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Socio-economic and Institutional Factors Influencing Adoption of Improved Maize Varieties in Hai District, Tanzania

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ABSTRACT The aim of this study was to explore households' socio-economic characteristics as well as institutional factors influencing the adoption of improved maize varieties (IMVs), using a cross-sectional data collected from a survey of 160 maize growing households in Hai District, Tanzania, using logistic regression model. Empirical result from the study show that off-farm income, access to extension services, access to credit, farmers membership of groups /association and participation in on-farm trials/demonstrations are statistically significant factors influencing the adoption of IMVs. The results suggest that improving smallholder farmers' basic education, access to extension service and credit facilities, and the promotion of farmers' groups/association could increase adoption of improved agricultural technologies. There is need for research institutes and extension services to increase on-farm trials/ demonstrations on improved agricultural technologies, in-order to enhance farmers' awareness and adoption of technologies.

INTRODUCTION

Increasing agricultural productivity using improved agricultural technologies that enhances sustainable food and fiber production is critical for sustainable food security and economic development (Mwangi and Kariuki 2015). In most developing countries, agricultural innovations are perceived as significant pathways out of poverty (Mwangi and Kariuki 2015; Simtowe et al. 2011) and therefore, new improved new agricultural innovation/technology adoption has become an important way of boosting productivity (Mignouna et al. 2011). A new technology is assumed to offer a pathway to substantially boost production and income (Beshir and Wegary 2014).

In Tanzania, agriculture is the mainstay of the economy, providing 85 percent of all exports and source of livelihood for more than 80 percent of the people (CIA World Factbook 2014; World Bank 2008), contributing also approximately 47 percent of the GDP (United Republic of Tanzania 2007). Maize is a major staple crop, grown in most of the agro-ecological zones of Tanzania (USAID 2010). In Sub-Saharan Africa, 2/3 of all maize from Africa is produced in eastern and southern Africa with Tanzania identified as a major producer (Verheye 2010; FAOSTAT 2014). Tanzania, in the last five decades according to Barreiro-Hurle (2012) has been ranked among the top 25 countries in the world producing maize. It is currently ranked first in East Africa, fourth in Africa, and 19th in the world (FAOSTAT 2014; McCann 2001).

According to Kirway et al. (2000), small-scale farmers produce 85 percent of maize in Tanzania which is often consumed at the household level, while commercial (large scale) production accounts for 15 percent. The per capita maize utilization is estimated at about 114 kilograms per year, contributing about 61 percent of the total calories intake in the peoples' diets, with more than 80 percent of the total populace depending on it as a food crop and for cash income. It is grown on more than 45 percent of the total land area devoted to agriculture (United Republic of Tanzania 2006; Kirway et al. 2000). Maize constitutes a significant component of agricultural development and livelihood sustainability for rural as well as urban dwellers in Tanzania, because of its importance and ability to grow almost everywhere in the country.

Improving maize production is considered to be an important strategies for promoting food

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security in Tanzania. One strategy to increase maize production and consequently the livelihoods of rural households is improved maize varieties (IMVs) adoption (Mongo 2001). An improved crop variety can be defined as those crops that has been advanced by formal plant breeding. They are recycled varieties that have not loss their desired qualities and, therefore, perform better than the local unimproved varieties (Lyimo et al. 2014). Since 1974, Tanzania Agricultural Research System has been involved in development of improved maize technologies for farmers in Tanzania. As of now, over ten IMVs, whose qualities have been improved for selected features like disease resistance, drought tolerance, quality protein, short maturity rate, and increased yield per unit of land have been developed and recommended together with improved production systems.

But, despite government efforts as well as those of development allies, the levels of IMVs adoption in Tanzania still remain low. While over the last decade increase in seed sales have been recorded, the percentage of maize area in IMVs has remain low, while the number of farmers using IMVs is even lower (Lyimo et al. 2014). The choice of IMVs by farmers, (which is affected by many factors) is an important factor affecting productivity of a crop (Neupane et al. 2002; Rogers 2003). The efficiency of technology diffusion programs depend mostly on the factors influencing adoption by the farmers. In order to deliver effective programs, extension agents need to be aware of the factors influencing technology adoption (Abebaw and Belay 2001).

To identify factors influencing a farmers' decision to adopt or not to adopt a new technology, the theory of adoption and diffusion of technologies has been extensively used (Rogers 2003). Information for improving agricultural research efficiency, food policy and extension services as well as for drawing implications for government involvement thus reducing the cost of non-adoption and enabling a rapid technical change can be derived from adoption studies. This study was, therefore, undertaken to identify the socioeconomic and institutional factors influencing the IMVs adoption in Hai district in Northern Tanzania.

Overview of Improved Maize Varieties (IMVs) in Tanzania

Maize research in Tanzania is carried out by the Tanzania National Agricultural Research System (NARS) under National Maize Research Programme (NMRP) in seven zones of Tanzania since 1974. The broad objective of the NMRP was to develop cultivars that are well appropriate for the key maize producing zones (Nkonya et al. 1998). From mid -1980s to 2004 many maize varieties such as the Open Pollinated Varieties (OPVs) and other hybrids has been developed for different agro-ecological zones by the National Maize Research Programme, these are high yielding, pests and disease resistant and drought resistant. Three OPVs namely Staha, Kito and Kilima, were released in November 1983. Staha is tolerant to maize streak virus (MSV) disease, while Kito is an early maturing variety that is well suitable to the low and intermediate regions. Kilima was recommended for the intermediate zone. Two OPVs, namely TMV-1 and TMV-2 were further released in 1987. The TMV-1 is resistant to white flint streak and it is intermediate maturing. This variety is most suitable for the lowland and intermediate regions. TMV-2 is also white flint, but it is most suitable for the highlands. The NMRP released versions of Kilima, Kito, UCA and Katumani in 1994 that are resistant to MSV diseases. Other varieties includes the Katumani-ST, Kilima-ST, Kito-ST, and UCA-ST. The NMRP released one OPV- Situka in 2000, while in 2001 in collaboration with CIMMYT, they released three varieties of Quality Protein Maize (QPM) named Lishe H1, Lishe H2 and Lishe K1 (Lyimo et al. 2014). The liberalization of trade and inventiveness of the Tanzanian structural adjustment program, have seen international seed companies massively involved in production and distribution of IMVs with many private businesses selling hybrids. Since mid-1992 up to 2000 several maize varieties have been released by the private seed companies.

MATERIAL AND METHODS

Sampling and Data Collection

Representative households used for the study was using a multistage stratified random sampling method. A reconnaissance survey was conducted in the first stage, to identify and list households in 8 villages that has been exposed to Improved Maize Varieties (IMVs) as well as those who have no prior knowledge of such technology. Contextual information on adaptions and on IMVs adoption was obtained through a focus group discussion. The information gathered was used to develop and structure the questionnaire administered to the respondent farmers during the face-to-face interview. Data were collected on household demographic, their socio-economic characteristics as well as institutional factors and the process of IMVs adoption. Also a random sampling of 160 households (20 respondent maize farming households from each of the 8 villages selected for the study) was undertaken in the second stage. Data were collected by trained enumerators. The questionnaire was pre-tested and slightly modified to improve reliability.

Conceptual Framework

New technology adoption is often modelled by way of a choice between two alternatives, the old (local) variety, and the new improved (modern) variety. Following random utility theory (Greene 2000), the *i*th farmers' utility derived from using an improved or local variety is given by U_{ij} with j = (0, 1) for the local and improved variety respectively, is defined as;

$$U_{ij} = \mu_{ij} + \varepsilon_{ij} \; j=0,1 \text{ and } i=\{1,2,....n\} \qquad (1)$$

where W_{ij} is an efficient utility - a non-stochastic function of explanatory and unknown factors, and e_{ij} is an unobservable random utility part which accounts for variation in taste together with stochastic errors.

It is assumed that the *i*th farmer will choose an option giving him the highest utility. Thus, the *i*th farmer, who wishes to maximize his utility will adopt IMVs if the random utility $U_{i1}. > U_{i1}$ A_i is a qualitative variable that indexes farmers' adoption decision. If $U_{i1}. \leq U_{i1}$ then $A = 0$ and $U_{i1}. \geq U_{i1}$ then A =1. Since the farmers' utilities are unobservable, what is observed is the choice he makes between the two varieties which depicts the one that offers the highest utility. Hence, a binary random variable is used to model the choice of the farmer of either variety. The probability of IMVs adoption can thus be presented as follows;

$$P\,(A_i = 1|X) = P\,(U_{i1} > U_{i0}) = P\,(\mu_{i1} + \varepsilon_{i1} > \mu_{i0} + \varepsilon_{i0})$$
$$= P\,(\varepsilon_{i0} - \varepsilon_{i1} < \mu_{i1} + \mu_{i0})$$
$$= \Lambda[\mu_{i1} - \mu_{i0}] \qquad (2)$$
$$P\,(A_i = 1) = \Lambda[\mu_{i1} - \mu_{i0}] = \Lambda(\beta' x)$$

where Λ is the cumulative distribution function of Σ_{i0} $\Sigma_{i1} = \zeta_i$, and R is a vector of parameters to be estimated; *Xs* are vectors of explanatory variables. The likelihood that a farmer adopts an improved maize variety is therefore a function of the farmers' socio-economic characteristics, institutional variables and the stochastic error term. If U_1 is normally distributed, thenis the cumulative density function consistent with the logistic model (Amemiya 1981).

Empirical Model

To determine the factors influencing the IMVs adoption in Hai district, the logistic regression model was used. This is a typical technique of analysis if an outcome variable is dichotomous (see, Hosmer and Lemeshow 2000). Following Demaris (1992), the logistic regression for the log odds ratio of adoption of IMVs can therefore be specified as:

$$\log\left(\frac{P_i}{1-P_i}\right) = \sum \beta_j x_{ij} + \xi_i$$

where $P_i = Pr\,(A = 1)$ is the probability conditioned that a farmer will adopt an IMVs; (1-p_i) = Pr (A = 0) is the probability conditioned that a farmer do not adopt; $\beta_j s$ are parameters to be estimated $X_{ij} s$; are vector of explanatory variables; ζ_i while is the stochastic or error term. The logistic regression model for IMVs adoption, expressed as a function of farmers' socio-economic characteristics and institutional variables is presented as:

$$A = \beta_0 + \beta_1 AGE + \beta_2 EDUC + \beta_3 LOBF + \beta_4 GENDER + \beta_5 FSIZE + \beta_6 TLU + \beta_7 EXP + \beta_8 OFF\text{-}F + \beta_9 CREDIT + \beta_{10} EXT + \beta_{11} FGROUP + \beta_{12} DEMO + \xi_I \qquad (3)$$

where A is the log of the odds ratio for adoption improved maize varieties (IMVs).

Explanatory Variables Used in the Empirical Model

Past studies on adoption have suggested that farmers' agricultural technology adoption decision is dependent on their socio-economic characteristics and institutional factors, such as their age, gender, education level, amount of labour force, land size, number of livestock, as well as off-farm income. Farmers' education level (EDUC) is generally associated with a superior ability to acquire, process, and use improved technologies information (Strauss et al. 1991). Therefore, educated farmers are expected to adopt new varieties than households with less or no education. Farmers' age (AGE) can create or wear away confidence; hence as a farmer ages he/she become more/less averse to risk regarding new technology (Kaliba et al. 2000). Thus, it is posited that farmers' age can increase/decrease the likelihood of IMVs adoption. Gender of the household head (GENDER) determines access to new information. Social behaviour makes male informants to address male-headed households leaving female-headed counterparts uninformed (Kaliba et al. 2000). It is therefore hypothesised that households headed by males are expected to adopt IMVs. Labour force (LABOUR) is measured by the number of adults in a household. A household with larger labour force is expected to adopt IMVs. Since the adoption of IMVs requires additional labour for other farm practices, a farmers' decision to adopt a new technology will dependent on the labour force available. Farm size (FSIZE) and livestock owned (TLU) often represent the physical capital endowment (wealth status of households). A wealthy farmers may have the proceeds to purchase improved farm technologies (Kaliba et al. 2000); hence a positive relationship is expected between adoption decision aand household wealth. Off-farm income (OFF-F) directly increased cash available for investment in improved maize varieties; hence it is hypothesized that off-farm income sources increases likelihood of IMVs adoption.

Variables included in the model to capture institutional factors that affect IMVs were access to credit, access to extension services, membership of farmer group/association and participation in on-farm trials/demonstrations. Extension services (EXT) is an important source of technical information for farmers. It is, therefore, posited that access to extension services will increase adoption. Access to credit (CREDIT) has been identified to increase farmers' ability to acquire new production technology and increase productivity, therefore access to credit is expected to increase the likelihood of IMVs adoption. Membership of a farmers' group/association (FGROUP) may increase access to information on improved technologies (Olwande and Mathenge 2012). Therefore membership of a farmers' association or group is expected to increase the likelihood of IMVs adoption. Farmers' participation in on-farm trials/demonstrations (DEMO) increased knowledge about the improved varieties. Farmers who are knowledgeable about the improved varieties are more likely to have higher adoption than those who do not know about the varieties (Zhang et al. 2002). The explanatory variables used in the empirical model are described and presented in Table 1.

Table 1: Description of explanatory variables used in the empirical model

Variable	*Description*	*Expected sign*
Socio-economic Characteristics		
AGE	Household head age (in years)	+/-
GENDER	Household head Gender (1 = male; 0 otherwise)	+
EDUC	Household head Education (years of schooling)	+
LABOR	Household labour force (Adult Equivalent Unit)	+ +
FSIZE	Farm size (acres)	+
TLU[1]	Livestock ownership (Total tropical livestock units)	+
OFF-F	Off-farm income (1=yes; 0 otherwise)	+
Institutional Factors		
EXT	Access to extension services (1=yes; 0 otherwise)	+
CREDIT	Access to credit (1=yes; 0 otherwise)	+
FGROUP	Member of farmer group/ association (1=yes; 0 otherwise)	+
DEMO	Participation in on-farm trials/demonstrations 1=yes; 0 otherwise)	+

[1]Tropical Livestock Units (TLU) was estimated using FAO conversion factors.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Sampled Households

The descriptive statistics of the socio-economic characteristics of the sampled households is presented in Table 2.

Table 2: Socio-economic characteristics of the sampled maize farming households

Variable	*Mean*	*Std. dev*
AGE	42.03	12.55
GENDER	0.61	0.32
EDUC	5.34	3.21
LABOR	5.10	2.10
FSIZE	1.70	1.25
TLU	1.54	2.19
OFF-F	0.24	0.45
EXT	0.41	0.18
CREDIT	0.38	0.11
FGROUP	0.30	0.26
DEMO	0.37	0.31

Calculated from field survey data.

Majority (61%) of the sample households are male-headed households with an average age of 42 years. This implies that most of the farmers are within the age classified as active and productive. A farmer has an average of 5 years of schooling (education). The average labour supply (number of adults) in a farming household was 5.1, while the average farm size of sampled farmer was very small, about 2 acres. Only 24 percent of sample households have off-farm income sources. The average livestock ownership was 1.5 TLU, indicating that majority of households has small number of livestock. There is low access to credit facilities and extension services; only 38 percent and 41 percent of sample farmers had access to a credit facility and extension services respectively). About 30 percent of households reported participating in farmer groups/associations. Participation in groups/association enables the diffussion of knowledge, information and innovations. The average proportion of sample households that participated in on-farm trials/demonstrations of IMVs in the study area was 30 percent.

Logit Regression Estimates of the Factors Influencing Improved Maize Varieties (IMVs) Adoption

The estimated result of the logit regression model of the factors influencing the adoption IMVs is presented in Table 3.

The log-likelihood of -40.30, the Pseudo R^2 of 0.347 and the LR-Chi^2 of 111.26 which is significant at 1 percent level implies that the model is well fit and the explanatory variables collectively explains the farmers' IMVs adoption decision. The overall classification accuracy of the model is relatively good at 73.3 percent, with adopters classified very well (81.2%) and non-adopters classified well (61.60%).

The results presented in Table 3 showed that of the 12 variables used in the model, 5 are identified to have statistically significant influence on IMVs. These variables are access to access to credit (CREDIT), extension services (EXT), membership in farmer group/association (FGROUP), participation in on-farm trials/demonstrations (DEMO), off-farm income (OFF-F) and education (EDUC).

Access to extension (EXT) variable is statistically significant with a positive influence on adoption of improved maize varieties. The odds ratio for EXT is 6.129; this implies that farmers that has access to extension services are over six times as likely to adopt IMVs compared to those with no access to extension services. This finding is consistent with Sisay et al. (2015), Ugwumba and Okechukwu (2014) and Kaliba et al. (2000), they find that the number of extension contacts has a positive association with IMVs adoption in South-Western Ethiopia, Nigeria and Central Tanzania respectively, and improved cassava (Ojo and Ogunyemi 2014) in Nigeria. Similarly, farmers with access to credit facilities are more likely to adopt IMVs compared to those without access. The odds of adoption is estimated to increase by a factor of 3.228; this implies that farmers with access to credit are over three times more likely to adopt IMVs than those with no access to credit. This result is consistent with that of Gecho and Punjabi (2011). Paucity of funds and lack of credit access have been shown to constrained the adoption of improved technologies (Gyinadu et al. 2015; Onumadu and Osahon 2014; Ogada et al. 2014).

Table 3: Binary regression estimates of the factors influencing IMVs adoption in Hai District, Tanzania

Variables	*Coefficient (β)*	*Std. error*	*Exp (β)*
Socio-economic Characteristics			
AGE	0.012	0.021	1.012
GENDER	0.040	0.973	1.041
EDUC	2.092***	1.012	8.101
FSIZE	0.020	0.101	1.020
TLU	0.031	0.022	1.031
LABOR	0.561	0.704	1.752
OFF-F	1.092**	0.470	2.980
Institutional Factors			
EXT	1.813***	0.824	6.129
CREDIT	1.172**	0.540	3.228
FGROUP	0.940**	0.562	2.560
DEMO	1.401*	0.603	4.059
Constant (Constant)	-2.167**	0.876	0.115
Observations	180		
LR $chi^2(11)$	111.26		
Prob>chi^2	0.000		
Log-likelihood	-40.30		
Pseudo R^2	0.347		
% of correct prediction for adopters	81.2		
% of correct prediction for non-adopters	61.6		
% of total correct prediction	73.3		

Note: ***, ** and * denote statistical significance at the 1%, 5% and 10% probability levels, respectively.

Education (EDUC) variable is statistically significant, with a positive influence on MIVs adoption. The odds ratio for EDUC is 8.101; this implies that a year increase in a farmers' education can increase the likelihood of IMVs adoption by 8.101. This finding is in pact with many studies that has reported positive influence between household level of education and new farm adoption technologies in developing countries (see Deepa et al. 2015; Ahmed 2015; Kebede and Tadesse 2015; Onumadu and Osahon 2014).

Off-farm income (OFF-F) variable is statistically significant, with a positive influence on IMVs adoption. The odds ratio for OFF-F is 2.980; this implies that farmers with off-farm income sources are about three times as likely to adopt IMVs compared to those without sources of off-farm income. Households involved in off-farm work can afford to invest in improved maize technologies. New improved farm technology demands more farm inputs; its adoption depends on cash availability for seeds and fertilizers purchases. Off-farm income directly increased cash available for investment in improved technologies. The result is agrees with the findings of Helder et al. (2005) and Ransom et al. (2003). Reardon et al. (2007) argued that off-farm income can help overcome a working credit constraints while Diiro (2013) argued it may finance productivity enhancing inputs such as improved seeds and fertilizers purchases.

Farmers' membership of farmer group/organization (FGROUP) variable is statistically significant, with a positive influence on farmer's IMVs adoption decision. The odds ratio for FGROUP is 2.560; this implies that farmers who are member of group/association are over two times as likely to adopt IMVs compared to those with no membership in farmer groups/association. This finding is consistent with those of Sisay et al. (2015) and Ahmed (2015), they observed that membership in a group has a positive influence with IMVs adoption in Ethiopia. Also Ugwumba and Okechukwu (2014), Ojo and Ogunyemi (2014) and Amaza et al. (2007) found similar results in Nigeria.

Finally, the odds ratio for participation in on-farm trials/demonstrations (DEMO) is 4.059, implying that farmers participated in on-farm trials/demonstrations are over four times as likely to adopt IMVs compared to those who did not participate. Farmers through their participation were able to get sufficient awareness, information and knowledge on IMVs to make adoption decisions. This shows the importance of sensitizing farmers about the existence of alternative technologies. This result confirmed those of Kebede and Tadesse 2015, Gecho and Punjabi (2011), Zhang et al. (2002) and Aïtchédji et al. (2000), they find that farmers' participation in on-farm trials has a positive influence on the adoption of high yielding varieties by farmers in Ethiopia, India and Nigeria, respectively.

CONCLUSION

This study evaluated the socioeconomic characteristics and institutional factors influencing IMVs adoption in Hai District in Tanzania using adoption data collected from 160 farming households. The empirical results revealed that education, access to credit facilities, access to off-farm income, access to extension services, membership of farmer groups/association and participation in on-farm trials/demonstrations are statistically significant factors influencing farmers' IMVs adoption decision in the study area.

RECOMMENDATIONS

This study recommends that improving smallholder farmers' basic education, easing market imperfections by improving access to information and credit are necessary for an accelerated farm technology adoption. The promotion of farmers' groups/association can increase adoption of improved agricultural technologies and will reinforce farmer-to-farmer knowledge sharing. Furthermore, there is need for research institutes and extension services to increase on-farm trials/demonstrations on improved agricultural technologies, in-order to enhance farmers' awareness and adoption of technologies. Therefore, policies aimed at strengthening the existing agricultural extension services through recruitment, incentives, training of the extension workers need to be encouraged.

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