are owned and managed by cooperatives.

Table 6: Adoption of Drying Technologies

Adoption of drying technologies	Frequency	%
Cemented dry ground (Mean=61.2; SD=31.9; Range=100)		
4	252	67.6
Drying shade (Mean=32.5; SD=27.72; Range=100)		
2	224	60.5
Plastic sheets (Mean=6.3; SD=15; Range=100)		
1	252	67.6

This study revealed that many respondents (67.6%) are major adopters of cemented drying ground. The average percentage of maize produce dried using cemented drying ground is 61.2. Drying shades ranks second in adoption of drying technologies, followed by plastic sheets.

Shelling technologies

The average percentage of maize produce shelled using mechanical shelling machine is 82, using electrical shelling machines is 7.2%, whereas use of hand represents a very low percentage of 9.9%.

Table 7: Shelling technologies

Adoption of shelling tech.	Frequency	%
Electr shell mach (Mean=7.2;SD=25.6)		
4	28	7.5
Mechanical shell mach (Mean=82.3; SD=26.2)		
4	336	90.1
Use of hands (Mean=9.9; SD=13.5)		
2	180	48.4

The study revealed that majority of respondents are not connected to electricity. This among others could be a main factor to explain a very low level of adoption of electrical shelling machine. Mechanical shelling machines are easy to handle and do not require electricity and are affordable compare to electrical shelling machines.

Adoption of Winnowing Technologies

The most adopted winnowing technology is winnowing machine. Majority of respondents are major adopters of winnowing machine.

Table 8: Adoption of Winnowing Technologies

Adoption of winnowing technologies	Frequency	%
Mechanical Winnowing machine (Mean=40.9; SD42.7; range=100)		
4	168	45
Sieve for winnowing (Mean=34.4; SD39.8; range=100)		
4	123	32.9
Mat for winnowing (Mean=22.8; SD30.9; range=100)		
2	138	37.1

The average number of quantity of maize winnowed using mechanical winnowing machines is 40.9. Given limited access to electrical power in the study area, adoption of electrical winnowing machine could be difficult. Key respondents in the study revealed that maize productivity has gradually increased due to the support from government in improved seeds, land consolidation and better agricultural policies and this led to the need to adopt new technologies in winnowing since using hands was labor intensive and time demanding.

Storage Technologies

The study revealed that the most adopted storage technology is warehouse. Metallic silo and concrete silos were not adopted in the study area.

Table 9: Adoption of Storage Technologies

Storage technologies	Frequency	**%**
Warehouse (Mean=95.3; SD14; range=100)		
4	361	96.8
Use of sacks on house floor (Mean=40.9; SD42.7; range=100)		
2	37	9.9

The average proportion of the quantity of maize handled using warehouse is 95.3% .It is important to note that use of sacks laid on the house floor represents a low percentage of 9.9 which indicates a very low level of adoption.

Influence of Personal and Institutional Factors on Adoption of Postharvest Technologies

This study sought to determine the influence of personal and institutional factors on adoption of maize postharvest technologies by smallholder farmers in Kirehe District. Data was analysed using stepwise multiple linear regression analysis. Independent variables were subjected to stepwise multiple linear regression analysis to identify the significant predictors of adoption of postharvest technologies.

This study revealed that some personal factors influenced adoption of postharvest technologies. None of the institutional factors influenced adoption of postharvest technologies. Access to market information through print media and perceived reason for joining cooperative was significant predictors of use of cemented drying grounds by cooperative members (beta=0.19, 0.18, tc=2.34**, 2.23**). It means that farmers used cemented drying grounds as a result of accessing market information through print media and as a result of farmers' conviction of the importance of joining a cooperative. This implies that increase in access to market information through print media and increase in perception on the importance of joining cooperative by farmers would result in increased adoption of cemented drying ground.

Table 10: Stepwise Multiple Linear Regression Analysis of Personal and Institutional Factors and Adoption of Postharvest Technologies

Adopted Technology and the predictors	**Associated Statistical values**				
	Beta	**t-value**	**R**	**R2**	**F-Ratio**
Cemented Drying Grounds			0.26	0.077	5.14
Market information/print media	0.19	2.34**			
Perceived reason of joining coops	0.18	2.23**			
Drying Shade			0.23	0.05	7.67
Perceived reason of joining coops	3.32	2.81**			
Sheeting			0.50	0.25	23.1
Postharvest info through print media	0.33	4.36**			
Market info through print media	0.30	3.89**			
Electrical Shelling			0.18	0.034	4.90
Years in cooperative	0.18	2.21**			
Mechanical Shelling			0.17	0.029	4.10
Years in cooperative	0.170	2.03**			
Shelling with Hands			0.197	0.39	5.55
Experience in farming	0.20	2.36**			
Sieves for Winnowing			0.24	0.036	4.08
Experience in farming	0.17	2.07**			
Age	0.17	2.02**			

Regression analysis also shows that Perceived reason of joining a cooperative had a positive and highly significant influence (beta=3.32, tc=2.81**) on how maize farmers adopt drying shade. This means that farmers used maize drying shades as a result of their perception on the reasons of joining cooperative. So this implies that increased perception on the importance of joining cooperative will result in increased adoption of maize drying shades.

Regarding adoption of sheeting, stepwise linear regression analysis indicates two variables namely access to information on postharvest technologies through print and access to market information through print media are significant predictors of adoption of sheeting by smallholder farmers in Kirehe District. Access to information on postharvest technologies through print media and access to market information through print media had positive significant influence (beta=0.33, 0.30, tc=4.36**, 3.89**) on maize farmers' adoption of sheeting.

This means that farmers have adopted sheeting as a result of their access to information on postharvest technologies and market information through print media.

Concerning adoption of shelling technologies, years in cooperative is a significant predictor of adoption of electrical shelling machine by maize smallholder farmers in Kirehe District. It had a positive significant influence (beta=0.18, tc=2.21**) on use of electrical shelling machine. This means that farmers have adopted electrical shelling machine as a result of the number of years in a cooperative.

The study also shows that the number of years in cooperative is a significant predictor of mechanical shelling machine by maize smallholder farmers in Kirehe District. Years in cooperative had a positive significant influence (beta=0.170, tc=2.03**) on adoption of mechanical shelling machines. This means that farmers have been using mechanical shelling machines as a result of the number of years they have been members of a cooperative.

Regarding farmers use of hand in shelling, the study reveals that experience in farming is its significant predictor. Experience in farming had a positive significant influence (beta=0.20, tc=2.36) on use of hands in maize shelling. The reasons to explain this as the study revealed are many experienced people among the respondents are old and less educated people. Their acceptance of postharvest technologies must be low and this affects negatively adoption of technologies.

The findings showed that the stepwise multiple linear regression analysis reveals that experience in farming and farmers' age are significant predictors of adoption of sieves for winnowing by maize smallholder farmers in Kirehe District. Experience in farming and respondents' age had positive significant influence (beta=0.17, 0.17 and tc=2.07**, 2.02**) on adoption of sieves for winnowing. So this means that farming experience and age influenced maize farmers' use of sieves for winnowing and this implies that increase in farming experience and age will result in increase in use of sieves in winnowing of maize.

CONCLUSION AND RECOMMENDATIONS

The study reveals that the personal factors were determinants of the level of adoption of postharvest technologies, whereas none of the institutional factors were found to influence adoption of the technologies. From the study, recommendations were formulated and are addressed to the ministry of agriculture and animal husbandry, Kirehe District, and farmer cooperatives.

Farmer cooperative:

- Maintain effective membership of farmers through enhanced leadership.
- Invest in extensive maize processing, to make cooking oil, and other products.

Kirehe District

- Local leaders should work together with cooperative members to make sure that the available infrastructural facilities are sustained.
- Sensitize more smallholder farmers to join cooperatives.

Ministry of Agriculture and Animal Husbandry

- Develop and implement efficient and widespread extension communication program
- Introduce ICT generated information to enhance transfer of useful knowledge
- Advocate for accelerated pace of rural electrification.
- Subsidize cost of technologies for individual farmers, use and maintenance.

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