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Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.5, No.25, 2014

www.iiste.org

# Drivers of adoption of Improved Maize varieties in Moist Transitional zone of Eastern Kenya

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**Abstract**

Despite its role in food security in Kenya, maize deficit has increased in the recent years posing serious food security threat. This worrying trend necessitates careful review of adoption. The paper quantifies determinants of adoption and intensity of use of improved maize varieties in moist transitional zone of Eastern Kenya based on data collected between September and October 2013 from 314 farming households. Double hurdle model was used to estimate the determinants of adoption and intensity of use of improved maize varieties. Many of the institutional factors: extension contacts, farmer group membership, distance to input market and extension office were significant in explaining the probability of adoption. Fertilizer use, livestock and consumer worker ratio were identified as important farm characteristics in the adoption. Age was the only household characteristic that was associated with the likelihood of adoption. These factors were not important in the intensity of adoption. Intensity of adoption was explained by intercropping of maize and legumes, ownership of mobile phones, household size, remittances, confidence in extension workers and availability of seed of improved maize varieties. Given that different sets of factors determined the probability and intensity of adoption, considering the two decision processes for the purpose of identifying appropriate strategies for increasing productivity is critical. The results suggest strengthening of farmer's groups, particularly innovation platforms, and extension services. Since distance to input and output market was factor in adoption, improving infrastructure would reduce transaction cost and encourage farmers to adopt modern technologies. Policies aimed at enhancing maize productivity and the adoption of improved maize by improving and maintaining the household asset base should also be central to food security strategies.

**Key words:** Double hurdle, food security, Kenya, maize

## 1. Introduction

In Kenya, food security has been viewed as synonymous with maize availability (Short *et al.*, 2012; Keya and Rubaihayo, 2013; Tegemeo, 2013). This is because maize is not only the main staple food but also the crop that is grown by most of the rural households, mainly for food. Maize (Zea *mays L)* accounts for 42 % of the dietary energy intake (FAO, 2012; Keya and Rubaihayo, 2013), 32 % of total protein consumption and 68 % of the daily per capita cereal consumption (FAO, 2012). The average land area under maize currently is 1.6 million hectares. Almost 3.5 million farmers are engaged in maize production, where smallholder and large scale farmers account for 75 % and 25 % of the of the maize production (Tegemeo, 2013). Despite its importance in food security, Kenya faces deficits in maize production (Short *et al*., 2012). Maize consumption outstrips supply in most of the years leading to perpetual food insecurity in the country as shown in Figure 2. On average, monthly maize consumption is estimated at about 3.5 million bags (Keya and Rubaihayo, 2013). National average maize yields is estimated at 1.8 t/hectare compared to potential yield of over 6 t/hectares (FAOSTAT, 2010). Given this low rate of growth in maize production and the growing demand, the country's import bill has risen in the recent years (Kirimi *et al.*, 2011; Short *et al*., 2012). Excluding unrecorded backyard localized importations, Kenya on average imports slightly above 3 million kilograms of maize mainly from Uganda and Tanzania (Short *et al*., 2012) . This pattern is expected to prevail in the future unless reforms are taken to ensure productivity growth.

In the moist transitional zone of Embu, Meru South and Imenti South sub-counties where maize is an important economic and subsistence activity, maize yields are low and are not able to match demand. Current maize harvests are not able to last till the next cropping season posing serious food security threats to most of the households (Ouma and DeGroote, 2011). Given that maize production is already operating at its land frontier with limited scope to increase supply of land to meet the growing demand for maize, future increase in maize production will depend on increasing yield per hectare through the use of improved maize varieties combined with good agronomic and cultural practices (Keya and Rubaihayo, 2013).

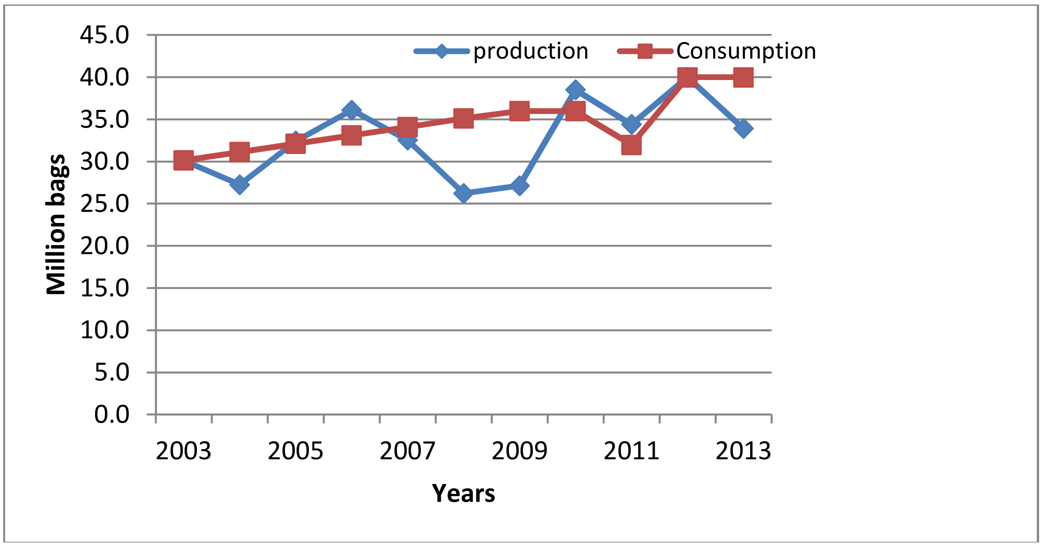


**Figure 2. Maize production and consumption trends (2003-2013)**

Source: Economic Review of Agriculture (2003-2013)

Among the many initiatives in increasing the productivity of maize, the development of improved maize varieties and management practices have been the most profound. Maize seed embodies the genetic trait and exerts a limit to the gains in productivity through the complementary use of fertilizer, pesticides and management techniques (Bola et al., 2012). Currently, there are over 164 registered maize varieties in Kenya and many more are being developed and released with the aim of increasing productivity (Olaf et al., 2011).

Given the continuous development and deployment of new maize varieties among farmers and the dynamic nature of farming system it is inevitable to reflect current situation with respect to use of technologies by determining drivers of adoption. This is important for providing informed and evidence based policy making such as to develop and implement appropriate support policy measures for improving targeting, access and use of modern varieties. Therefore, this study analyzes the determinants of adoption and intensity of use of improved maize varieties among maize growing households in Embu, Meru South and Imenti South sub-counties. The information generated through adoption studies enriches subsequent impact studies.

## . 2. Methodology

### *2.1 Description of the study area*

The moist transitional zone is the main maize growing areas in Eastern Kenya (Figure 2). The zone lies at an altitude of 1500 meters above sea level, annual mean temperature is 20°C and annual rainfall varies from 1000 to 1,400 mm. The rainfall pattern is bimodal (Jaetzold & Schmidt, 1983). It is characterized by complex farming systems with the production of cash and food crops and livestock. The principal sources of income are tea, and dairy. Macadamia (Macadamia tetraphylla) is also currently a major cash crop and has replaced coffee because of its poor performance. Miraa (Catha edulis) is also considered an important cash crop, particularly in parts of Embu sub-county. Maize is the main food crop and there is a perception in the region that a family without maize grain is food insecure.

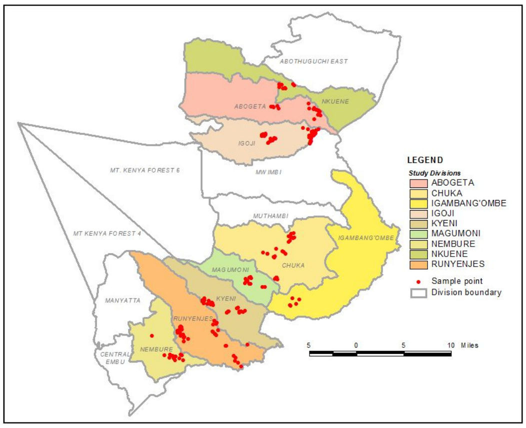


**Figure 3. Geographical location of the study area**

*2.2 Sampling, data collection and analysis*

Embu, Meru South and Imenti South sub-counties were selected among the many sub-counties in moist transitional zone based on their maize–legume production potential. Multi stage sampling was employed to select lower levels sampling clusters: divisions, locations, sub-locations and villages. Determination of sample size followed proportionate to size sampling approach (Groebner & Shannon, 2005) and is specified as follows:

$$n = \frac{(z^2 PQ)}{d^2}$$

Where, 'n' is the sample size 'z' = 1.96, 'P' is the proportion of smallholder farmers growing improved maize varieties in Embu, Meru South and Imenti South sub-counties. Based on adoption rates of 70 % (Ouma & DeGroote, 2011), P was set at 0.70. The variable'd' is the significance level and was set at 5%. This also led to a 'z' value of 1.96. Variable 'Q' is the weighting variable and is computed as 1-P. Therefore, based on the above proportionate to size sampling formulae, the sample size proposed was: [1.962 x 0.7 x 0.3] / [0.052] = 323. Data was collected through face to face interviews and analysis was done in STATA 13 based on 314 households.

*2.3 Double hurdle model*

Some studies suggest that the choice to plant improved maize varieties and how much land to allocate to improved maize varieties can be modeled jointly, if they are made simultaneously by the household; independently, if they are made separately; or sequentially, if one is made first and affects the other one (Berhanu and Swinton, 2003) . There is no theoretical justification to believe that the two decisions are made jointly (Berhanu and Swinton, 2003; Katengeza et al., 2012; Beshir, 2014).

In the double-hurdle model the two decisions are determined by two separate stochastic processes and as such two equations incorporate the effects of explanatory variables. Such explanatory variables may appear in both equations or in either of one (Teklewold et al., 2006). Empirical studies have shown that a variable appearing in both equations may have opposite effects in the two hurdles. The double hurdle model has been widely applied in many studies (Teklewold et al., 2006; Katengeza et al., 2012; Beshir, 2014).

In this paper, the two decisions relate to the choice of adopting improved maize varieties and intensity of adoption. The two decisions are closely related but they do not necessarily follow the same data generation process. The first hurdle represented by (E) takes the value of 1 for farmers who have adopted improved maize varieties and 0 otherwise. The first expression of the double hurdle model has an adoption equation represented by (E) as follows:

$$E_i = \alpha z_i + \mu_i \text{ ..........................................................equation 1}$$

Where $\mu_i$ is a dummy variable that takes the value of 1 if the farmer adopts improved maize varieties and 0 otherwise, Z is a vectors of household characteristics, $\alpha$ is a vector of parameters to be estimated. The second hurdle, involves an outcome equation which uses a truncated model to determine the intensity of adoption. This second hurdle uses observations only from those respondents who indicated a positive value for improved maize varieties. The truncated model, which closely resembles the Tobit model, is expressed as follows:

$$Y_i^* = \beta X_i + V_i \quad \text{equation 2}$$

$$Y_i = Y_i^* \text{ If } Y_i^* > 0 \ \& \ D_i > 0 \quad \text{equation 3}$$

$$Y_i = 0 \text{, otherwise}$$

Where $Y_i$ =observed variable for the area allocated to improved maize varieties, X=vector of individuals characteristics $\mu$ = vector of parameters. The error tem $\mu_i$ and $v_i$ are normally distributed with zero mean and constant variance $\sigma$.

The log-likelihood function for the double hurdle model is specified as follows:

$$\log L = \sum_0 \ln\left[1 - \phi(z_i'\alpha)\phi(\frac{x_i'\beta}{\delta})\right] + \sum \ln\left[\phi(z_i'\alpha)\frac{1}{\delta}\phi(\frac{y_i - \beta x_i'}{\delta})\right] \quad \text{equation 4}$$

Under the assumption of independency of the error terms, $v_i$ and $\mu_i$, the double hurdle model is similar to a combination of truncated regression model and univariate probit model. The test of hypothesis for the double hurdle model vs Tobit model can be determined by estimating Tobit, truncated regression and the probit models separately. Thereafter the log likelihood ratio (LR) test is used to determine the suitability of either Tobit or double hurdle model. The LR statistic is computed according to (Greene, 2003)

$$\Gamma = -2[\ln L_T - (LnL_P + LnL_{TR})] \approx \chi^2 k \quad \text{equation 5}$$

Where LT = refers to the likelihood ratio of the Tobit model: LP = Likelihood ratio for the probit model: LTR= Likelihood for the truncated model and k=is the number of independent variables in both equations.

If the test of hypothesis $H_0 : \lambda = \frac{\beta}{\delta}$ and $\lambda \neq \frac{\beta}{\delta}$, $H_0$ will be rejected on a pre-specified level if $\Gamma > \chi^2 k$.

Akakie's Information Criterion (AIC) can also be used as model selection criteria. The model with the lowest AIC is preferred.

## 3. Results and discussions

**Error! Reference source not found.** presents the empirical results of the double hurdle model. Among the factors included in the model, institutional factors (membership in farmers group, extension visits, proximity to agricultural extension office and main input market were the most profound in explaining the probability of adoption. Farm characteristics such as dependency ratio, livestock ownership, inorganic fertilizer use, manure use, and area planted under legumes and crops were also important in explaining the likelihood of adoption. Age was the only household characteristic that affected adoption. Ownership of livestock was significant (p<0.001) in explaining the likelihood of adoption of improved maize varieties at 1 % significance level. Owning livestock increased the chances of adopting improved maize varieties by a factor of 0.2 and agrees with the hypothesis stated earlier. Livestock denotes a significant asset that could be used either in the production process or in exchange. Livestock also provides a sense of security to the household. Moreover, livestock may increase availability of manure and act as a major conduit of nutrient flows on the farms through nutrient re-cycling and subsequently enhance technology adoption. The results are similar to earlier studies (Salasya *et al.*, 1998; Doss, 2003; Kafle, 2010; Katengeza *et al.*, 2012). It is also worth mentioning that more specialization in livestock rather than cropping may reduce investment in crops. Use of inorganic fertilizer was found to be positively significant (p<0.001) in explaining the probability of adoption of improved maize varieties and increased by a factor of 0.28 the likelihood of adopting improved maize varieties. The finding corresponds with the earlier assertion that fertilizer use promotes adoption of improved maize varieties. In considering the adoption decision, it is important to keep in mind that there is an interaction between improved maize varieties and inorganic fertilizer, so that the benefits of adopting both technologies exceed the sum of the benefits achieved by adopting only one or the other (Doss and Morris, 2001). It is clear from the results, that farmers in the study area are aware of this advantage. Almost ninety two percent of the farming households use a combination of improved maize seed and fertilizer. The positive effect of fertilizer use has also been reported in other studies (Amaza *et al.,* 2007; Ouma, 2011). The study also established a positive and significant (P<0.05) association between extension visits and likelihood of adoption of improved maize varieties. The chance of adopting improved maize varieties increased by a factor of 0.4 as a result of extension contact. Frequent contact with extension agents exposes farmers to new technologies and how they can be applied. The positive influence of extension contact on adoption of improved maize varieties has also been reported in several studies (Salasya *et al.*, 1998; Kaliba *et al.*, 2000; Ouma *et al*., 2002; Wekesa *et al.,* 2002; Amaza *et al.*, 2007; Langyintuo, 2008; Ouma, 2011; Beshir, 2014). Membership in farmers group exerted a positive and significant ($p<0.1$) influence on the likelihood of adoption of improved maize varieties. Households that had at least one member of the household in a farmers group were likely by a factor of 0.4 to plant improved maize varieties. With limited information sources and imperfect markets and transactions costs, social networks facilitate the exchange of information, enable farmers to access inputs on time, and overcome credit constraints. In addition, social networks reduce transaction costs and increase farmers' bargaining power, helping farmers earn higher returns when marketing their products. Farmers who do not have contacts with extension agents may still find out about new technologies from their networks, as they share information and learn from each other. Current literature has paid attention on the effect of social networks and personal relationships on technology adoption (Barrett, 2005; Bandiera and Rasul, 2006; Isham, 2007; Matuschke and Qaim, 2008; Munyua *et al*., 2010; Nyangena, 2011). There was a significant ($p<0.10$) and positive influence of area available for crop production and adoption of improved maize varieties. Households that had larger land holding for crop production allocated more land to improved maize varieties. For each increase in land area allocated to crop production, the probability of adoption increased by 1.1 %. The positive association possibly shows that farm size is a sign of wealth and a proxy for social status and influence within the community. These results collaborate other earlier studies (Feder and O'Mara, 1981; Nkonya *et al.*, 1997; Gabre-Madhin and Haggblade, 2001; Gabre-Madhin and Johnston, 2002; Langyintuo, 2008; Katengeza *et al.*, 2012). Gabre-Madhin and Hagglbade (2011) for instance showed that large scale commercial farmers adopted new high-yielding maize varieties much faster than smallholder farmers in Ethiopia. This is because large scale commercial farmers have high access to resources. Other studies (Etoundi and Dia, 2008) have shown the contrast. Etoundi and Dia (2008) for instance established that increasing the area diminished the probability of adopting improved maize varieties in Cameroon. The larger the area sown to improved maize varieties, the more manpower and resources are required. There was a positive and significant ($p<0.001$) relationship between distance to extension office and probability of adoption of improved maize varieties. This means that as distance to agricultural extension office increased, the likelihood of adoption of improved maize varieties increased. This is surprising and does not correspond with the earlier stated hypothesis. In justifying this finding, however, the author notes that farmers take advantage of social network for information on new agricultural technologies. The dummy variables for three districts namely Embu, Meru South and Imenti South representing geographical dispersion were also included. Imenti South served as a reference district. This was important in avoiding the problem of dummy trap. Households in Embu and Meru South districts were more likely to adopt improved maize varieties by factors of 0.9 and 0.6 respectively compared to households in Imenti South. Households in Imenti South have relatively higher dependency ratio, are further away from the main input markets, have fewer livestock units. In addition to the variables that had positive effects on probability of adoption of improved maize varieties, age, dependency ratio, manure use and distance to input markets were significant and negative drivers of improved maize variety adoption. Age was significant ($p<0.001$) and for each one unit increase in age of the household head there was a decrease of 0.03 in the probability of adoption of improved maize varieties. The effect of age in explaining technology adoption is somewhat controversial in the literature and is often an empirical question (Feder *et al.*, 1985). Age happens to be one of the human capital characteristics that have been frequently associated with non adoption of improved maize varieties in many studies (Etoundi and Dia, 2008; Cavane and Subedi, 2009; Simtowe et al., 2009; Kalinda et al., 2014). Among the several reasons that could explain the negative effect of age on adoption is the fact that older farmers tend to stick to their old production techniques and are usually less willing to accept change. Moreover, young people are associated with a higher risk-taking behavior than the elderly as noted by Simtowe et al (2007). The negative association between age and adoption of improved maize varieties can be explained by the assumption that as farmers grow older, there is an increase in risk aversion and a decreased interest in using new agricultural technologies such as improved seed. Young household heads on the other hand display a lower risk aversion and being at an earlier stage of a life cycle, are more likely to adopt new technologies that have better yields compared to the traditional technologies. Other studies (Etoundi and Dia, 2008) in Cameroon have reported positive association between adoption of improved maize varieties and age.. Consumer-worker ratio or dependency ratio was significant ($p<0.1$) and its negative coefficient imply that a high consumer-worker ratio retards the adoption of improved maize varieties. For each unit in consumer-worker ratio, the chances of adoption decreased by a factor of 0.02. A high consumer-worker ratio is dominated by young children, elderly and sick members who are less productive on the farm and little investment goes towards purchase of inputs. Market access is an important variable in adoption decision of improved maize varieties. This is because a relatively closer distance of farmer's home to the market enables and facilitates marketing of inputs and outputs. The coefficient of distance to market had the expected negative sign and was significant (p<0.1) in explaining the likelihood of adoption of improved maize varieties. The closer the farmer was to the input market, the more likely by a factor of 0.002 was adoption of improved maize varieties and the vice versa. The higher probability of adoption of improved maize varieties associated with shorter distance to input market has also been reported by other authors (Salasya *et al.*, 2007; Langyintuo, 2008; Munyua *et al.*, 2010).. The coefficient on manure use was negative and significant (p<0.1) and decreased the probability of adoption of improved maize varieties by a factor of 0.24. Manure is generally bulky and discourages farmers from using it. Moreover, public extension services have always encouraged the use of inorganic fertilizer on maize. An earlier study in Embu district(Ouma *et al.*, 2002), however established that manure use increased the probability of adoption of improved maize varieties. This mixed results have also been reported in other studies (Amaza *et al.,* 2007). Area planted to legumes was negatively related to adoption of improved maize varieties. This may be because of competition for land to plant legumes and maize.

The second hurdle of adoption of improved maize varieties, the intensity of use was determined by different sets of variables. Some of the variables had a positive influence, while others exerted negative influence. The variables that exerted positive influence on the amount of land allocated to improved varieties were maize/legume intercropping, ownership of mobile phones and area planted under legumes. The negative factors on intensity of use of improved maize varieties were household size, remittances from relatives, manure use; area devoted to crop production, confidence in extension worker and perceived late availability of improved maize varieties. Maize/legume intercropping was found to have a positive relationship with intensity of adoption of improved maize varieties**.** Maize/legume intercropping increased the likelihood of adoption of improved maize varieties by a factor of 6. Maize/legume intercropping is considered as good means of conserving moisture and controlling pests and diseases. Comparable effects of maize/legume intercropping on the intensity of adoption of improved maize varieties are few... Increase in area planted under legumes was found to increase the intensity of adoption of improved maize varieties. This follows the fact that most farmers practice maize/legume intercropping and therefore increase in area under legumes leads to increase in area under improved maize varieties. Mobile phone was significant (p<0.05) in increasing the intensity of use of improved maize varieties. It increased the intensity of adoption by a factor of 0.7. It is possible to obtain useful information pertaining to agricultural technologies use and in this respect could lead to expansion of area under improved maize varieties because of certainty of information. Household size had a significant (p<0.01) and negative influence on intensity of adoption of improved maize varieties. A unit increase in household size resulted in a decrease in intensification by a factor of 1.2. It is difficult to generalize the influence of family size on intensification since positive and negative effects have been reported. The family members may be supportive or non-supportive towards adoption of new technology. Adoption of new technology requires more labour inputs(Feder *et al.*, 1985). If this requirement is fulfilled by the family members, intensity of adoption of improved maize varieties is likely to increase. It is also likely that farmer with larger families attach greater importance to non-farm activities than smaller households (Amaza *et al.*, 2007). Farmers with larger family size have fewer resources to invest on farm inputs since most of the resources is tied on meeting food obligations. Remittances from relatives was significant (p<0.01) and negative in explaining the intensity of improved maize varieties. Receipt of remittances from relatives reduced the intensity of improved maize varieties by a factor of 4.4. Given, the high household size, it is possible that the amounts of remittances received are meager and irregular to support investment in farm inputs such as expansion of area under improved maize varieties. As was noted previously with respect to the probability of adoption of improved maize varieties, manure use negatively affected the expansion of area under improved maize varieties by a factor of 4.1. Manure is bulky and thus its use on a large area of improved maize varieties is a disincentive. Rarely are farmers perceptions included in the analysis of adoption of agricultural technologies. This study included three variables namely price of seed and grain price and timely availability of seed. Among the three variables, untimely available of improved maize varieties was significant (p<0.10) and negative in explaining the adoption of improved maize varieties. The feeling of late availability of seed reduced the by a factor of 2.5 the area allocated to improved maize varieties.

**Table 2: Estimates of the double hurdle model for adoption of improved maize varieties**

| Variable description | Probit (D) | | | Truncated (Y.>0) | | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **Robust Std. Err.** | **dy/dx** | **Coefficient.** | **Robust Std. Err.** | **dy/dx** |
| Gender of head 1=male | 0.075 | 0.463 | 0.00035 | 0.013 | 0.014 | 0.01321 |
| Age of head in years | -0.058*** | 0.016 | - | -0.000 | 0.001 | - |

| Variable description | Probit (D) | | | Truncated (Y.>0) | | |
|---|---|---|---|---|---|---|
| | Coefficient | Robust Std. Err. | dy/dx | Coefficient. | Robust Std. Err. | dy/dx |
| | | | 0.00025 | | | 0.00004 |
| Household size ( adult equivalent) | 0.051 | 0.097 | 0.00023 | -0.012*** | 0.004 | -0.01207 |
| Education of head | -0.029 | 0.040 | -0.00013 | -0.002 | 0.002 | -0.002 |
| Consumer/Worker Ratio | -0.846* | 0.499 | -0.00378 | 0.007 | 0.021 | 0.00733 |
| Salary of household member 1=Yes | -0.071 | 0.608 | -0.00034 | 0.002 | 0.015 | 0.00219 |
| Remittances from relatives 1=Yes | 0.238 | 0.413 | 0.00086 | -0.044*** | 0.017 | -0.04381 |
| Livestock(Tropical Livestock Unit) | 4.565*** | 1.475 | 0.02009 | 0.003 | 0.041 | 0.00295 |
| Adoption of inorganic fertilizer 1 =Yes | 1.164*** | 0.403 | 0.02820 | 0.043 | 0.029 | 0.04295 |
| Adoption of manure 1 =Yes | -0.811* | 0.483 | -0.00243 | -0.041** | 0.017 | -0.04119 |
| Maize/legume intercropping 1=Yes | 0.517 | 0.409 | 0.00262 | 0.060*** | 0.014 | 0.05984 |
| Crop area in acres | 2.566* | 1.373 | 0.01129 | -0.296*** | 0.063 | -0.29583 |
| Member of farmers group 1=Yes | 0.575* | 0.339 | 0.00422 | -0.005 | 0.013 | -0.00461 |
| Previous Extension visits | 0.644** | 0.329 | 0.00359 | -0.004 | 0.012 | -0.00439 |
| Confidence in extension worker 1=Yes | 0.228 | 0.344 | 0.00114 | -0.023* | 0.012 | -0.023 |
| Mobile phone 1=Yes | 0.018 | 0.341 | 0.00008 | 0.007** | 0.015 | 0.00708 |
| Radio 1=Yes | -0.134 | 0.408 | -0.00051 | 0.035** | 0.016 | 0.03455 |
| Distance to extension office (walking minutes) | 0.008*** | 0.003 | 0.00003 | -0.000 | 0.000 | -0.00012 |
| Distance to main input market (walking minutes) | -0.004* | 0.002 | -0.00002 | -0.000 | 0.000 | -.000107 |
| Late seed availability 1=Yes | 0.216 | 0.377 | 0.00084 | -0.025* | 0.013 | -0.0249 |
| High grain price 1=yes | -0.142 | 0.372 | -0.00066 | -0.015 | 0.014 | -0.01537 |
| Perceived lower maize seed price 1=Yes | -0.405 | 0.309 | -0.00174 | 0.014 | 0.013 | 0.01377 |
| Value of assets (KES) | 0.460 | 0.344 | 0.00202 | -0.012 | 0.010 | -0.01214 |
| Dummy for Embu district 1=Embu | 1.788*** | 0.504 | 0.00887 | 0.075*** | 0.018 | 0.07514 |
| Dummy for Meru South 1=Meru South | 1.457*** | 0.402 | 0.005683 | 0.057*** | 0.015 | 0.05731 |
| Intercept | -1.332 | 1.293 | | 0.502*** | 0.053 | |
| Wald $\chi^2$(26) | 47.900 | | | | | |
| Log Likelihood | -31.634 | | | 273.205 | | |
| R2 | 0.475 | | | - | | |
| Number of observations | 314 | | | 236 | | |

## 4. Conclusion

Adoption of new maize varieties is important in improving food security. The results of the double hurdle model established that different factors determined the probability and intensity of adoption of improved maize varieties further qualifying the choice of the model. The results therefore showed that the decision to adopt or not to adopt and the choice on the area planted to improved maize varieties are independent decisions. The findings indicate that the probability of adoption were determined by several factors namely age of the household head, dependency ratio, livestock ownership, use of inorganic fertilizer and manure, area under legumes and crops, membership in farmers group, extension visits, distance to extension office and input market and geographical location. Intensity of use of improved maize varieties was influenced by different sets of factors such as maize/legume intercropping, ownership of mobile phones and area planted under legumes, household size, remittances from relatives, manure use, area devoted to crop production, confidence in extension worker and perceived late availability of improved maize varieties. These results suggest strengthening of research/extension farmer's linkage. Group based extension should be encouraged not only for their role in collective action but for their positive impact in information and technology adoption. Given the importance of distance to input and output market, it is important to improve infrastructure so as to reduce transaction cost and encourage farmers to procure inputs easily. Policies aimed at enhancing maize productivity and the adoption of improved maize by improving and maintaining the household asset base should also be central to food security strategies in Kenya.

**Acknowledgment**

The authors appreciate the funding provided by Australian Centre for International Agricultural Research (ACIAR) through Sustainable Intensification of Maize and Legumes Cropping System in Eastern and Southern Africa (SIMLESA). We acknowledge the technical support from International Centre for Maize and Wheat Improvement Centre (CIMMYT), Nairobi and Kenya Agricultural Livestock and Research Organization (KALRO). We thank the farmers for their valuable time.

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