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Influence of demographic characteristics on adoption of improved potato varieties by smallholder farmers in Mumberes Division, Baringo County, Kenya

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Potato (*Solanum tuberosum* L.) is widely consumed as a staple world over with direct consumption by humans as food being 31.3 kg per capita. Ministry of Agriculture through collaborative efforts with other stakeholders has developed improved potato varieties and released them for farmers to plant in Kenya. The main aim of this study was to investigate the influence of selected factors on adoption of improved potato varieties in Mumberes division, Baringo country. The study used a cross sectional survey research design where 128 household heads were sampled and interviewed. Statistical Package for Social Sciences (SPSS) version 17.5 aided data analysis. Descriptive statistics were used to summarize key observations in the study. Ordinal Logit regression was used to test the study hypothesis. It was revealed that perception, access to extension services, family size and access to credit were the key factors influencing adoption of improved potato varieties. The study recommended that there is need to increase access to extension services in the study area. Credit service providers should intensify their provision of these services. The research institutions should endeavor to look for varieties more resistant to blights so as to promote further adoption.

Key words: Adoption, Baringo County, demographic characteristics, improved potato varieties, perception, smallholder farmers.

INTRODUCTION

Irish potato (*Solanum tuberlosum,* L.) is a crop of major economic significance worldwide. Potatoes play a major role in food security due its usefulness as both a cash crop and a food crop. With increasing cereal prices, potatoes have the potential of relieving pressure from the poorest of the poor and promote food security (Hoffler and Ochieng, 2009). Potatoes are ranked fourth after wheat, rice and maize in cultivation on a global scale.

Among the tuber crops, potato is the most important and ranks first. It has an estimated annual output of 300 million tonnes cultivated on about 19 million hectares globally (FAO, 2008). Further, FAO asserts that the average production globally is about 17 t/ha whereby the direct consumption by humans as food is 31.3 kg per capita. The importance of potatoes as food in developing countries is because they are grown and eaten locally with

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little significance in the international market.

In Kenya, potato ranks second after maize in order of importance for utilization purposes (Muthoni and Nyamongo, 2009). About 500, 000 farmers grow this crop on about 120, 000 ha per season where the annual production is about 1 million tons in two growing seasons (MoA, 2008). The average annual production of potato is reported to be 1 million tones and per hectare yield of 7.3 mt/ha (Obare et al., 2010). However, 14.5-20 mt/ha at farm level and 25-35mt/ha under research conditions are attainable.

Food security in Kenya is a measure of available maize in the country. Nonetheless, maize productivity has steadily declined over the years, which has promoted low food security in the country. In addition, the prices of cereals such as maize and rice have been on an upward trend thus increasing the burden on the poorest of the poor (Hoffler and Ochieng, 2009). However, potato may act as a way out of this situation. This is so because potatoes produce more calories compared to cereals and are easy to cook and process. These aspects combined with a short maturity period of about three months imply that potato production is able to address the twin problem of food security and low household incomes that faces smallholder farmers in developing countries (Mpogole et al., 2012).

In the recent years, there has been a steady decline in the output and productivity per unit area of the potato varieties being grown by farmers. This has prompted research institution and organizations to look for newer varieties which are higher in productivity and less resistant to blights and other potato diseases. Improved potato varieties promise increased savings since they are bred with superior characteristics such as pest resistance and high yields (Abong et al., 2009). Through colla-borative efforts between Kenya Agricultural Research Institute (KARI), the International Potato Centre (CIP) and the Regional Network for Improvement of Potato and Sweet Potato (PRAPACE), significant developments of several high yielding varieties of potato have been made in Kenya (Kaguongo et al., 2008). The MoA (2007) also indicated that efforts have been focused on development and dissemination of high yielding varieties.

Research on adoption has pointed to factors such as demographic characteristics of famers; for example, level of education, gender, age and experience of the farmers, farmers perception about the technology, family size, technological factors such as complexity, the location of adopter institutions, access to extension services and access to production resources as some of the factors that may influence adoption of agricultural technologies (Ani and Ifah, 2004; Delgado and Johnson, 2005; Idrisa et al., 2010; Mwabu et al., 2006; Namwat et al., 2010; Obare et al., 2010). Given the role that improved potato varieties can play in averting food insecurity, the adoption rate of improved potato varieties is expected to be high for potato farmers world over. To the contrary, this was not the case in the study area. Thus, this study was designed to investigate the influence of demographic factors namely access to extension, access to credit, age, level of education, family size, gender and perception on adoption of improved potato varieties in Mumberes division, Baringo County, Kenya.

Significance of potato sector in food security

Potato (*S. tuberlosum* L.) is a crop of major economic significance worldwide. This crop provides a reliable source of income, employment and food for many populations in the developing countries (FAO, 2008). Globally, potato provides employment and food security to an estimated 800 million people (Hoffler and Ochieng, 2009). As the prices of major staples including wheat, rice and maize continue to rise, millions of people in the developing countries including Kenya are facing food crises. However, the prices of potato have remained relatively stable and thus can be targeted in improving food security in the developing countries (Muthoni and Nyamongo, 2009).

Potatoes have less significance in international trade compared to cereals and therefore they can form a significant source of food in developing countries. Maganga (2012) has pointed out that the potato sector can help improve the incomes of smallholder farmers and subsequently curb food insecurity together with poverty. This is partly because potatoes are grown and consumed locally, mature within a short period (3 to 4 months) and have high yields (about 40 tons/ha). Additionally, potato can be grown in areas with limited land and abundance of labour (FAO, 2008).

According to FAO (2008), Kenya's annual potato output is about 790, 000 tons. Thus, Kenya ranks 8th in Africa and 5th in sub Saharan Africa in potato production. The crop follows maize in order of importance as a staple and plays a vital role in food and nutritional security of the country. Additionally, in high altitudes, it is a major cash crop for smallholder famers and is grown by about 500, 000 farmers on 120, 000 ha. The farmers produce about 1 million tons in two growing seasons (MoA, 2008).

Potato has a superior comparative advantage to major cereals in the high altitude areas. While farmers complete only one planting season for maize, three cropping season are possible with potato in these areas (Muthoni and Nyamongo, 2009). This way, it acts as a more reliable source of income for farmers. In addition, in the high altitude areas, the average revenue for potato is more than twice that of maize (Obare et al., 2010). Thus, in such areas, potato becomes a more realistic venture which should be promoted not only for food security but also to ensure increased revenues for farmers. With the increasing population and low output from agricultural land, use of improved potato varieties may be one way out of the looming food security situation world over.

Adoption of technologies: Significance of demographic factors

For a farmer to decide whether or not to adopt an innovation, there are other aspects and characteristics that come into play. They include farmers' specific demographic characteristics such as age of the household head, education level, family size, marital status and gender of the household head, access to credit services as well as access to extension services. All these factors have been shown to be significant in determining farmer's decision to adopt a technology.

Perceptions act as a filter through which new technologies are taken in and interpreted. Through perception, farmers are able to transform the information they receive into psychological awareness and later make decision of whether or not the information can be utilized. The way a farmer perceives a technology may influence adoption. The technology-specific attributes have been shown in the past to significantly determine farmers' decision to adopt a technology (Idrisa et al., 2010).

Kafle and Shah (2012) noted that farmer's perception on an innovation largely depends on their knowledge and the information they have about the technology. Thus, by evaluating their yield for a short period, farmers are able to prefer a said technology compared to another. More so, base on their perceptions, farmers are able to assess the expected outcomes of any innovation. The actions taken by the farmer many times depend on their evaluation of the outcomes depending on his/her personal perspectives. Since the role of any technological improvement in agriculture is to improve production, adoption of improved potato varieties may be influenced largely by the perceptions that the farmers have (Idrisa et al., 2010). Perception was treated as either positive or negative as this is a subjective aspect emanating from an individual.

Access to extension is a function of whether or not one is visited by extension service providers and the number of times such a farmer is visited. Influence of this factor to adoption is widely acknowledged by various authors (Okoedo-Okojie and Onemolease, 2009; Odoemenem and Obinne, 2010; Namwata et al., 2010). Using knowledge obtained from extension agents, farmers are expected to increase the outputs of their farm enterprises. Extension agents fragment manage the complex agronomic aspects of an agricultural technology by simplifying it for the farmers. This may facilitate adoption of agricultural technologies. Namwata et al. (2010) indicated that access to extension services is a significant factor that influences adoption of improved potato varieties.

Accessing credit helps farmers to invest in buying of raw materials. Therefore, if farmers can access credit within the household, their chances of adopting a said improved crop variety will increase. However in Kenya, there are gender based differences in accessing credit (Mikalista, 2010). Olwade et al. (2010), noted that among the strongest determinants of fertilizer use intensity in Kenya were gender and access to credit. Research has shown that if farmers cannot purchase farm inputs, they are less likely to intensify their adoption of improved agricultural technologies.

Potato production is a relatively labor intensive venture since it increases labor demand during planting, weeding and harvesting (Muthoni and Namgongo, 2009). Thus, it provides employment for family members during peak seasons. Improved potato varieties promise to reduce labor since they are developed with resistance to chemical damage thus facilitating chemical weeding. Subsequently, both families with larger family sizes and those with smaller family sizes would adopt.

Thus adoption may not necessarily be influenced by family size. Gender of the household head is an indicator of marital status. The influence of gender on adoption of agricultural technologies is widely acknowledged. Gender influences division of labor, the type of agricultural commodity to be planted (Nkamleu and Manyong, 2005) and access to extension services (Feder and Umali, 2002; Mikalista, 2010; Namwata et al., 2010; Ofuoko et al., 2009). Delgado and Johnson (2005) reported that gender of the household head would influence the enterprise the family would be involved in. Thus, gender may influence adoption of the improved potato varieties in the study area.

Summary

The past studies reviewed have shown that the said factors are significant in influencing adoption of various agricultural technologies world over. However, specific technologies may vary in their adoption depending on subjective treatment of the technology by the farmers. More so, there are temporal and spatial variations in the adoption patterns of various technologies. In this study, the aim was to investigate if the factors that were believed to influence adoption of other technologies in other parts of the world could have influenced adoption of improved potato varieties in Mumberes division, Baringo County.

Theoretical framework

This study was guided by both the general systems theory as developed by von Bertalanffy (1968) and the diffusion of innovation theory as developed by Rogers (1995). According to the systems theory, components of a system interact with one another to form one whole. The theory's stronghold is its use of the feedback loops to restore equilibrium. The proponents of the theory argue that incase one component of the system changes, the systems equilibrium is compromised and has to be restored using these loops. This is by looking at the two-

way flow of technology and information between farmers and the public organizations, through extension, and nature of families and their characteristics that constitute the system. The interdependence of these sub systems within the larger system made it more suitable for a study such as this one.

According to the diffusion of innovation theory, a technology has four main elements that may influence its adoption. They are the innovation itself, the communication channels, time and the social context within which the adopter institutions are located (Rogers, 1995). Viewed from a multidisciplinary perspective, adoption is a multi-dimensional process dependent on many of factors such as perceived profitability, costs of establishment, compatibility with value systems and the ability to com-municate new knowledge and information between developers and among adopters or potential adopters.

Definition of variables

Adoption of an innovation can be viewed from two diverse points. One, it can be viewed as merely the utilization of the technology or innovation which creates a dichotomous dependent variable. Alternatively, it can be viewed as the extent to which the technology is being used or utilized and this creates a continuous dependent variable. This study used dichotomous dependent variable approach where adoption was measured by whether or not famers were growing the improved potato varieties. Lack of adoption was defined by failure to grow the improved potato varieties in the past four years preceding the study.

MATERIALS AND METHODS

Study area

The study was conducted in Mumberes division which is located in Baringo County at an altitude of about 2400 m above sea level. The division has a cool climate with an average annual rainfall of approximately 1425 mm per year and a mean temperature of about 18°C. Night temperatures range between 14 and 18°C. The average slope of the land ranges between 14 and 22% (MoA, 2010). Soils are mainly clay loams with an average pH of between 5.0 and 6.5. These features make this division a high potential area characterized by its ability to promote crop growth. The main agricultural activities in this area are crop and animal agriculture. Various crops are grown which include potatoes, maize, vegetables such as cabbages and kales, and fruits such as plums and pears. However, potato farming is the main agricultural activity for farmers and forms the backbone of agricultural sector in this area. The area has a total population of 21, 891 of which 11,009 are males and 10,882 are females. Also, there are 2660 farming households in Mumberes division (Kenya National Bureau of Statistics, 2010). The division has four locations namely; Mumberes, Chemoswon,

Timboroa and Seguton. Their populations are 1253, 482, 581 and 344 households, respectively (KNBS, 2010). All these locations were included in this study.

Population and sample

The study involved a cross sectional survey of all the four locations in Mumberes division. The study was carried out between March and May 2013. A sample size of 128 households was used which was determined using the formula suggested by Gatotoh et al. (2011).

The formula is stated as:

$$n = NC^2/C^2 + (N-1)e^2.$$

Where n is the sample size, N is the population size, C is the coefficient of variation, while e is the standard error.

Nassiuma (2000) asserts that the coefficient of variation should be less than 30% while the standard error should lie between 2 and 5%. In this study, C was set at 23% while the standard error was set at 2%. Thus,

N = 2660(0.23^2)/0.23^2 + (2660-1)0.02^2 = 128

The locations were equally represented in the study as the 128 household heads were selected proportionately from all the locations as shown in Table 1.

Data collection

Primary data for this study was collected using pre-tested structured interview guides. The interview guides were preferred because the population is comprised of illiterate and semi literate persons who cannot complete questionnaires (Ministry of Planning and National Development, 2005). Household heads that were purposively selected from the households were interviewed. Heads of households are at the core of decision making in many households of African communities (Idrisa et al., 2010). The instrument contained both close-ended and open-ended questions. Close ended questions provided a basis for quantifying the data obtained while the open ended ones provided useful information that was used in explaining observations in the study.

The instrument had three sections. Section I contained information on demographic characteristics of the farmers, including age, gender, education level, experience and family size. Section II contained information on social aspects of the farmer, including awareness and perceptions about improved potato varieties, and access to extension services. The third section collected data on farmers' economic factors namely access to credit services, other sources of income, land owned and actual land committed to potato production.

Statistical analysis

Descriptive statistics were used to summarize the main findings of the study. Ordinal logit regression model was used to test the study hypothesis. The logistic models have been widely used in adoption studies due to their slightly flatter tails compared to the probit models. The data was analyzed with the aid of SPSS version 17.5. The logit regression equation was stated as follows:

$$Adoption\ (Yi) = \beta_0 + \beta_1 AGEHH + \beta_2 EDUCLEV + \beta_3 PERCEPT + \beta_4 FAMSIZE + \beta_5 EXTENS + \beta_6 CREDIT + \beta_7 GENDER + \varepsilon$$

Table 1. Summary table for proportionate sampling.

Location	Population (households) (n)	Proportion (p) (n/N)	Number to be sampled (n/N)x 128
Mumberes	1253	0.471	60
Chemoswon	482	0.181	23
Timboroa	581	0.218	28
Seguton	344	0.130	17
Totals (N)	2660	1	128

Adopted from Kenya National Bureau of Statistics (2009).

Table 2. Definition of variables as used in the model.

Variable	Type	Measurement
Dependent variable		
Y_i	Dummy	1 = Adopted; 0 otherwise
Explanatory variables		
Gender (GENDER)	Dummy	1 = Male; 0 otherwise
Age of the household head (AGEHH)	Continuous	Age in years
Education of the household head (EDUCLEV)	Continuous	Total number of years in school
Family size (FAMSIZE)	Continuous	Total number of persons in the household
Access to credit (CREDIT)	Dummy	1 = Household head receives credit; 0 otherwise
Amount of credit received (AMOUCRED)	Continuous	The total amount of credit received for farming per year
Access to extension services (EXTENS)	Dummy	1 = Household head receives extension services; 0 otherwise
Perception (PERCEPT)	Dummy	1 = Farmer perceives that improved potato varieties are tastier, cook faster, increase family incomes, can improve food security, mature faster, have a ready market; 0 otherwise

Measurement of dependent and explanatory variables

Adoption (the dependent variable) was dichotomized such that a value of 1 was for an adopter farmer while 0 was given or a non adopter. The explanatory variables namely age of the household head, education level, family size, access to credit services, access to extension services and marital status and perceptions were defined as shown in Table 2.

RESULTS AND DISCUSSION

The demographic characteristics of the respondents that were studied in this study are gender of the household head, age of the farmer, level of education of the farmer, household size and marital status of the respondents.

Most of the respondents (68%) were males indicating that many of the households in the division are male-headed. Majority of the respondents (more than 70%), were aged between 20 and 40 years with average age being 34.22 years. Additionally, results showed that most of the respondents (about 70%) had at least primary level education with the average years in school being 1.59. Many households (about 58%) had family sizes of between 5 and 9 members with average family size of

4.59 members. The study further showed that only 17% of the respondents were able to access extension services while the rest did not. Furthermore, about 78% of the respondents were able to access credit services while the rest did not. The study also showed that only 26.8% of the farmers had adopted improved potato varieties and were growing them on their farms. Farmers in the study had land sizes ranging between 0.25 and 5 ha allocated to potato production. The average land size allocated for potato production was 1.25 ha.

This study was designed with a key objective of identifying the factors that may be influencing adoption of improved potato varieties in Mumberes division Baringo country. To achieve this, we performed a regression analysis and the results of which are indicated in Table 3. The pseudo R^2 value obtained was 0.645. This indicates that the explanatory variables can accurately predict the dependent variable and thus be able to explain farmer's adoption of improved potato varieties. The overall model thus is significant at 95% confidence interval.

From the results, it can be shown that family size was a significant factor influencing adoption of improved potato varieties. Large families provide readily available and

Table 3. Logit analysis for the adoption of improved potato varieties.

Parameter	B	Std. Error	Z	Significance
(Constant)	.081	.223	.364	.717
Gender of the respondent	-.704	.095	-7.437	.000
Age of the farmer	-.006	.004	-1.379	.171
Family size	.009	.011	.828	.409
Education level	-.074	.064	-1.160	.248
Extension services	.644	.139	4.647	.000
Access to credit	.595	.133	4.461	.000
Farmer perception $R^2 = 0.645$	.276	.095	2.891	.005

cheap labor which is important in adoption decision. Improved potato farming is labor intensive especially during peak seasons, that is, planting, weeding and harvesting. Availability of cheap labor thus will enhance adoption (Muthoni and Namgongo, 2009).

Access to extension services was also another factor that had significant influence on adoption. Although, only 17% of the farmers received extension services, this factor is significant. Low access to extension services has been noted to be a limiting factor to increasing agricultural productivity in Sub-Saharan Africa and in many developing countries (Kabungo, 2008; Okoedo-Okojie and Onemolease, 2009). Access to extension influences farmers' profitability as farmers become equipped with information by the extension agents (Okwoche et al., 2012). This may influence their adoption of agricultural technologies as they know which agricultural investments are more profitable to them. Extension services also provide farmers with the required agronomic knowledge which allows farmers to accept or reject technologies (Namwata et al., 2010). The information required by potato farmers includes availability of seeds, agronomic practices such as fertilizer application and spacing as well as available of markets. The results from this study supported Barungi et al. (2013) who acknowledged that although access to extension services was among the important factors that influenced adoption of agricultural technologies, the level of access to extension is important in the adoption process.

Access to credit services was another significant factor that influenced adoption of improved potato varieties by the farmers. Access to credit was measured by whether or not the farmers were receiving any financial support for their agricultural production. Access to credit allows farmers to purchase farm inputs which are major constraint in agricultural production especially in Sub Saharan Africa (Okwoche et al., 2012). Smallholder farmers face the challenge of lack of collaterals to secure credits thus leading to low access to credit (World Bank, 2008). However, this may lead to a vicious cycle of poverty as the poor are trapped in a cycle of income in-equality as they try to repay the credit with other sources of income on the farm or off the farm. Simtowe and Zeller

(2006) argued that access to credit allows farmers to adopt even risky technologies since their household's-risk bearing ability is boosted while at the same time relaxing their liquidity constraint. The findings supported Barungi et al. (2013), Namwata et al. (2010) and Simtowe and Zeller (2007) who reviewed various factors that affect adoption in Uganda, Tanzania and Malawi, respectively. The authors independently highlighted credit access as an important factor in adoption of improved agricultural technologies. The authors reported that actual access to credit had a significant influence on adoption in their study areas.

Farmer perception was another key significant factor in influencing adoption in the study area. Farmers had strong positive perceptions about high yields, short time to maturity, good taste, market availability and increased incomes from the improved potato varieties may have influenced the adoption of improved potato varieties in Mumberes division. Farmers agreed that improved potato varieties were tastier, matured early, increased household incomes and yields more compared to the old varieties they had been growing. The attribute of early maturity is especially important in food security as well as helping families to meet their economic obligations such as paying schools fees and loans. Thus, this may have been a key motivating factor to adopting the improved potato varieties. Additionally, it allows farmers to have many cropping seasons in a year thus reducing pressure on land especially where land pressure is dominant.

As noted by Idrisa et al. (2010), early maturity allows a farm produce to be harvested early thus avoiding droughts or heavy rains. The results from this study are in line with Kaguongo et al. (2008), Idrisa et al. (2010) and Chi (2008) who found out that a farmer's perception about a technology actually influences their adoption of such a technology. Attributes related to a technology largely influences how a farmer will perceive its importance. This in turn will influence their decision of whether or not to adopt (Idrisa et al., 2010).

The perception by farmers that improved potato varieties were not resistant to blight may lead to low adoption among the study population. This may be because blights require a lot of capital investment in controlling

controlling since only chemical control is possible. In addition, losses as a result of blights in African countries go as high as 75% on varieties that are susceptible. Kaguongo et al. (2008) attributes this to the high number of times farmers in the tropics have to apply fungicides in order to control late blights. The authors note that farmers can spray up to ten times with an average of 5 sprays per growing season in Kenya.

CONCLUSION AND RECOMMENDATION

The decision of a farmer to adopt a technology or not is influenced by many factors. These factors are either farmer related (farm and nonfarm) or they may be technology related. Technology related factors are mainly judged by famers through their perception. Farmer characteristics including age, gender of the household head, family size, access to extension services and access to credit services are also key factors in in-fluencing adoption. In this study, the key factors that were significant in influencing adoption were perception, family size, access to extension services and access to credit services. Farmer perception was also key in influencing adoption. Short time to maturity, good taste, increased incomes and market availability were the main aspects that motivated farmers to adopt improved potato varieties.

However, susceptibility to blights was also a key issue that farmers felt needs to be addressed in light of the improved potato varieties. The study recommends that there is need to increase farmers' access to extension by increasing the number of extension agents in the study area. Financial institutions also need to increase their presence in the study area and educate farmers on the need to have increased access to credit services. To ensure that there is increased adoption and for it to be main-tained, there is need for research institutions to keep researching on improving the resistance to blight as this may deter further adoption due to the susceptibility of the current grown varieties.

Conflict of Interest

The authors have not declared any conflict of interest.

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