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Full Length Research Paper

# Analysis of livelihood diversification practice to promote rural households' food security: The case of Hawassa Zuria District of Sidama Zone, Ethiopia

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**The livelihood diversification increases sources of income and smoothens consumption by promoting rural food security. In Ethiopia little attention has been given to livelihood diversification and the numerous factors that determine the abilities of rural household's choice of different livelihood activities. Thus, the objective of this study is to generate location specific data regarding the livelihood diversification and its role in attaining household's food security. A multi-stage sampling technique was used to select 191 sample households, by undertaking structured questionnaire to obtain data pertaining to livelihood diversification and its implication to food security during the year of 2016. Additionally, key informant interview, focus group discussion and observation were the principal methods used to generate data. Descriptive statistics and ordered logit regression model were used to analyze quantitative data. The result of ordered logit model showed that education level of household-head, land size of household, annual income of household head, membership of households in the organization, credit utilization, and access of extension services were significant in determining the livelihood diversification of households in the study area. On the other hand, while age and family size of households were found to be negatively correlated (P<0.5) and related to household level of livelihood diversification. Moreover, the findings of this study gave insight into factors affecting livelihood diversification and its importance to food security. Therefore, government should promote livelihood diversification in order to promote food security in the area.**

**Key words:** Education level, household size, livelihood diversification, ordered logit model, rural households.

## INTRODUCTION

Poverty is predominantly a challenging phenomenon in majority of the developing countries (Alderman, 2000). The situations are becoming worst in the sub-Saharan Africa. The region constitutes 239 million out of the world 925 million food insecure people and it is one of the world's most food-insecure region. Food insecurity continues to be a major developmental problem in the country, undermining people's health, productivity and

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often their very survival. Poverty and food insecurity continues to be mutually reinforcing, 34 million people are food insecure (FAO, 2012). The livelihood of people in Africa depends mainly on agriculture and this seems to continue in the future (Karen et al., 2013). In Ethiopia, undiversified livelihood options and complete dependency on agricultural production is also the main problems that exacerbate food insecurity in the area. The ability to diversify at all is often critical to the food security of the most vulnerable populations (Ellis, 2000). An estimated 5–6million people are considered chronically food insecure that is, they require some type of food aid to meet their minimal food requirements every year (Haan et al., 2006). Smallholder farming is the dominant livelihood activity for the majority of Ethiopians, but it is also the major source of vulnerability to poverty, food insecurity and, recurrent famines (Devereux et al., 2005).

Regardless of substantial resources invested each year by the Government and its partners to reduce food insecurity, both chronic and transitory food insecurity problems continue at the household level (FAO/WFP, 2010). According to Asmamaw (2004), the limited opportunity for livelihood diversification, due to absence of supplementary income from other non-farm activities has made the Ethiopian rural poor more vulnerable. According to Haan et al. (2006), African farmers try to diversify their livelihood strategies through on-farm and off-farm activities even though significant numbers of farmers in developing countries depend on rain fed traditional farming system that expose their production to climatic change.

Despite ample resources and agro-climatic stability for production, Ethiopia is not able to achieve food self-sufficiency yet and a significant share of the population depends on food aid. The number of people vulnerable to famine and food insecurity increases during unfavorable years of drought, (EEA, 2004/2005). Due to the growth of a population in the rural areas and the resulting consequences of sub-division and fragmentation of land, added to this the problem of drought due to erratic rainfall, deforestation, soil erosion and lack of portfolio diversification for livelihood strategies exacerbate the problem of food insecurity and poverty in many rural parts of Ethiopia (Gebre, 2005). The study area is in one of the areas severely affected by drought in the Sidama Zone. Land fragmentation, loss of soil fertility, limited access to safe drinking water, and droughts are the factors that make the population of the area susceptible to food insecurity and poverty. Most parts of the district are predominantly food insecure due to the reliance on irregular rainfall. This research work, therefore, tends to investigate the livelihood strategies and its challenges of rural farmers, and their willingness to expand their successful practices. This study provides the baseline information that will help to initiate further research work. Therefore, I seek to analyze the determinants of rural livelihood diversification based on evidence gathered from Hawassa Zuria District, Sidama Zone, Ethiopia.

## Aim and objectives of the study

This research aim to examine factors affecting the livelihood diversification strategies and the extent to which these livelihood diversification strategies contribute to the household food security.

## Specific objectives

(i) To identify the various types of livelihood diversification strategies in the study area.
(ii) To examine factors affecting livelihood diversification strategies of the households.
(iii) To analyze the extent to which livelihood diversification contributes to household food security.

## MATERIALS AND METHODS

### Description of the study area

This study was carried out in Hawassa Zuria District which is one of the 19 rural Districts in Sidama Zone of SNNPR. The study area is located at about 298 km south of Addis Ababa. It is bounded by Oromiya in the north and west, Lake Hawassa in the east and Tula Sub-city of Hawassa Town Administration and Shebedino District of Sidama Zone in the south east and Hawassa Zuria District of the Sidama Zone in the south. The District is divided into 23 rural and 3 urban Peasant Association and covers a total area of 245.15 $km^2$. From rural 23 Peasant Association, 18 are found in kolla and 5 in woina dega agro- ecological Zone respectively. Out of this population, 68,395 were men and 67,223 were women. The average population density is estimated to be 553.2 persons per square kilometer. This indicates that the District is one of the most densely populated Districts in the zone (Sidama Zonal Finance and Economic Development report, 2016). Of the total population, more than 97% were estimated to live in rural areas.

### Sample size and sampling technique

A multi-stage sampling technique was used to select District, Peasant Association and respondents for the study. Hawassa Zuria District was selected because of the greater number of people who are food insecure and on local knowledge derived from personal experience. In the first stage, the *Kebels* in the District was stratified into lowland *(Kolla)* having 18 *Peasant Associations* and mid-altitude (*Woina Dega)* having 5 *Peasant Associations.* In the second stage, four *Peasant Association* (three from *Kolla* and one from *Woina Dega* stratum respectively) were selected by using simple random sampling technique to represent each stratum. In this study, households were the major units of analysis. Therefore, the population of the study comprised the total households of the randomly selected Peasant Association. In the third stage, households were selected by using systematic sampling techniques from the sampling frame which is a complete list of households in the four Peasant Association obtained from the District Administration, Office of Finance and Economic Development and Peasant Association offices. The sample size was determined using the formula suggested by Israel (1992) as follows:


**Figure 1.** Administrative map of Hawassa Zuria District.
Source: Sidama Zone Finance and Economy Development Office Report (2016).

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision or the sampling error (0.07). Using the total number of households of 2996 of the study area, the total sample size is determined as:

$$n = \frac{N}{1 + N(e)^2} = \frac{2996}{1 + 2996(0.07)^2} = 191$$

The probability proportional to size sampling technique was employed to decide the sample size for each Peasant Association. In addition to this, to increase reliability of data, focus group discussions (FGD) were carried out in each Peasant Association with 10 to 15 participants taking into consideration community leaders, elders, religious leaders, women and youth to take care of heterogeneity and specific experience on the issue. Key informant interview was held with 15 knowledgeable key informants, which include Peasant Association administrators, Development Agents (DAs), health extension workers, District administrator, and heads of relevant District offices to supplement the household survey data.

**Econometric model**

The ordered logistic regression technique is used when the dependent variable is ordered categorical, in which case the events of dependent variable is ordered. In this study, the dependent variable is livelihood diversification, which includes income sources from both on farm and nonfarm activities; and it is categorized as follows:

a) No diversification (y1 =1 livelihood sources),
b) Two diversifications (y2 = 2 livelihood sources),
c) Three and more diversifications (y3 = 3 and more livelihood sources).

For more than one independent variable, that is for K independent variables ($X_1$, $X_2$, …… $X_k$), the ordered logit model can be written as:
Derivation of the ordered logit model can be performed as follows:

$$Prob(Yi = j|xi) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=1}^{J} e^{\beta' kxi}} \; for \; j = 0,1,2, \dots, J$$

Let y be an ordered response taking on the values {0, 1, 2. . . J} for some known integer J. The ordered logit model for y (conditional on explanatory variables x) can be derived from a latent variable model. Assume that a latent variable y* is determined by

$$y * = x\beta + e, \quad e|x \sim Normal(0,1) ----------1$$

Where $\beta$ is KX1 and, for reasons to be seen, x does not contain a constant. Let $\alpha 1 < \alpha 2 < - - - < \alpha J$ be unknown cut points (or threshold parameters), and define

y=0 if $y^* \leq \alpha 1$

y=1 if $\alpha 1 < y^* \leq \alpha 2$

y=J if $y^* > \alpha J$

Given the standard normal assumption for *e*, it is straightforward to derive the conditional distribution of y given x; we simply compute each response probability:

$$\mathrm{p}(\mathrm{y}=0|\mathrm{x}) = \mathrm{p}(\mathrm{y} * \leq \alpha 1|\mathrm{x}) = \mathrm{p}(x\beta + e \leq \alpha 1|\mathrm{x}) = \Delta(\alpha 1 - x\beta)$$
$$\mathrm{p}(\mathrm{y}=1|\mathrm{x}) = \mathrm{p}(\alpha 1 < \mathrm{y} * \leq \alpha 2\,|\mathrm{x}) = \Delta(\alpha 2 - x\beta) - \Delta(\alpha 1 - x\beta)$$
$$\mathrm{p}(\mathrm{y}=\mathrm{J}-1|\mathrm{x}) = \mathrm{p}(\alpha J - 1 < \mathrm{y} * \leq \alpha \mathrm{J}\,|\mathrm{x}) = \Delta(\alpha J - x\beta) - \Delta(\alpha J - 1 - x\beta)$$
$$\mathrm{p}(\mathrm{y}=\mathrm{J}|\mathrm{x}) = \mathrm{p}(\mathrm{y} * > \alpha J\,|\mathrm{x}) = \Delta(\alpha 2 - x\beta) - \Delta(\alpha 1 - x\beta) = 1 - \Delta(\alpha J - x\beta)$$

The parameters $\alpha$ and $\beta$ can be estimated by maximum likelihood procedures. For each i, the log-likelihood function is

$$li(\alpha,\beta) = 1[yi=0]\log[\Delta(\alpha 1 - xi\beta)] + 1[yi=1]\log[\Delta(\alpha 2 - xi\beta)] - \Delta(\alpha 1 - xi\beta)] + \cdots$$
$$+ 1[yi=J]\log[1 - \Delta(\alpha J - xi\beta)]$$

This log-likelihood function is well behaved, and many statistical packages routinely estimate ordered logit model.

$X_i = X_1, X_2, X_3$…………….. $X_n$ : are the independent variables used in the model.

$B_i = B_1, B_2, B_3$……………… $B_n$ : are the regression coefficients indicating the magnitude of change (increased or decreased participation livelihood ) in the independent variable.

By following Gujarat (2004) and Greene (2003), from the likelihood function decomposition of marginal effects was proposed as follows for ordered logit model: The marginal effects of the dependent variable can be estimated as:

$$\frac{\partial \mathrm{p}_0(\mathrm{x})}{\partial \mathrm{x}_\mathrm{k}} = -\beta_\mathrm{k}\Delta(\alpha 1 - xi\beta), \frac{\partial \mathrm{p}_\mathrm{J}(\mathrm{x})}{\partial \mathrm{x}_\mathrm{k}} = \beta_\mathrm{k}\Delta(\alpha J - xi\beta)$$

$$\frac{\partial \mathrm{p}_\mathrm{J}(\mathrm{x})}{\partial \mathrm{x}_\mathrm{k}} = \beta_\mathrm{k}[\Delta(\alpha_{J-1} - xi\beta) - \Delta(\alpha J - xi\beta), \quad 0 < j < J$$

The odds ratio $Z_i$ is the factor by which the odds change when $i^{th}$ independent variable increases by one unit. If coefficient is positive, this factor will be greater than one, which means that the odds are increased with increase in livelihood diversification. If coefficient is negative, the factor will be less than one, which means that, the odds are decreased (decreased participation of livelihood diversification opportunity); when β is zero, the factor equals one which levels the odds unchanged.

## RESULTS AND DISCUSSION

The household food accessibility index was measured using household calorie acquisition method. Household food accessibility index was computed through the analysis of quantitative data collected on food consumption pattern of the households. The amount and type of food consumed per household per week converted into amount of energy in kcl consumed per Adult Equivalent (AE) per household per day. The study revealed that out of the total sample households, about 55 % were food secured and the remaining 45% were not food secured. Of the reported reasons for food insecurity, irregular rainfall distribution accounted for 37.2, having no livelihood diversification accounted for 27.9; shortage of land accounted for 20.9 and increased family size accounted for 13.9 % (Table 1).

### Livelihood diversification from on farm income sources

Use of diversified income sources provides to build better livelihood outcomes and well-beings. Rural household life is mainly based on agricultural production but agriculture in the country is dependent on climatic situations, and a risky activity. Thus, according to the findings of Abduselam (2011) using technological inputs against risks of agriculture and diversifying both on-farm and non-farm income sources are vital to promote total annual income of HHs; thus to increase national production.

Accordingly, 56.79% income earned from crop production, 31.27% from livestock and 11.93% income earned from vegetable and fruit production (Table 2). This implied that, crop production is still taking the higher share of on-farm production. Based on respondents' engagement, annual income earned from livestock sector indicated higher than vegetable and fruit production. As reported by FGD participants, livestock were mainly used as saving in the form of live bank rather than using as annual income source. Furthermore, they were considered as a means of saving and insurance for various risks of crop production. Vegetable and fruit production, as well as earning income from this activity started new and it requires water accessibility. That was why the annual income earned is lower.

### Livelihood diversification from non farm income sources

Non-farm activities was performed to generate additional income and to minimize the probable risk of on-farm activities. Farm households of the study area were found to engage mainly in small business and renting of houses and animal power. Thus, out of the overall annual income earned, non-farm contributed 18775 Birr income. Of which, 17.27% was earned from remittances, 55.83% income earned from trade and 26.88% income earned from renting (Table 2). Even though there were respondents, who earned income from both trade and renting of houses and animal power, prioritization was

**Table 1.** Food security of living condition.

| Food security status | Frequency | % |
|---|---|---|
| Food secured | 105 | 54.97 |
| Non food secured | 86 | 45.02 |
| Total | 191 | 100 |
| | | |
| **Reasons for food insecurity** | | |
| Increased family size | 12 | 13.9 |
| Irregular rainfall distribution | 32 | 37.2 |
| No livelihood diversification | 24 | 27.9 |
| Shortage of land | 18 | 20.9 |
| Total | 86 | 100 |

Source: Own survey, 2016.

**Table 2.** Livelihood diversification from on farm and non farm income sources.

| Variable | On farm | | | | Non farm | | | |
|---|---|---|---|---|---|---|---|---|
| | Crop production | Livestock | Perennial fruit and vegetables | Total | Trade | Renting | Remittances | Total |
| Mean annual Income | 21808.35 | 12009.87 | 4582.06 | 38400.28 | 10483.48 | 5048.43 | 3243.09 | 18775 |
| %age | 56.79 | 31.27 | 11.93 | 100 | 55.83 | 26.88 | 17.27 | 100 |

Source: Own survey, 2016, Income is in a Birr, 1$=27.346 Birr.

made on the basis of the amount of income earned from the two activities. That means, higher income provide income source, which gets priority to be selected as a major income source of each respondent. Hence, most respondents perform small business to maximize their income level.

### Benefit and barriers of livelihood diversification

Of the total respondents, 31.4, 28.7, 14.6, 12.5, 9.9 and 2.6% of households found, benefit from livelihood diversification with the indicators of the households' food security status improvement, income increase, vulnerability to risk reduction, increase farm input, purchase assets increase and environmental problems reduction respectively (Table 3). This result is similar to DFID (1999) who argue that improved livelihood increases well-being, help to earn more income, reduce vulnerability, and improve food security and sustainable use of natural resources. As indicated in Table 2, the result of the study revealed that lack of working capital is the major constraint in accessing off-farm activities (Table 3). As shown in Table 3, 35.6, 21.9, 17.2, 13, and 12% of households reported that lack of credit and capital, poor asset base, lack of opportunities, fear of taking risk and lack of knowledge and awareness respectively are the major barriers for households that could impede households' participation in livelihood activities.

### Analytical analysis

This section presents the results from the logistic regression model aimed at determining the likely effects of key selected explanatory variables on livelihood diversification. The ordered Logit Regression model showed that eight out of ten variables were statistically significant ($P<0.05$) and influenced livelihood diversification.

Age of households had a negative effect on livelihood diversification. Youth became a significant predictor of livelihood diversification. This is the proportional odds ratio for a one-year increase in age on livelihood diversification level, given that the other variables in the model are held constant. Thus, for a one-year increase in age, the odds of three and more diversifications versus the combined two diversifications and no diversification categories are 0.04 times lesser, given the other variables are held constant in the model. Likewise, for a one year increase in age, the odds of the combined three and more diversifications and two diversifications versus no diversification are 0.04 times lesser, given the other variables are held constant. Thus, a one-year increase in age would result in a 2.995 unit decrease in the ordered log-odds of being in a three or more diversification

**Table 3.** Benefit and barriers of livelihood diversification.

| Variable | Frequency | % |
|---|---|---|
| **Benefit of livelihood diversification** | | |
| Increase farm input purchase | 24 | 12.5 |
| Household income increased | 55 | 28.7 |
| Food security status improved | 60 | 31.4 |
| Reduce environmental problems | 5 | 2.6 |
| Reduce vulnerability to risk | 28 | 14.6 |
| Increase household assets | 19 | 9.9 |
| | | |
| **Major barrier for livelihood activities** | | |
| Lack of credit/capital | 68 | 35.6 |
| Poor asset base | 42 | 21.9 |
| Lack of awareness and knowledge | 23 | 12.0 |
| Fear of taking risk | 25 | 13.0 |
| Lack of opportunities | 33 | 17.2 |

Source: Own survey, 2016.

categories, while the other variables in the model are held constant.

As the ordered logistic regression result indicated, family size and livelihood diversification are negatively related. The family size had the odds ratio ($e^{\beta}$=0.0011); indicating that for every increase in family size, the odds of three and more diversifications versus the combined two diversifications and no diversification categories are 0.001 times lesser, given the other variables are held constant in the model. Likewise, for an increase (by one) in family size, the odds of the combined three and more diversifications and two diversifications versus no diversification are 0.001 times lesser, given the other variables are held constant. In other ways, any increment in family size would result in a 6.755 unit decrease in the ordered log-odds of being in a three or more diversification category, while the other variables in the model are held constant. According to the results of ordered logit model, households with small family size could more readily participate in livelihood diversification. Such parents are able to provide enough land and other agricultural input resources for their children to engage in livelihood diversification, so youths are motivated to participate in livelihood diversification opportunity to fulfill their livelihood needs.

Education is also one of the factors affecting rural youth participation in livelihood diversification in the study area. The result of education level of the respondents is not different from what was assumed to have positive sign. Education of households had the odds ratio ($e^{\beta}$=2.83) indicating that for a one level increase in education, the odds of three and more diversifications versus the combined two diversifications and no diversification categories are 2.83 times greater, given the other variables are held constant in the model. Likewise, for a one level increase in education, the odds of the combined three and more diversifications and two diversifications versus no diversification are 2.83 times greater, given the other variables are held constant. In other ways, a one level increase in education would result in a 1.04 unit increase in the ordered log-odds of being in a three or more diversification category while the other variables in the model are held constant. Those households who have a higher level of education would have a higher tendency to participate in livelihood diversification.

Result of the ordered logit regression indicated, access to agricultural land for rural households also found to have a positive effect on the participation in livelihood diversification. Farm size is significant (P<0.01) and has direct association with in livelihood diversification (β= 5.651). The farm size of parents had the odds ratio ($e^{\beta}$=284.61) indicating that for a one hectare increase in farm size, the odds of three and more diversifications versus the combined two diversifications and no diversification categories are 284.61 times greater, given the other variables are held constant in the model. In other ways, a one-hectare increase in farm size would result in a 5.651 unit increase in the ordered log-odds of being in a three or more diversification category while the other variables in the model are held constant. This implies that those households who have access to farmland would participate in livelihood diversification more likely than those who have no access to agricultural land.

Households who have better access to extension services could have willing to participate in livelihood diversification than their counterparts. In the ordered logit regression model utilization of extension services is statistically significant (P<0.01) and shows a positive

**Table 4.** Ordered logistic regression estimates of factors influencing livelihood diversification.

| Variable | Coefficient | Robust standard error | Odd ratio |
|---|---|---|---|
| Sex | 1.3920 | 1.7647 | 4.0231 |
| Age | -2.9957*** | 1.6322 | 0.0499 |
| Family size | -6.7557** | 3.0857 | 0.0011 |
| Education | 1.0411 ** | 0.4055 | 2.8324 |
| Expenditure | 1.0586 | 1.6188 | 2.8824 |
| Farm size | 5.6511*** | 1.8810 | 284.61 |
| Extension service | 0.3905*** | 0.1344 | 1.4770 |
| Membership coop | 0.3295* | 0.1763 | 1.3903 |
| Credit | 8.1592** | 3.2075 | 3495.4 |
| Income | 6.1980*** | 1.1253 | 491.78 |
| /cut1\| | 10.689 | 2.4750 | |
| /cut2\| | 22.188 | 3.9590 | |
| Pseudo R2 = 0.932<br>Log pseudo likelihood = -24.2 Number of obs = 191 | | Wald chi2(10) =80.2 | Prob > chi2 =0.0000 |

***, ** and * indicate level of significance at 1, 5 and 10%, respectively.
Source: Model output (2016).

relationship with participation in livelihood diversification (β= 0.3905). The odds ratio for participation in extension service $(e)^{\beta}$ is 1.477 shows that, for households who got access to an extension service, the odds of three and more diversifications versus the combined two diversifications and no diversifications are 1.477 times greater than for counterparts, given the other variables are held constant. In other words, those who get extension service adequately have a greater probability to participate in livelihood diversification.

Membership of cooperatives was found to be positively related and but not significantly (P<0.10) affecting livelihood diversification in the study area. Farmers` organizations played an important role in organizing members into input cooperatives and in creating access to inputs. Ratio estimate of comparing effects of being membership to cooperatives on expected participation in livelihood diversification, given the other variables are held this ordered odds constant in the model. The odds ratio for having membership of cooperatives $(e)^{\beta}$ is 1.3903 shows that, for households who are members of cooperatives, the odds of three and more diversifications versus the combined two diversifications and no diversifications are 1.3903 times greater than their counterparts, given the other variables are held constant. Meaning, those households who became members of cooperatives show a greater probability to participate in livelihood diversification.

Households who have better access to credit are more likely to participate in livelihood diversification than their counterparts. In the ordered logit regression model utilization of credit is statistically significant (P<0.05) and there is a positive relationship with participation in livelihood diversification (β=8.1592). Accordingly, odds ratio for participation in extension service $(e)^{\beta}$ is 3495.4 shows that, for households who got credit service, the odds of three and more diversifications versus the combined two diversifications and no diversifications are 3495.4 times greater than for counterparts, given the other variables are held constant. In other words, those who get credit service adequately have a greater probability to participate in livelihood diversification.

Income of households is one of the factors motivating participation in livelihood diversification. Those households who get more income can fulfill their financial requirements for inputs and found to participate more in livelihood diversification. Income of households had the odds ratio (eβ=491.78) indicating that for a one unit increase in income, the odds of three and more diversifications versus the combined two diversifications and no diversification categories are 491.78 times greater, given the other variables are held constant in the model. Likewise, for a one unit increase in income, the odds of the combined three and more diversifications and two diversifications versus no diversification are 491.78 times greater, given the other variables are held constant (Table 4).

## Conclusion

The study employed observational, descriptive as well as cross sectional survey design with quantitative and qualitative methods. The result of the study indicates that 56.1% of households had diversified their activities into multiple livelihood activities, while 43.9% did not diversify livelihood activities, which means non-diversified livelihood activities of households have relied on one livelihood activity to lead healthy and productive lives. In general, diversification of livelihoods has been found to be very limited among rural households in Hawassa Zuria District. The result of ordered logit model shows that education level of household-head, land size of household, annual income of household head, membership of households in the organization, credit utilization, and access of extension service significantly determine the livelihood diversification of household in the study area; while age and family size of households were found to be negative statistically significant and related to household level of livelihood diversification. Similarly, as the level of livelihood sources or livelihood activities increases, the food security of households is improved.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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## RECOMMENDATIONS

(i) Stakeholders should motivate farm households to engage in multiple livelihood sources because this would solve household income shortfall and critical land constraints in the area.
(ii) Government should critically design situation fitting non-farm strategies that supplement farm income because land size owned by farm household regardless of its fertility level is considered as one of the key determinants of livelihood diversification.
(iii) Government should intensify its role in the country's educational system particularly in basic and vocational education to provide in rural areas.
(iv) Strengthening rural organizations, helps not only to preserve the values of a particular society but also to facilitate livelihood diversification and hence improve food security.
(v) It is strongly recommended that credit facilities should be improved and made easily accessible for households.

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*Full Length Research Paper*

# Poverty analysis of cassava farming households in Osun State

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**The study examined the poverty status as well as analysed the factors affecting poverty profile of cassava farming households in Osun State. Primary data were obtained from 180 cassava farmers by multistage random sampling with the aid of well-structured questionnaire and interview schedule. The data were analysed using descriptive statistics, Foster-Greer Thorbecke index and Tobit regression model. The results of descriptive statistics revealed that 85.6% of cassava farmers were male with majority (50.0%) between 31 and 50 years of age who were married (85.0%) with relatively large household members. The results also showed that 73.3% of them acquired farmland by inheritance and had formal education. The results of FGT analysis showed that poverty incidence was 28.9%, poverty depth was 5.3% and poverty severity was 1.5%. Meanwhile, Tobit regression model results revealed that household size, farming experience and revenue generated from cassava farms were factors affecting the poverty profile of the farming households. The study therefore recommends that farmers in the study area could reduce their poverty depth by controlling the number of child births, increase revenue generated from cassava farm and frequent.**

**Key words:** Cassava, households, poverty, Foster-Greer-Thorbecke index, Tobit regression model.

## INTRODUCTION

Agriculture has been described as the lifeblood of Africa as it employs about 70% of the workforce and generates, on average, 30% of Africa's Gross Domestic Product (GDP) (Kariuki, 2011). Agriculture is a reliable key to industrialization in Africa and has been adjudged as the most assured engine of growth and development. Nigeria has a highly diversified agroecological condition, which makes possible the production of a wide range of agricultural products such as cassava, maize, rice, etc. Cassava is grown throughout the tropics and could be regarded as the most important root crop in terms of area cultivated and total production for which Nigeria is no exception (Oriola and Raji, 2013).

Cassava (*Manihot esculenta*) is a tuberous starchy root crop of the family Euphorbiaceae (Kochlar, 1981). It is a woody shrub with an average height of one metre and has a palmate leaf formation (SESRTCIC, 2006). The crop has continually played very vital roles which include income for farmers, low cost food source for both rural and urban dwellers as well as household food security

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(Nweke, 1996). The shoots grow into leaves that constitute good vegetable rich in proteins, vitamins and minerals. It is a very important staple food consumed in different forms by millions of Nigerians (Ebukiba, 2010; Oladeebo and Oluwaranti, 2014) as well source of raw materials in many agro allied industries. Cassava, known for drought tolerance and for thriving well on marginal soils, serves as a cheap source of calorie intake in human diet and a source of carbohydrate in animal feed (Kordylas, 2002).

Nigeria is the largest producer of cassava in the world as its production is about 37.5 million metric tonnes per year (FAO, 2013). In Nigeria, cassava is generally believed to be cultivated by small scaled farmers with low resources (Ezebuiro et al., 2008). As a result, it also plays a major role in the effort to alleviate the food crisis thereby alleviating poverty. In Nigeria, rural poverty levels are relatively high. For example, a national poverty survey carried out in 2003 and 2004 indicates that the urban areas have poverty levels estimated at 43.2% while the rural areas have poverty levels that are as high as 63.8% (NBS, 2006). Poverty is a plague afflicting people all over the world and it is considered one of the symptoms or manifestations of underdevelopment (Amao et al., 2013). "Poverty is a situation where people have unreasonably low living standards when compared with others; cannot afford to buy necessities, and experience real deprivation and hardship in everyday life" (McClelland, 2000). Poverty is the main cause of hunger and malnutrition, which are aggravated by rapid population growth, policy inadequacies and inconsistencies or weak administrative capabilities, unhealthy food storage and processing techniques (Sanni, 2000). Poverty in rural communities is related to poor physical facilities, food insecurity, obsolete agricultural practices, poor nutritional value, little access to savings and credit, general inability to educate children due to high cost, irregular water supply and electricity as well as the inability to cloth oneself (Amao et al., 2013). This study therefore carried out poverty profile of cassava farming households in Osun State and the effect of incomes generated from cassava farming on the poverty profile of farming households have not been clearly defined.

## METHODOLOGY

The study was carried out in Osun State. The state is located in the south-western part of Nigeria which has the incidence of poverty of 19.5 and 80.5% for food poor and non-poor, respectively (NBS, 2010). It covers a total area of approximately 14,875 $km^2$ while the land area is about 9,251 $km^2$. There are two distinct climatic seasons which are the rainy season which exists from March to October and the dry season from November to early March. Annual rainfall average is 1570 mm while temperature ranges from 25 to 27.5°C. Osun state is agrarian state with large production of cassava tubers which is associated with soil area that is deep and well drained sandy loam (Afolami et al., 2015). Agriculture is the traditional occupation of the people of Osun State.

A multi-stage sampling technique was employed in selecting the respondents. The first stage was purposive selection of Osun State being one of the cassava producing state due to the intensity of cassava production (Afolami et al., 2015). Second stage involved random selection of 3 local government areas (LGAs) out of 6 LGAs which, according to Akande and Ogunlade (2009), had the highest practice of cassava production in the state. The LGAs identified include Egbedore, Ife North, Orolu, Oriade, Ila and Aiyedire. Out of the six, Egbedore, Ife North LGA was randomly selected. In the third stage, 4 communities were randomly selected from each of the three LGAs. Finally, primary data collected from a cross-sectional survey of 15 cassava farmers were randomly selected from each community to give a total of 180 respondents.

To achieve the objectives of this study, descriptive statistics, poverty indices and Tobit regression model were the analytical techniques used in this study. The poverty line was set at two-third of the mean of monthly per capital expenditure. This poverty line was employed in the calculation of the measures of poverty. These measures of poverty are called p-alpha measures, the Foster-Greer-Thorbecke index (Oke, 2005; Oke and Adeyemo, 2007). The index is calculated using the formula:

$$P_x = \frac{1}{N}\sum_{i=1}^{a} \frac{(z-y_1)^a}{z} \qquad (1)$$

where N = the total population in the group of interest, Z = poverty line, N = number of individual below the poverty line, $Y_1$ = expenditures on food and non-food consumption of the household in which the individual lives, x = the degree of concern for the depth of poverty it takes on the value of 0, 1 and 2, for poverty incidence, poverty gap and poverty severity, respectively. The indices are then derived as follows:

$$P_0 = \frac{1}{N}\sum_{i=1}^{a} \frac{(z-y_1)^0}{z} \qquad (2)$$

$$P_1 = \frac{1}{N}\sum_{i=1}^{a} \frac{(z-y_1)^1}{z} \qquad (3)$$

$$P_2 = \frac{1}{N}\sum_{i=1}^{a} \frac{(z-y_1)^2}{z} \qquad (4)$$

Three poverty measures can be calculated based on three values of x.

Tobit regression model was employed to analyse the factors affecting poverty profile of cassava farming households. The model is stated as follows:

$q_i = p_i = βX_i + u_i$ (if $p_i > p_i^*$) (5)
$q_i = 0 = βX_i + u_i$ (if $p_i \le p_i^*$)
$_i$ = 1, 2, 3, …180

where qi is the dependent variable. It is discrete when the household is not poor and continuous when poor. $P_i$ is the depth of the intensity of poverty defined as (Z- Y/ Z), where pi* is the poverty depth when the poverty line (Z) equals the per capita household expenditure. $X_i$ is a vector of explanatory variables, $\beta$ is the vector of unknown coefficients and $u_i$ is an independently distributed error term. The independent variables specified as determinants of poverty are defined as follows:

$X_1$ = Age of household head (years)
$X_2$ = Years of education of household head
$X_3$ = Years of farming experience
$X_4$ = Household size (persons)
$X_5$ = Revenue from cassava farm (₦)
$X_6$ = Number of extension visits

**Table 1.** Distribution of farming households by socioeconomic characteristics.

| Socio-economic characteristics | Frequency | Percent | Cumulative percent |
|---|---|---|---|
| **Gender** | | | |
| Male | 154 | 85.6 | 85.6 |
| Female | 26 | 14.4 | 100.0 |
| **Age** | | | |
| Below 30 | 20 | 11.1 | 11.1 |
| 31-40 | 34 | 18.9 | 30.0 |
| 41-50 | 56 | 31.1 | 61.1 |
| 51-60 | 36 | 20.0 | 81.1 |
| 61-70 | 33 | 18.3 | 99.4 |
| Above 70 | 1 | 0.6 | 100.0 |
| **Marital status** | | | |
| Single | 11 | 6.1 | 6.1 |
| Married | 153 | 85.0 | 91.1 |
| Widowed | 13 | 7.2 | 98.3 |
| Separated | 3 | 1.7 | 100.0 |
| Total | 180 | | |
| **Household size (Persons)** | | | |
| Below 6 | 85 | 47.2 | 47.2 |
| 6-10 | 94 | 52.2 | 99.4 |
| Above 10 | 1 | 0.6 | 100 |
| **Level of education** | | | |
| Did not go to school | 61 | 34.4 | 34.4 |
| Adult school | 6 | 3.3 | 37.8 |
| Quaranic school | 2 | 1.1 | 38.9 |
| Primary school | 45 | 25.0 | 63.9 |
| Secondary school | 60 | 33.3 | 97.2 |
| Tertiary school | 5 | 2.8 | 100.0 |
| **Years of experience** | | | |
| Below 10 | 48 | 26.7 | 26.7 |
| 11-20 | 52 | 28.9 | 55.6 |
| 21-30 | 55 | 30.6 | 86.1 |
| 31-40 | 21 | 11.7 | 97.8 |
| Above 40 | 4 | 2.2 | 100.0 |
| **Method of land acquisition** | | | |
| Inheritance | 132 | 73.3 | 73.3 |
| Lease | 36 | 20.0 | 93.3 |
| Gift | 12 | 6.7 | 100.0 |
| Total | 180 | 100.0 | |

Source: Field Survey (2015)

## RESULTS AND DISCUSSION

Table 1 shows that most of the respondents (85.6%) were male while the rest 14.6% were female. This implies that in the study area, cassava farming is dominated largely by men; hence, the economic wellbeing of farm households is largely dependent on the income earned by the men. The presence of female farmers was due to

**Table 2.** Distribution of respondents according to poverty level.

| Category | Frequency | Percent | Cumulative percent |
|---|---|---|---|
| Poor | 52 | 28.9 | 28.9 |
| Non-poor | 128 | 71.1 | 100.0 |
| Total | 180 | 100.0 | - |

Source: Data Analysis (2015).

**Table 3.** Distribution of summary of poverty indices among cassava farming household.

| Poverty level | Poverty index | Percentage | Osun State estimate | National estimate |
|---|---|---|---|---|
| Incidence ($P_0$) | 0.28889 | 28.9 | 0.1515 | 0.5053 |
| Depth ($P_1$) | 0.05388 | 5.3 | 0.0412 | 0.1974 |
| Severity ($P_2$) | 0.01485 | 1.5 | 0.0150 | 0.1030 |

Source: Data Analysis (2015); Obayelu and Awoyemi (2010).

death of male heads, migration, divorce and economic reasons (Olorunsanya and Omotesho, 2011). This result also reveals that the age distribution of respondents ranged between 28 and 78 years. The respondents that fell between 41 and 50 years are the majority with about 31.1%. This suggests that the respondents were in their economically active and productive age bracket. This is consistent with the result of Mukhtar (2012) that majority of the farmers are within 41 and 50 years age bracket.

Eighty-five percent of the household heads were married while 7.2% were widowed. Only 6.1% were single while remaining 1.7% were separated. This indicates that married people dominated the enterprise and use of family labour in various farm operations would be available. This is in line with the study carried out in Ekiti State (Toluwase and Abdu-raheem, 2013) that the married people in cassava farming accounted for 67.0% while the single were 23.0%. The distribution of respondents based on the household size reveals that the mean household size was 5.81. The majority of the respondents had between 6 and 10 members of household while 47.2% had below 6. Only 0.6% of them had above 10 members. This suggests that family labour is readily available in the household under this study. These results agree with the finding of Osinubi (2003) that members of household were mostly between 6 and 10. Moreover findings from this study show that 34.4% of the farmers did not have formal education while 65.6% had semi-formal or formal education. This suggests that a good number of the farmers in the rural areas are educated and this enable them to be more efficient and rational in farm decision making.

The number of years of experience varied from 3 to 45 years. Majority of the farmers (30.6%) had between 21 and 30 years of experience in cassava production. The mean and standard deviation of their years of experience were 20.1 and 10.7, respectively which is an indication that they have been in the production for many years and are well experienced. It was found that 73.3% of the farmers acquired their farmland by inheritance, 20.0% were through lease method while as few as 6.7% were through gift. This connotes that majority of the farmers still acquired their land by inheritance which also help to decrease the total cost of production.

## Poverty classification

The poverty status of respondents is presented in Table 2 showing different categories of households in the study area. The percentage of the poor households was about 28.9% with two-third of mean per capita expenditure being below ₦3129.74 per month while those categorized as being non-poor constituted about 71.1% of the total respondents with their two-third of mean per capita expenditure being above ₦3129.74 per month. In other words, none of the respondents fell below ₦1564.87 which is less than one-third of mean per capita expenditure.

Table 3 shows the poverty incidence, depth and severity. According to Obayelu and Awoyemi (2010), poverty incidence was 28.9% as this implies that 28.9% of the total respondents are living below the poverty line, poverty is slightly pervasive in the study area. The poverty depth was 5.3% which means that in addition to poverty being pervasive, it is considerably deeper too. This suggests that these poor households need to raise their monthly expenditure on food and non-food consumption by ₦165.88 to escape poverty. The poverty severity index was 1.5% among household respondents. The poverty severity index means that about 1.5% of the respondents were extremely poor.

This means that approximately 1 out of 70 sampled farmers are extremely poor. This result is in line with Adebayo (2013).

From the maximum likelihood estimates of the Tobit

**Table 4.** Maximum likelihood estimates of Tobit model for factors affecting poverty profile of cassava farming households in Osun State.

| Variable | Maximum likehood estimate (β) | Conditional marginal effects |
|---|---|---|
| Age of household head | -0.0035 (0.0029) | -0.0009 (0.0008) |
| Years of education of household head | -0.0049 (0.0054) | -0.0013 (0.0014) |
| Household size | 0.0868*** (0.0142) | 0.0236*** (0.0038) |
| Years of farming experience | 0.0055** (0.0026) | 0.00151** (0.0007) |
| Revenue from cassava farm | -0.00000099*** (0.0000003) | 0.0000*** (0.00000009) |
| Number of extension visits | -0.0541* (0.0320) | 0.01474* (0.00871) |
| Constant | -0.3459* (0.1704) | - |
| Sigma | 20.01 | - |
| $Chi^2$ | 83.50 | - |
| Prob>$chi^2$ | 0.0000 | - |
| Pseudo $R^2$ | 0.5793 | - |
| Loglikelihood | -30.321 | - |

***Significant at 1%, **Significant at 5%, *Significant at 10%. Figures in parentheses represent standard error.
Source: Data Analysis (2015).

regression (Table 4), the results show that the model (regression line) fits the data reasonably. The log-likelihood was -30.321 with a Chi-square value of 83.50 which was significant at 1%. This indicates that variation in poverty depth is explained by the maximum likelihood estimates of the specified explanatory variables, suggesting that the model as specified explained significant non-zero variations in factors influencing poverty depth among the respondents. The pseudo R-Square value suggests that 57.93% variation in poverty depth is explained by variations in the specified explanatory variables; hence, the model has good explanatory power on the changes in poverty depth among the respondents with 95% level of confidence.

Household size was significant and positively related to poverty depth. The result of the marginal analysis indicates that an increase in the household size by one member will likely increase the poverty depth by about 2.36%. This result is in line with Babatunde et al. (2007) who concluded that poverty increases with increase in household size. Years of farming experience was also statistically significant and positively related to poverty depth. This result suggests that a one-unit increase in the years of farming experience will likely increase the poverty depth by 0.15%. The experience is not in improved agricultural technologies that could boost their production and thereby increase their income.

On the contrary, revenue generated from cassava farming had a negative and statistically significant influence on poverty depth of the farmers. Although, the estimated coefficient of this variable was very small, but it suggests that funds from cassava farm will marginally reduce the poverty depth among the respondents. Interestingly, the number of extension visit was also statistically and negatively related to poverty depth. The implication of this is that as the number of extension contacts to the farmer increases, the poverty depth will reduce by about 1.47%. Thereby emphasizing the critical importance of capacity building through extension visits to improve income and reduce poverty level among the households. This result is consistent with Asogwa et al. (2012) that households that had access to extension services had lower probabilities of being poor.

In conclusion, the study showed that farmers were over 40 years of age with low educational status while majority of the farmers were married with relatively high household size. Almost all the farmers acquire their farm land by inheritance. Poverty is not only pervasive but also deeper and most of those who were poor were deficient on spending. Tobit regression model results revealed that household size, farming experience and revenue generated from cassava farms were factors affecting the poverty profile of the farming households. The study therefore recommends that farmers in the study area could reduce their poverty depth by controlling the number of child births, increase revenue generated from cassava farm and frequent visitations by extension agents through which there will be increase in their income and hence poverty will be greatly alleviated.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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# Determinants of agricultural technology adoption: Farm household's evidence from Niger

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**This paper investigates the determinants of agricultural technology adoption decisions taken by Nigerian farm households such as improved seeds, inorganic fertilizers and plant protection products. We use the multinomial probit model on cross-sectional data of 1395 farm households that are representative of farm household in Niger. According to the type of agricultural technology, the results showed that agricultural technology adoption decisions taken by farm households were determined by the age and education level of the farm household head, the size of the farm household, the membership of agricultural cooperative, the number of plots owned, the level of farm household income and wealth, the plot size, the types of soil on the plot, the plots located on the valley and gentle slope, and the land tenure status.**

**Key words:** Adoption, agricultural technology, farm households, multinomial probit, Niger.

## INTRODUCTION

According to the United Nations Food and Agriculture Organization (FAO, 2009), to meet people's needs of food worldwide by 2050, it is necessary to dramatically increase agricultural yields, by 70% in relation to their current level. In developing countries, production must double. This increase in agricultural yields is likely to come from the intensification of agricultural production through the use of new agricultural technologies by farmers (FAO, 2009), as the extension of agricultural land becomes increasingly difficult to achieve because of population pressure (FAO, 2012); hence the importance for farmers to adopt agricultural technologies to increase agricultural productivity (FAO, 2009). Feder et al. (1982) defined adoption at individual farmer's level as the degree at which a new technology is used in a long-run equilibrium when the farmer has full information about the technology and its potential.

According to the National Institute of Statistics of Niger (INS), in Niger State, over 80% of the population depends, to a large extent, on agricultural activities (INS, 2014). Despite the importance of the primary sector in the country's GDP, either 42.3% of GDP in 2014 (INS, 2015), Niger's population is confronted with recurrent food insecurity situations. More than 4 million people are affected by food insecurity (INS, 2013). In addition, agricultural productivity and the rate of adoption of agricultural technologies are low in Niger (Asfaw et al., 2015). To increase agricultural productivity, reduce

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poverty and ensure food security in Niger, we try to identify the factors that determine the agricultural technologies adoption decisions taken by farm households. The literature considered agricultural technologies like forage technologies, improved seeds, inorganic fertilizers, land conservation practices, tractors, stall-feeding management, and irrigation technologies with little evidence on the determinants of the plant protection products adoption. In the Nigerian's context, Asfaw et al. (2015) analyzed the determinants of adaptive capacity such as modern inputs, among others. Among the modern inputs, they considered improved seeds and inorganic fertilizers jointly without emphasizing the plant protection products. To fill this gap, in our study, we consider agricultural technologies that help mitigate the risks of crop production related to crop pests such as plant protection products in addition to agricultural technologies that increase agricultural productivity like improved seeds and inorganic fertilizers (De Janvry et al., 2010). In the existing literature, depending on the context and type of agricultural technologies considered, the determinants of the adoption of agricultural technologies are numerous and varied. From these, our question is what are the determinants of the adoption of agricultural technologies by farm households in Niger State?

The contribution of this article is multilevel. First, we use representative sample of agricultural households' data in Niger. Second, unlike most studies on the determinants of adoption of agricultural technologies, the multinomial probit model is implemented. The determinants of the adoption of agricultural technologies are perceptions of farm households of agricultural shocks like climate shocks, crop diseases, locust attack, inputs and food products prices. This article not only extends knowledge of the field by considering these shortcomings but also adds the determinants of the adoption of plant protection products. Also, among the studies carried out in Sub-Saharan Africa, there are very few studies carried out in West Africa, and more particularly in Niger. In addition, our hypothesis is there are explanatory reasons for the adoption of improved seeds, inorganic fertilizers and plant protection products by farm households in Niger.

## REVIEW OF LITERATURE

In the theoretical literature on the determinants of the adoption of agricultural technologies, there are intrinsic characteristics of technology and factors that are exogenous and endogenous to the adopter (Rosenberg, 1976; Roussy et al., 2015). The intrinsic characteristics of technology refer to the attributes of technology (Rosenberg, 1976; Roussy et al., 2015). Endogenous factors refer to the adopter's age, experience, education, income and wealth, among others. Among the factors exogenous to the adopter are geographic and climatic factors, institutional factors (Binswanger and Sillers, 1983; Byerlee and De Polanco, 1986; Caswell et al., 1990; Feder et al., 1982; Feder and Slade, 1984; Havens and Flinn, 1976; Hiebert, 1974; Leathers, 1991; Lindner et al., 1979; Yapa and Mayfield, 1978; Just and Zilberman, 1983), socio-cultural factors, political and regulatory factors (Suri, 2011), transport, irrigation, information and communication infrastructures (Feder et al., 1982; Griliches, 1957; Roussy et al., 2015; Sunding and Zilberman, 2001), soil quality, availability of water (Hiebert, 1974), land use (Bhaduri, 1973; Feder et al., 1985; Just and Zilberman, 1983; Newbery, 1975; Scandizzo, 1979) and economic profitability (Feder et al., 1982; Heady, 1952; Just and Zilberman, 1983).

In the empirical literature on the determinants of adoption of agricultural technologies related to our study, some studies analyzed the determinants of improved seeds adoption (Feder et al., 1985; Feder and Umali, 1993; Foster and Rosenzweig, 1995; Gecho and Punjabi, 2011; Kassie et al., 2011; Kohli and Singh, 1997; Minten and Barrett, 2008; Negatu and Parikh, 1999; Ogada et al., 2014; Shapiro et al., 1993; Zeller et al., 1998) and inorganic fertilizers adoption (Duflo et al., 2006; Hailu et al., 2014; Minten and Barrett, 2008; Yanggen et al., 1998) in developing countries. Some studies found that factors such as risk, uncertainty, human capital, plot size, ownership of land, access to credit and work (Feder et al., 1982) and economic profitability (Besley and Case, 1993) determine the agricultural technologies adoption in developing countries.

Foster and Rosenzweig (1995) showed that the adopters' and neighbours' experiences favour the adoption of improved seeds in India. Bindlish and Evenson (1997) found that group membership and extension services determine the adoption of agricultural technologies in Kenya and Burkina Faso. Conley and Udry (2010) and Bandiera and Rasul (2006) also found that social networks and adopters' experience determine the respective adoption of improved varieties of pineapple in Ghana and sunflower in Mozambique. Shapiro et al. (1993) found that economic profitability determines the adoption of improved varieties of millet and beans in Niger. Kohli and Singh (1997) showed that local's conditions, transport, irrigation and communication infrastructure explain the adoption of improved varieties of wheat and rice in the Punjab Region of India. Zeller et al. (1998) found, among other things, that access to credit, agricultural inputs increases the likelihood of adopting hybrid maize in Malawi. The likelihood of adopting hybrid corn declines with market access transaction costs for agricultural inputs (Zeller et al., 1998). Gecho and Punjabi (2011) showed that access to credit, the prices of agricultural inputs, the experience of the farm household's head and the possession of a radio by the farm household, among others, explain the adoption of improved maize in Damot Gale in Ethiopia. Adesina and Baidu-Forson (1995); Adesina and Zinnah

(1993) respectively showed that in Burkina Faso, Guinea and Sierra Leone, the subjective perceptions that farmers have about the characteristics of new sorghum and rice varieties affect their decisions to adopt these agricultural technologies. Negatu and Parikh (1999) found that perceptions of yield and marketing of improved wheat explain its adoption by farmers in Ethiopia. Kassie et al. (2011) found that the size of farms, access to the land market, number of parcels owned by the farm household, the farmers' education level and membership of a local agricultural organization determine the adoption of improved peanut varieties in Uganda. In addition, Duflo et al. (2006) showed that the unsuitability of chemical fertilizers for soils, the inability to save and imperfect information on the profitability and the use of chemical fertilizers explain their non-adoption in Kenya. Hailu et al. (2014) found that off-farm work and contact with vulgarization agents increase the likelihood of adopting chemical fertilizers in Ethiopia. Moreover, land tenure security, irrigation infrastructure, and access to credit increase the likelihood of adopting chemical fertilizers and improved seeds, while this probability decreases for farm households that hold livestock. Ogada et al. (2014) found, among others things, that the expectation of high yield, plot size, and the farm household head's education level determine the joint adoption of inorganic fertilizers and improved maize varieties in Kenya.

On the other hand, the high variability of yields reduces this probability of adoption of inorganic fertilizers and improved varieties of maize. Hailu et al. (2014) and Ogada et al. (2014) showed that males' heads of farm households were more likely to adopt inorganic fertilizers and improved maize than females' heads of farm households. Minten and Barrett (2008) found that literacy rate, secure land tenure and rainfall, among others, explain the adoption of chemical fertilizer, seedling transplanting, improved rice seeds and a new System of Rice Intensification (SRI) in Madagascar. Asfaw et al. (2015) showed that high climate variability and recent climate shocks reduce the likelihood of adopting modern agricultural inputs in Niger. Their results can not only be supplemented by identifying other determinants of agricultural technologies using a multinomial probit model, which requires the exploitation of appropriate data and also fills the gap on the determinants of the adoption of plant protection products.

## SURVEY DESIGN AND DATA

Data from the 2014 Survey on Farm households Living Conditions (ECVMA) conducted by the National Institute of Statistics of Niger (INS) with the support of the World Bank are used. The sample was obtained by a two-stage random draw. At the first stage, the counting areas or clusters were drawn with probabilities proportional to their size. 270 enumeration areas or clusters were selected from the 8064 enumeration areas identified in the country. At the second stage, households were drawn with equal probabilities in each enumeration area. In each enumeration area, 30 households were randomly drawn:12 urban and 18 rural households. In total, 4000 households were surveyed. The sample was representative of farm households at the national level. It included households from 8 regions of the country namely Agadez, Diffa, Dosso, Maradi, Tahoua, Tillabery, Zinder and Niamey (the capital).

The investigation was conducted on two field visits. The first visit concerned the planting period, from September to November 2014, and the second visit was made during the harvest period, from December 2014 to February 2015. Three questionnaires were administered for each visit including a household questionnaire, an agriculture/livestock questionnaire and a community questionnaire. The household questionnaire collected information on households' characteristics and socio-demographic characteristics of household members. The agriculture/livestock questionnaire collected data on access to land, plot and field characteristics, and data on perceptions of climate change, among others. The community questionnaire considered data on the existence and accessibility of social services, data on consumer prices. Given the peculiarity of the data from the two visits, the data from the two visits were merged on the corresponding variables to obtain a single database in 2014. We had also merged household, agriculture/livestock and community data on the unique identifier. In total, 4000 households were surveyed. Finally, after data processing, our sample considers 3860 households. Due to the scarcity of livestock data, our study focuses on households engaged in farming and using their plots. Finally, there were 1395 farm households operating 4978 plots.

## THEORETICAL, EMPIRICAL AND SPECIFICATION MODELS

### Theoretical model

This is the model of farm households where the farm household is rational and risk-averse (Asfaw and al., 2015; De Janvry et al., 2010; Foster and Rosenzweig, 2010, Feder et al., 1985). The objective is to maximize the utility in terms of agricultural profit expected under the constraints of agricultural technologies, constraints of income, labor, constraints of availability of land (Asfaw et al., 2015; De Janvry et al., 2010). The profit function of the farm household can be expressed as:

$$E(\Pi_{t+1}) = Pa_t Qa_t\left(La_t, Ka_{t,} Ta_t\right) - \mathrm{w}La_t - \mathrm{r}Ka_t - \mathrm{l}Ta_t \quad (1)$$

Where $E(\Pi_{t+1})$ represents the expected profit in period t+1, $P_{at}$ and $Q_{at}$, represent, respectively, the price of agricultural production and the quantity of agricultural products produced in period t. $L_{at}$, $K_{at}$, $T_{at}$ are, respectively, the labor, capital and land factors available at period t. w, r, l represent, respectively, the wage rate, the return on capital and the remuneration of the land factor. The farm household adopts agricultural technology when the expected profit is positive. This expected profit can be expressed in terms of utility. So, the decision to adopt agricultural technology comes when the utility ($U_{Ai}$) associated with the adoption of agricultural technology is greater than the utility ($U_{NAi}$) associated with the non-adoption of agricultural technology, that is, $U_{A_i} - U_{NA_i} > 0$> 0. The utility of the farm household adopting agricultural technology is $U_{A_i} = X_{A_i} + u_{\mathrm{ai}}$, and the utility of the farm household that does not adopt agricultural technology is $U_{NA_i} = X_{NA_i} + u_{\mathrm{nai}}$. The probability that the farm household i adopts the agricultural technology j on plot l is $P\left(A_{ij}^l = 1/B\,, \Sigma\right) = P\left(U_{\mathrm{Ai}} - U_{N_{Ai}} > 0\right)$ where $P\left(A_{ij}^l = 1\right) = \int_{-\infty}^{A_j} \phi\left(A_i^* / X_{i^{\mathrm{B}}}, \Sigma\right) dA_i^*$ with ϕ the probability density function of the multinomial normal distribution and Σ the variance matrix- covariance. The probability of adopting agricultural technologies according to the distribution function is:

$$P\left(A_{ij}^{l} = 1\right) = F(X'_{i}\text{B}) \quad (2)$$

Where F is the cumulative distribution function, $X_i$ represents the explanatory variables, which is the error term that is normally distributed in a multinomial fashion, whose average is zero and of variance-covariance Σ. B represents the parameters to be estimated.

### Empirical model and specification

The farm household i adopts the technology j on the parcel l ($A^{l}_{ij}$ = 1) if and only if $A_{ij}^{l^*} = U_{Ai} - U_{NAi} > 0$. Where $A_{ij}^{l^*} = U_{Ai} - U_{NAi} < 0$, farm household i does not adopt technology j on plot l ($A^{l}_{ij}$ = 1). This can be expressed as follows:

$$A_{ij}^{l} = \begin{cases} 1 & si \quad A_{ij}^{l^*} > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

$A_{ij}^{l^*}$is a latent variable that is only observed when the farm household makes the decision to adopt or not the agricultural technology. With reference to Maddala (1983), Alvarez and Nagler (1998), Powers and Xie (2000), Asfaw et al. (2015) and De Janvry et al. (2010), we assumed that $A_{ij}^{l^*}$ is a linear function of observable characteristics.

$$A_{ij}^{l^*} = aX_i + \beta Z_k + \mu G_h + u_{ikh} \quad (4)$$

$A_{ij}^{l^*}$is a function of the characteristics of the farm households $X_i$, the local characteristics $Z_k$ and the characteristics of the head of farm household $G_h$, and the error term $u_{ikh}$, which considers, among other things, the specific unobservable characteristics related to farm households. α, β, μ represent the parameters to be estimated.

To estimate this model, we used the multinomial probit because it is more appropriate to analyze the determinants of the adoption of a set of agricultural technologies (Dorfman, 1996; Alvarez and Nagler, 1998; Dow and Endersby, 2004; Teklewold et al., 2012; Asfaw et al., 2015). The variables to be explained are the dependent variables namely the adoption of improved seeds, inorganic fertilizers and plant protection products. They are discrete variables that take, respectively, the value 1 when the farm household adopts one of them and 0 if the farm household does not adopt any of these agricultural technologies. The explanatory variables are the variables considered in our model.

## RESULTS AND DISCUSSION

### Descriptive results

The definition of variables and their descriptive statistics are given in Table 1. Among 3860 households, their average age is 48 years old[1]. Men were heads of household in 83% of households, while they controlled household income in only 16% of households. More than 86% of the household's head had no level of education. On average, we had 6 persons in the household. To calculate the wealth and equipment index, we applied the principal component analysis on assets[2] and equipment[3], by keeping the two main axes, respectively. The asset or equipment considered takes the value of 1 if the household held this asset or equipment and 0 if otherwise. The adoption rate of improved seeds, inorganic fertilizers and plant protection products on plots used by farm households represent 2.86, 22.1 and 9.57% on average. The adoption rate of local seeds, crop residues and organic fertilizers is 90.17, 30.04 and 38.75% on average. The average age of the farm household's head is 47 years old. Men were heads of farm household in 90% of farm households, while they controlled farm household income in only 36% of farm households. The average area of land used by farm households was about 2.57 ha. More than 95% of the farm household's head had no level of education. On average, 71.9% of farm households owned the plots they farm.

On average, 71.33% of plots farmed by farm households were on plains. On average, 9.41 and 2.09% of farm households were affected by drought and irregular rainfall and locust attacks, respectively. Higher prices for agricultural inputs affected on average 1.96% of farm households.

### Econometric results

We presented the results of the estimation of the multinomial probit model in Table 2. In order to take into account the heterogeneity between the localities, the estimation is carried out by retaining the clusters at the commune level. The likelihood ratio test is significant at 1%. The assumption that there is a correlation between the error terms of the three equations of adoption of agricultural technologies was not rejected. The results showed a positive and significant correlation, on one hand, between adoption decisions for improved seeds and inorganic fertilizers, and, on the other hand, between decisions to adopt inorganic fertilizers and plant protection products. This means that the uses of inorganic fertilizers and plant protection products were complementary, as well as the use of improved seeds and inorganic fertilizers. These results had important implications in terms of agricultural policy.

Among the variables presented in our regression, there were some exogenous and endogenous factors that

[1] The descriptive statistic's table on the 3860 households is available on demand.

[2] The assets considered are armchair, living room, chair, table, dining table, bed, mattress, other furniture, iron, gas stove, kerosene stove, sewing machine, grinder, stove, fireplace, refrigerator, fan, air conditioner , radio, television, video recorder, decoder, car, motorcycle, bicycle, camera, musical instrument, portable, camera, wheelbarrow, computer, group and phone.

[3] Agricultural equipment considered are hoe, machete, "hilaire", shovel, pickaxe, ax, hoe, plow, cart, tractor, yoke, seeder, sprayer, motorcycle pump, powder, watering can, thresher, loft, generator, dryer, huller and livestock.

explained improved seeds, inorganic fertilizers and plant protection products, respectively. We found, moreover, that most of the estimated coefficients had expected signs. The results showed that the use of crop residues and organic fertilizers, the non-food expenditure of the farm household, as well as the membership of a farm household member in an agricultural cooperative and the locust attacks suffered by farm households had positive impact and significant at 1, 5, 5, 10 and 1%, respectively, on the likelihood of adopting improved seeds. In other words, an increase in these different factors had led to an increase in the probability of farm households adopting improved seeds. However, we found that the use of local seeds, higher education level of the farm household's head, size of the farms, drought and irregularity of rains and rise in the prices of agricultural inputs influenced negatively and in a way the probability of farm households adopting improved seeds. The substitutability relationship between the use of improved seeds and local seeds was confirmed. Negative agricultural shocks such as drought, erratic rainfall and rising prices of agricultural inputs led to a decline in the likelihood of farm households adopting improved seeds. Asfaw et al. (2015) also found that climatic variability and negative rainfall shocks led to a decrease in the probability of farm households adopting modern agricultural inputs in Niger. Farm households with plots in the valleys were more likely to adopt improved seeds than plots with gentle and steep slopes, respectively.

Moreover, we found that the use of organic fertilizers, level of secondary education of the farm household's head, farm household size, farm household non-food expenditures, as well as rising prices of agricultural inputs and wealth level of the farm household positively and significantly affected the probability of farm households adopting inorganic fertilizers. We found a complementary relationship between the use of organic and inorganic fertilizers. The same result was obtained by Marenya and Barrett (2007) in their study conducted in Kenya. On the other hand, the age and level of higher education of the farm household's head, as well as the high rate of crop diseases had a negative and significant impact on the probability of farm households to adopt inorganic fertilizers. Farm households with clay-like plots were more likely to adopt inorganic fertilizers than those with silty and glacial plots. Also, farm households whose plots were located respectively on plains and gentle slopes were less likely to adopt inorganic fertilizers than those whose plots were on the valleys. Asfaw et al. (2015) found similar results in their study on the determinants of adoption of climate change adaptation practices in Niger. On the other hand, the use of crop residues and organic fertilizers, as well as the level of wealth and number of plots held by farm households had a positive and significant influence on the probability of farm households adopting plant protection products. Thus, the probability of farm households adopting plant protection products increased, respectively, with the level of wealth and number of plots held by farm households. However, the study level of the farm household's head affected negatively and significantly the probability of farm households adopting plant protection products. According to the sex of the farm household's head, there was no difference in adopting improved seeds, inorganic fertilizers and plant protection products, respectively. There were some characteristics common to farm household that hindered inorganic fertilizers and plant protection products adoption decision.

Although the high rate of crop diseases and locust attacks on farm households had a positive impact on their likelihood of adopting plant protection products, they were insignificant. The results showed that owners and co-owners of plots were more likely to adopt plant protection products than plot occupants in the form of loans, whereas they were less likely to adopt inorganic fertilizers and improved seeds that occupy the plots as a loan.

## CONCLUSION AND POLICY IMPLICATIONS

In this study, we used the multinomial probit model on cross sectional data. The data used were representative of farm households in Niger. The results showed that the error terms of adoption decisions for improved seeds, inorganic fertilizers and plant protection products correlated. We found that the uses of inorganic fertilizers and plant protection products were complementary, as well as the use of improved seeds and inorganic fertilizers. There was interdependence, on one hand, between decisions to adopt improved seeds and inorganic fertilizers, and on the other hand, between decisions to adopt inorganic fertilizers and plant protection products. And depending on the type of agricultural technologies considered, the explanatory factors for their adoption were different.

We found that factors such as crop residues and organic fertilizer use, level of wealth and non-food expenditures of the farm household, membership in an agricultural cooperative, and locust attacks experienced by farm households favoured the adoption of improved seeds. However, factors such as the use of local seeds, higher education level of the farm household's head, size and co-ownership of plots, drought, irregular rainfall and high price of agricultural inputs hindered adoption of improved seeds. Moreover, plots located on gentle and steep slopes did not allow the adoption of improved seeds. On the other hand, factors such as organic fertilizer use, farm household's non-food expenditures, wealth and secondary education level of the farm household's head, farm household size, and high prices of agricultural inputs favoured adoption of inorganic fertilizers. The age and level of higher education of the farm household's head, ownership of plots and high rate of crop diseases did not favour the adoption of inorganic

**Table 1.** Descriptive statistics and definition of variables.

| Variable | Sample mean | Definition of variables |
|---|---|---|
| Improved seeds | 0.0286 | 1 if the farm household uses improved seeds on the plot, 0 otherwise |
| Inorganic fertilizers | 0.2210 | 1 if the farm household uses at least one of the inorganic fertilizers on the plot, 0 otherwise |
| Pesticides | 0.0957 | 1 if the farm household uses at least one of the plant protection products on the plot, 0 otherwise |
| Local seeds | 0.9017 | 1 if the farm household uses local seed on the plot, 0 otherwise |
| Culture residues | 0.3004 | 1 if the farm household uses crop residues on the plot, 0 otherwise |
| Organic fertilizers | 0.3875 | 1 if the farm household uses organic fertilizer on the plot, 0 otherwise |
| Age of head of farm household | 47.8301 | Age of the farm household's head in year |
| Head of farm household (male = 1) | 0.8990 | 1 if the head of the farm household is a man, 0 otherwise |
| No level of the farm household's head | 0.9558 | 1 if head of farm household has no education, 0 otherwise |
| Primary level of the farm household's head | 0.0384 | 1 if the head of farm household has a primary level of education, 0 otherwise |
| Secondary level of the farm household's head | 0.0040 | 1 if the head of farm household has a high school education, 0 otherwise |
| Higher level of the farm household's head | 0.0018 | 1 if the head of farm household has a higher level of education, 0 otherwise |
| Farm household size | 7.4350 | the number of people in the farm household |
| Income control (man = 1) | 0.3608 | 1 if the person controlling the income in the farm household is a man, 0 otherwise |
| Wealth index (equipment's axis) | 1.1667 | Principal component analysis on assets[4] held by the farm household, keeping the two main axis (axis 1 refer to equipment and axis 2 refer to living environment) |
| Wealth index (living environment's axis) | -0.0487 | |
| Equipment index (axis 1) | -0.9285 | Principal component analysis of equipment[5] held by the farm household, keeping the two main axis (axis 1 and 2) |
| Equipment index (axis 2) | -0.0689 | |
| Non-food expenditure per capita | 64454.7299 | Farm household's non-food expenditure per capita and per year in cfaF |
| Food expenditure per capita | 136039.9332 | Farm household's food expenditure per capita and per year in cfa F[6] |
| Number of animals kept | 5.3158 | The number of animals kept by the farm household |
| Number of plots owned | 6.7895 | The number of plots owned by the farm household |
| Member of a cooperative | 0.0983 | 1 if the farm household is a member of an agricultural cooperative, 0 otherwise |
| Agricultural advice received | 0.2467 | 1 if a member of the farm household received agricultural advice, 0 otherwise |
| Area of parcels | 25782.0407 | The area of plots in square meter ($m^2$)[7] , GPS estimate ( *Global Positioning System)* |
| Sandy | 0.7327 | 1 if the soil of the plot is sandy, 0 otherwise |
| Slimy | 0.0779 | 1 if the soil of the plot is loamy, 0 otherwise |
| Clayey | 0.1288 | 1 if the soil of the plot is clay, 0 otherwise |
| Glacis | 0.0606 | 1 if the soil of the plot is glazed, 0 otherwise |
| Valley | 0.0804 | 1 if the plot is on a valley, 0 otherwise |
| Hill | 0.0438 | 1 if the plot is on a hill, 0 otherwise |
| Plain | 0.7133 | 1 if the plot is on a plain, 0 otherwise |
| Gentle slope | 0.1488 | 1 if the plot is on a gentle slope, 0 otherwise |
| Steep slop | 0.0137 | 1 if the plot is on a steep slope, 0 otherwise |
| Property | 0.7190 | 1 if the plot is occupied as a property, 0 otherwise |
| Co-property | 0.1493 | 1 if the plot is occupied as a co-ownership, 0 otherwise |
| Leasing | 0.0173 | 1 if the plot is occupied as a rental, 0 otherwise |

[4]The assets considered are armchair, living room, chair, table, dining table, bed, mattress, other furniture, iron, gas stove, kerosene stove, sewing machine, grinder, stove, fireplace, refrigerator, fan, air conditioner , radio, television, video recorder, decoder, car, motorcycle, bicycle, camera, musical instrument, portable, camera, wheelbarrow, computer, group and phone.

[5]Agricultural equipment considered are hoe, machete, "hilaire", shovel, pickaxe, ax, hoe, plow, cart, tractor, yoke, seeder, sprayer, motorcycle pump, powder, watering can, thresher, loft, generator, dryer, huller and livestock.

[6]The monetary unit of which 1 € = 655.957 cfaF, the rate is fixed.

[7]$1m^2=10^{-4}$ha (hectare)

**Table 1.** Contd.

| | | |
|---|---|---|
| Mortgage | 0.0123 | 1 if the plot is occupied as a mortgage, 0 otherwise |
| Loan | 0.0986 | 1 if the plot is occupied as a loan, 0 otherwise |
| Drought / Irregular rain | 0.0941 | 1 if the farm household has been negatively affected by drought or irregular rainfall in the last 12 months, 0 otherwise |
| High rate of crop diseases | 0.0258 | 1 if the farm household has been negatively affected by a high t disease crop in the last 12 months, 0 otherwise |
| Locust Attack | 0.0209 | 1 if the farm household has been negatively affected by a locust attack in the last 12 months, 0 otherwise |
| Major drop in prices of agricultural products | 0.0114 | 1 if the farm household was negatively affected by a significant drop in prices of agricultural products in the last 12 months, 0 otherwise |
| High price of agricultural inputs | 0.0196 | 1 if the farm household has been negatively affected by a high price of agricultural inputs in the last 12 months, 0 otherwise |
| High price of food products | 0.0784 | 1 if the farm household was negatively affected by high food prices in the last 12 months, 0 otherwise |
| Non-family labor | 0.1227 | 1 if the farm household used non-family labor (employee) on the plot, 0 otherwise |
| mutual aid | 0.0803 | 1 if the farm household used mutual help on the plot, 0 otherwise |
| Number of observations | 4978 | |

Source: Authors, ECVMA data, 2014.

**Table 2.** Determinants of agricultural technologies adoption: multinomial probit estimates.

| Variable | Adoption decision | | |
|---|---|---|---|
| | Improved seeds | Inorganic fertilizers | Plant protection products |
| Local seeds | -1.843*** (0.00) | 0.064 (0.65) | 0.051 (0.73) |
| Culture residues | 0.909*** (0.00) | 0.092 (0.31) | 0.314** (0.02) |
| Organic fertilizers | 0.323** (0.01) | 0.351*** (0.00) | 0.350*** (0.00) |
| Age of farm household's head | 0.003 (0.55) | -0.007** (0.01) | -0.004 (0.22) |
| Head of farm household (Male = 1) | -0.305 (0.30) | -0.103 (0.43) | 0.123 (0.32) |
| Primary level of the farm household's head | -0.678 (0.25) | -0.065 (0.75) | -0.121 (0.65) |
| Secondary level of the farm household's head | -0.457 (0.36) | 0.848* (0.08) | -0.701* (0.09) |
| Higher level of the farm household's head | -3.336*** (0.00) | -5.753*** (0.00) | -3.354*** (0.00) |
| Farm household size | 0.008 (0.75) | 0.042** (0.01) | 0.008 (0.75) |
| Income Control (Male = 1) | 0.038 (0.82) | 0.081 (0.39) | -0.027 (0.84) |
| Log (non-food expenditure per capita) | 0.440** (0.02) | 0.252*** (0.01) | 0.047 (0.60) |
| Log (food expenditure per capita) | -0.239 (0.20) | -0.008 (0.93) | 0.302* (0.05) |
| Wealth index (equipment's axis) | 0.160* (0.06) | 0.055 (0.16) | -0.053 (0.18) |
| Wealth Index (living environment's axis) | -0.003 (0.96) | 0.193*** (0.00) | 0.149*** (0.00) |
| Equipment index (axis 1) | 0.016 (0.80) | 0.069 (0.15) | -0.019 (0.70) |
| Equipment index (axis 2) | 0.075 (0.35) | -0.078 (0.13) | 0.079 (0.31) |
| Number of animals kept | -0.033 (0.15) | -0.006 (0.75) | -0.026 (0.16) |
| Number of plots owned | -0.043 (0.21) | 0.005 (0.82) | 0.044** (0.04) |
| Member of a cooperative | 0.500* (0.05) | 0.182 (0.16) | 0.019 (0.93) |
| Agricultural advice received | 0.084 (0.67) | 0.066 (0.65) | 0.002 (0.98) |
| Log (area of plots) | -0.087** (0.03) | 0.025 (0.39) | 0.001 (0.95) |
| Non-family labor | -0.068 (0.71) | 0.114 (0.37) | 0.158 (0.23) |
| mutual aid | -0.186 (0.53) | 0.214 (0.13) | 0.093 (0.63) |
| Hill (reference: Valley) | -0.072 (0.81) | -0.361 (0.11) | -0.110 (0.66) |
| Plain | 0.239 (0.22) | -0.317** (0.03) | 0.002 (0.99) |
| Gentle slope | -0.671** (0.01) | -0.357*** (0.01) | -0.046 (0.77) |
| Steep slope | -3.967*** (0.00) | -0.067 (0.78) | 0.120 (0.75) |

**Table 2.** Contd.

| | | | |
|---|---|---|---|
| Sandy (reference: Clay) | -0.175 (0.26) | -0.095 (0.32) | -0.158 (0.14) |
| Silty | -0.116 (0.74) | -0.181 (0.23) | 0.249 (0.18) |
| Glacis | -0.378 (0.26) | -0.432** (0.04) | -0.002 (0.98) |
| Property (reference: Loan) | -0.183 (0.18) | -0.302** (0.04) | 0.350** (0.01) |
| Co-property | -0.524** (0.02) | -0.307 (0.17) | 0.466** (0.01) |
| Leasing | 0.582 (0.29) | -0.192 (0.44) | 0.422 (0.20) |
| Mortgage | 0.278 (0.52) | -0.248 (0.47) | 0.159 (0.67) |
| Drought / Irregular rain | -1.126** (0.05) | -0.055 (0.730) | -0.250 (0.14) |
| High rate diseases crops | -0.291 (0.38) | -1.052*** (0.01) | 0.179 (0.65) |
| Locust Attack | 1.434*** (0.00) | -0.195 (0.63) | 0.478 (0.33) |
| Major decrease in prices of agricultural products | 0.133 (0.89) | -0.117 (0.66) | -0.447 (0.16) |
| High price agricultural inputs | -4.779*** (0.00) | 0.634*** (0.01) | -0.290 (0.33) |
| High price food products | -0.548 (0.19) | 0.150 (0.43) | -0.354 (0.13) |
| atrho21 | 0.125** (0.02) | | |
| atrho31 | 0.076 (0.17) | | |
| atrho32 | 0.339*** (0.00) | | |
| Constant | -1.548 (0.51) | -3.182** (0.01) | -5.619*** (0.00) |
| Log-Likelihood pseudo | -2139.26 | | |
| Likelihood ratio test | rho21 = rho31 = rho32 =0 | chi2(3) = 56.69 | Prob> chi2 = 0.0000 |
| Dummy Regions | Yes | Yes | Yes |
| Number Observations | 3,168 | 3,168 | 3,168 |

Source: Authors, ECVMA data, 2014 P- robust values between brackets: * p<0.1; ** p<0.05; *** p<0.01.

fertilizers. In addition, plots on gentle plains and slopes and glacis plots did not encourage the adoption of inorganic fertilizers. Otherwise, we found that the use of crop residues and organic fertilizers, level of wealth, food expenses and number of plots owned by farm households, as well as the ownership and co-ownership of plots allowed adoption of plant protection products.

In terms of agricultural development policy and to promote the adoption of agricultural technologies, emphasis should be put on raising awareness and educating farm household's heads about the benefits of adopting agricultural technologies. Moreover, not only the development of the land market, but also the development of the insurance market for the management of agricultural risks must be allowed, namely drought, irregular rainfall, crop diseases and rising prices of agricultural inputs, among others. Research institutions could further develop agricultural technologies adapted to soil types, as well as soil conservation techniques. However, this paper presented as a limitation the possible recall bias due to the retrospective nature of certain questions for the respondents.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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