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International Journal of Current Research
Vol. 9, Issue, 12, pp.62095-62102, December, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

## RESEARCH ARTICLE

# BARRIERS TO AND DETERMINANTS OF THE CHOICE OF AGRICULTURAL LAND MANAGEMENT STRATEGIES TO COMBAT CLIMATE CHANGE IN DEJEN DISTRICT, NILE BASIN OF ETHIOPIA

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**ARTICLE INFO**

***Article History:***
Received 13th September, 2017
Received in revised form
20th October, 2017
Accepted 18th November, 2017
Published online 25th December, 2017

***Key words:***
Agricultural land management,
Barriers to adopting,
Determinants,
Nile Basin of Ethiopia.

**ABSTRACT**

Agriculture is the most important economic sector of many developing countries including Ethiopia. Improving agricultural land management is key to combat climate change impacts and increase crop productivity. The adoption of agricultural land management practices has been relatively low globally. Thus, there is considerable interest in understanding better the barriers, and determinants to the adoption of these practices. Stratified and snowball sampling techniques were employed to select a sample of 398 households. The household survey was employed to collect data on current adaptation strategies. Logistic regression was used to analyse the determinants of choice of adaptation strategies. Logistic regression analysis were carried out at $p \leq 0.05$. Poor access to water resources, limited knowledge and skills, shortage of farmland, lack of money, and inadequate extension services are some of the barriers to adopting agricultural land management practices. Age, gender, education farmland size, agro-ecology, income, farming experience, and total livestock units were significantly related to the choice of most of the agricultural land management practices. The results suggest that in order to increase the adoption of agricultural land management strategies, the reasons for non adoption must first be defined and addressed. Consequently emphasis needs to be placed on understanding and addressing farmers' reasons for being unable or unwilling to adopt because in many cases is not the farmers' failure as it is systems failure. Government policies and aid organizations should strengthen the current adaptation strategies used by rural communities and support less adopted adaptation strategies.



**Citation: Zerihun Yohannes Amare, 2017.** "Barriers to and determinants of the choice of agricultural land management strategies to combat climate change in Dejen district, Nile basin of Ethiopia", *International Journal of Current Research*, 9, (12), 62095-62102.

## INTRODUCTION

Agriculture is the main economic sector of many developing nations including Ethiopia. Based on IPCC (2007), in Africa between 75 and 250 million people are projected to be exposed to increased water constraints; yields from rain-fed agriculture could be reduced by up to 50% in some regions by 2020. In its Fourth Assessment Report, the IPCC concludes that global climate change has already had observable and wide-ranging effects on the environment in the past 30 years. Given the expected increase in temperature, the IPCC expects more impacts in the future (IPCC, 2007). According to Parry *et al.* (2004), adaptation has now emerged as policy priority both within and outside the climate change negotiations. The primary aim of adaptation is reducing the adverse effects of climate change through different actions that are targeted at the vulnerable system (Füssel and Klein, 2006). This implies adaptation addresses effects of climate change. In the aspects of the literature, as the confidence in climate change projections is getting higher, adaptation to combat climate change is given increasing international attention. For example, according to Mertz *et al.* (2009), developing nations have specific needs for adaptation due to high climatic vulnerabilities, and they will in this way carry a great part of the global costs of climate change and the rising atmospheric greenhouse gas concentrations are mainly the responsibility of industrialized countries. There are many reasons and convincing arguments for a more comprehensive consideration of adaptation as a response measure to climate change. Firstly, given the amount of past greenhouse gas emissions and the inertia of the climate system, the communities are already bound to some level of climate change. This can no longer be prevented even by the most ambitious emission reductions (Füssel and Klein, 2006). Second, the effect of greenhouse gas emission reductions takes several decades to fully manifest, whereas most adaptation measures have more immediate and sustainable benefits (Rahman, 2013). Third, adaptations can be effectively implemented on a local or regional scale. Its efficiency is also less dependent on the actions of international cooperation. On the other hand, mitigation of climate change

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requires international cooperation (IPCC, 2007b). Fourth, most adaptations to combat climate change also reduce the risks associated with current climate variability, which is a significant hazard in many world regions (Rahman, 2013). Both adaptation and mitigation can help to reduce the risks of climate change to nature and society (IPCC, 2007b). However, the advantage of adaptation strategies are largely local to regional in scale, but it can be immediate, especially if it also address vulnerabilities to current climate conditions (Rahman, 2013). The increasing interest in adaptation to climate change is reflected in the evolution of the theory and practice of climate change vulnerability assessments (IPCC, 2007b, Rahman, 2013). Previous study (Godfray *et al.*, 2010) show that identified adaptation measures of agricultural land management at the national levels did not necessarily translate into changes. This is because there are context specific social, financial, cultural, psychological, and physiological barriers to adaptation.

The adoption of agricultural land management practices has been relatively low globally (FAO, 2010a). In order to increase the adoption of agricultural land management strategies, the reasons for non-adoption must first be defined and addressed. Consequently, emphasis needs to be placed upon understanding and addressing farmers' reasons for being unable or unwilling to adopt because in many cases, it is not the farmers' failure as it is systems failure. Thus, there is considerable interest in understanding better the barriers, and determinants to the adoption of agricultural land management practices. Therefore, this study could fill gaps in knowledge of barriers to and determinants of the choice of agricultural land management strategies to combat climate change at grass root levels.

## MATERIALS AND METHODS

### Study area

Dejen district of Nile Basin is located in west-central Ethiopia (Fig.1) at a road distance of 335km south of the regional state capital, BahirDar, and 230 km northwest of the capital city of Ethiopia, Addis Ababa. The District lies between longitude $38^{o}$ 6' E and $38^{o}$ 10' E, and between latitude $10^{o}$ 7' N $10^{o}$ 11' N, with an elevation of 1071 and 3000 meters above sea level (m.a.s.l). The same to most parts of Ethiopia, the study area has a mixed production system with both crop and livestock rearing. Crop production is completely rainfed, except in a small number of localities where small-scale water harvesting processes have been recently introduced by the office of Agriculture and Rural Development. In the lowland parts of the district, the combination of moisture stress and poor soil fertility is the limiting factor for agricultural production (DDARDO, 2016). The climate of the district is traditionally classified based on altitude and temperature. Annual average temperature and total annual rainfall of the district range between $20^{o}$C and $24^{o}$C and 800 mm and 1200 mm, respectively. The district has been categorised into three traditional climatic zones, 41%, highland, 31 % midland and 28 % lowland (DDARDO, 2016, DDEPO, 2016).

### Research design and sampling

The study employed cross-sectional research design with both quantitative and qualitative research methods. This study used a multi-stage sampling technique to select the agro-ecology, *Kebeles* (the lower administrative unit next to district), and

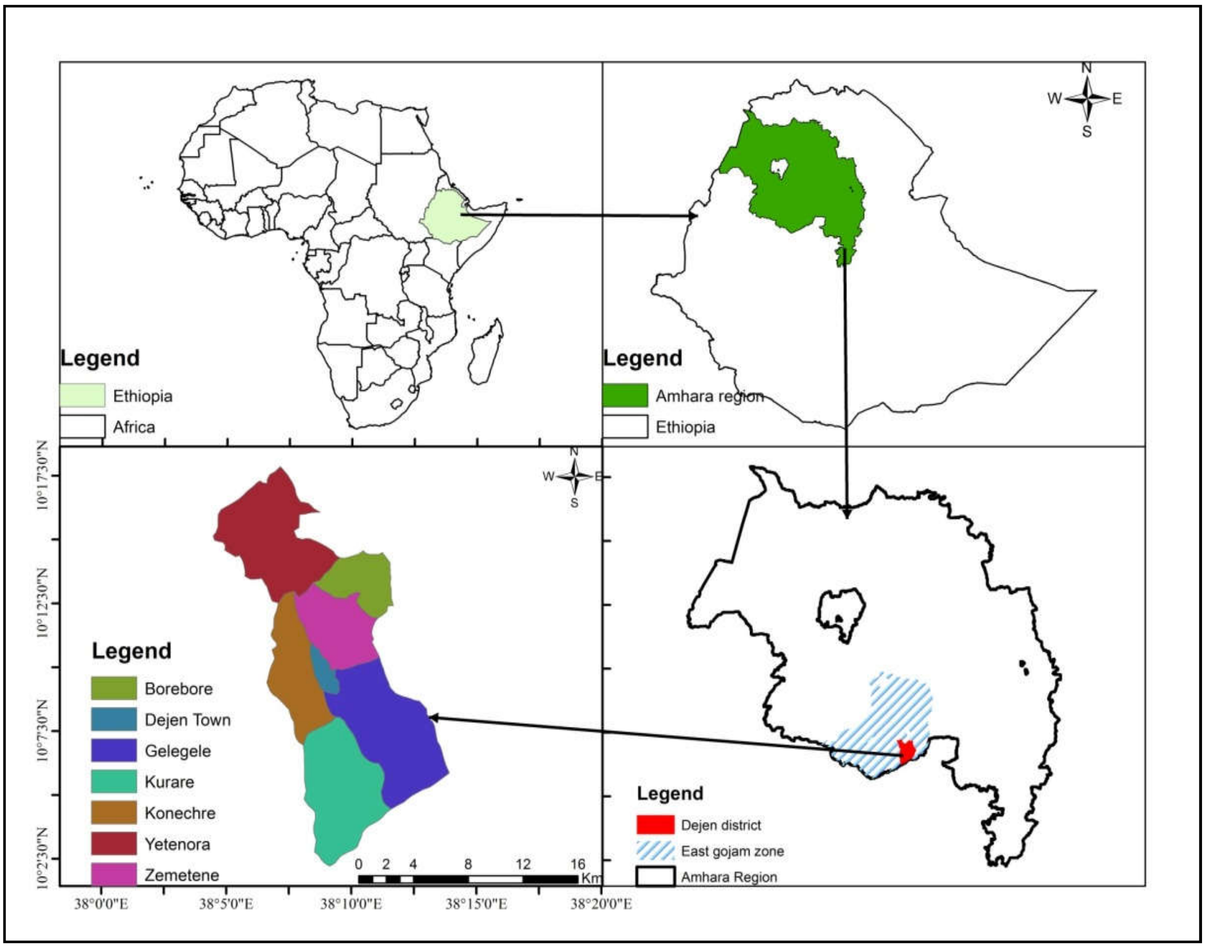


**Fig. 1. The study area**

households. At the first stage, Dejen district of the Nile Basin was selected purposely due to its highly undulated topography and frequent susceptibility to extreme events and representativeness of the three agro-ecological settings such as highland, midland, and lowland. In the second stage, six *kebeles* (two from each agro-ecological setting) were selected purposely based on the above-listed district selection criteria.

Climate change affects the rural communities differently in different agro-ecological zones. As a result, communities' knowledge and skill to adapt to the climate change impacts varies from place to place. In the third stage, stratified sampling was employed to select households. Under the stratified sampling, the population was divided into male and female-headed households, and then the sample was selected from each male and female-headed household to constitute a representative sample. The sample size was determined proportionately. In Ethiopia, in some of the rural communities, disclosing of the marital status of older females is culturally not allowed. Thus, to get female-headed households, snowball sampling was employed. Based on the formula provided by Yemane (1967) at the 95 % confidence interval and 5%, level of precision, 398 households were selected at the six *kebeles* of the district.

**Data collection**

The study used both primary and secondary data sources. The primary and secondary data sources were both quantitative and qualitative in nature. The household survey was used to collect quantitative data on households' current adaptation strategies, the barriers, and the factors that determine the choice of adaptation strategies. The survey questions were prepared in English. It was translated into local language-Amharic and then encoded into English during data processing and analysis. To assess whether the instruments were suited and appropriate to the study, the pretest of questionnaires was done from the three agro-ecological settings. After pretesting, ambiguous words were rephrased, inappropriate questions were deleted and replaced. The data was collected by the trained data collectors under the close supervision of the author in the period March to October 2016.

**Data analysis**

The descriptive statistics used in this study were percentage, mean, maximum, minimum, and frequencies to summarise and categorize the information gathered. The binary logistic regression was used to analyse determinants of the choice of agricultural land management strategies. Logistic regression method can be used when the dependent variable Y, or outcome, is dichotomous. In binary logistic regression, Y is coded as 1 when the outcome is present and Y is coded as 0, when the outcome is not present (Agresti, 2007). Analysis of the logistic regression of binary response model can be defined as:

$$y=\frac{1}{e^{-[\beta 0+\beta 1(x1)+\beta 2(x2)+\beta n(xn)}}\, e^{\beta 0+\beta 1(x1)+\beta 2(x2)+\beta 3(x3)+\beta n(xn)} \quad [1]$$

Where; y is response variable, y=1, outcome is present (adopt) y=0, outcome is not present (not adopt)

$\beta_0$ is constant

$\beta_1+\beta_2+\beta_3+\ldots\ldots\ \beta_n$ are regression coefficients that explain the change in the log odds for each unit change in x. $x_1+x_2+x_{n\ldots\ldots}$= set of predictor variables included in the model (see Table 1). $e^{\beta}$ represents the change in the odds of the outcome (multiplicatively) by increasing x by 1 unit. The current agricultural land management strategies in the study area such as manure-compost, chemical fertilizer, irrigation, water harvesting, and construction of water pond were used as dependent variables. The choices of adaptation strategies were determined by socio-economic and demographic characteristics, institutional factors, and agro-ecological setting (Table1).

**Goodness-of-Fit and Multicollinearity**

The fitness of the logistic regression model to the data was measured by applying the SPSS classification table (crosstabs), and the Hosmer-Lemeshow test. Collinearity among predictor variables was checked using multicollinearity statistics. The Hosmer-Lemeshow test used 95% confidence interval (CI) and asymptotically follows $X^2$ distribution. This condition suggests that the logistic regression model adequately fits the data. Empty cells or small frequency were checked by doing crosstabs between categorical predictor variables and the outcome variables. When the cell has very few cases, the model becomes unstable. The Hosmer-Lemeshow statistics indicate a poor fit if the significance value is less than 0.05(Kothari, 2014, SPSS, Version20). Techniques to remedy these problems were by using; 1), re-categorized (for example educational levels were categorized as cannot read & write and primary school level and above), 2), dropping the least theoretically important predictor variables that contribute to the model a poor fit to the data. For example, predictor variables such as income, access to weather information and access to credit were excluded from entering and competing in the model in the manure-compost adaptation option. 3).Partial computation, for example, all the surveyed households in the midland agro-ecology had used manure-compost adaptation option. As a result, the midland was not included in the regression model, and only the highland and lowland households were compared in the analysis. In the logistic regression model, the Exp (B) is the "Odds ratio" which explains the effect of the independent variable ($X_n$) on the dependent variable. The beta coefficient (β) is the estimated logit coefficient which is the rate of change in the Y (the dependent variables) as X (independent variable) changes. When the beta coefficient (β) is negative, it shows the dependent and independent variables have an inverse relationship, and when it has a positive coefficient, there is a positive relationship. Odds ratio=1 indicates the same probability of an event occurring between the two situations. Odds ratio>1 probability of an event occurring with a unit increase in the independent variable is higher than at original/reference variable. Odds ratio<1 probability of an event occurring with a unit increase in the independent variable is lower than at original/reference variable (See Table 1). Multicollinearity was assessed by examining tolerance and variance inflation factors (VIF). The variance inflation factor (VIF) quantifies how much the variance is inflated. The tolerance is the percentage of the variance in a given predictor that cannot be explained by the other predictors. When VIF>5, X(the explanatory variable) is highly correlated with the other explanatory variables (Kothari, 2014, SPSS, Version20). Mathematically variance inflation factor (VIF) can be expressed by:

$$\text{VIF} = \frac{1}{1-R^2 j} \quad (2)$$

Where $R^2j$ is the coefficient of determination of a linear regression model that uses Xi as the response variable and all other X variables as the explanatory variables. Tolerance is the reciprocal of VIF (i.e., Tolerance = $\frac{1}{VIF}$) (3)

A tolerance of less than 0.20 and/or a variance inflation factor (VIF) greater than5 and above indicates a multicollinearity problem. However, in this study, the results of the variance inflation factor indicated that, there was no multicollinearity problem.

## RESULTS

### Barriers to adaptation of land management strategies

Rural communities' ability to adapt is constrained by many internal and external factors. Households who did not employ adaptation strategies gave many reasons for their failure to adopt including; poor access to water sources, limited knowledge, and skill, shortage of labour, lack of and/or constraints of land, lack of money, lack of information, inadequate agricultural extension services, and other institutional factors.

**Manure-compost:** Manure-compost is prepared from livestock wastes with the help of development agents', non-governmental organizations, and model farmers' technical assistant. Some farmers also know how to use their indigenous knowledge. The majority(92.2%) of the surveyed households use manure as organic soil fertility increment strategy. Whereas, among those who did not use manure-compost explained, they did not have skill(35.7%) to make compost, shortage of labour(21.4%), small land/no land at all (39.3%) to apply manure, insignificant numbers of households(3.6%) have doubt on manure-compost to increase soil fertility.

**Table 1. Variables that affect households' choice of agricultural land management strategies to climate change**

| Explanatory variables | Description |
|---|---|
| Sex | Dummy, 1=Male*,2=Female |
| Age | Discrete, ( years), 18-35*,36-55,>55 |
| Educational level | Discrete, (years),cannot read & write*, Primary school and above |
| Farming experience | Continuous (years), <10*,10-20,21-30, >30) |
| Income | Continuous(ETB),<10,000*,10001-30000,30001-50000,>50000 |
| Family size | Discrete (number),<4*,and >4 |
| Weather information | Dichotomous, 1= Yes*, 2.=No |
| Farmer to farmer extension services | Dichotomous,1=Yes*,2= No |
| Government experts extension service | Dichotomous,1=Yes*,2= No |
| Agro-ecology setting | Dummy, 1=highland*; 2 =midland; 3= lowland |
| Farmland size | Continuous( hectare),<1.2*,and >1.2 |
| Access to credit | Dichotomous, 1= Yes*, 2.=No |
| Livestock ownership | Continuous, Tropical livestock unit(TLU) |

Note: * taken as reference (base value for analysis), ($1=22.3) Ethiopian Birr (ETB) is Ethiopian currency (NBE, 2016)

**Table 2. Parameter estimates of logistic regression model for land management practices**

| Explanatory variables | Manure-compost | | chemical fertilizer | | Irrigation | | Water harvesting | | Construction of water pond | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sig | Exp(B) | Sig | Exp(B) | Sig | Exp(B) | Sig | Exp(B) | Sig | Exp(B) |
| Sex_HHH(1) | 0.086 | 2.968 | .096 | .275 | .194 | .194 | .012 | .301 | .178 | .435 |
| Age_HHH | 0.039 | | .018 | | .833 | .833 | .093 | | .903 | |
| Age_HHH(1) | 0.027 | 3.879 | .021 | 6.280 | .545 | .545 | .043 | 5.554 | .702 | .741 |
| Age_HHH(2) | 0.553 | 0.456 | .435 | .367 | .676 | .676 | .216 | 3.485 | .656 | .625 |
| Edu_HHH(1) | 0.569 | 0.734 | .004 | .135 | .335 | .335 | .683 | 1.184 | .199 | 1.944 |
| Farm_exp_HHH | 0.104 | | .096 | | .862 | .862 | .264 | | .577 | |
| Farm_exp_HHH(1) | 0.085 | 3.343 | .091 | 5.006 | .854 | .854 | .631 | .725 | .897 | 1.116 |
| Farm_exp_HHH(2) | 0.205 | 2.827 | .354 | 2.527 | .459 | .459 | .201 | .417 | .832 | .821 |
| Farm_exp_HHH(3) | 0.064 | 12.502 | .043 | 12.233 | .664 | .664 | .846 | 1.155 | .418 | 2.272 |
| Income_HHs | N/C | N/C | .087 | | .879 | | .721 | | .342 | |
| Income_HHs(1) | | | .038 | 4.744 | .797 | .871 | .766 | 1.396 | .166 | .323 |
| Income_HHs(2) | | | .028 | 10.306 | .806 | 1.154 | .469 | 2.251 | .077 | .194 |
| Income_HHs(3) | | | .060 | 9.170 | .797 | 1.163 | .678 | 1.613 | .102 | .220 |
| Family_size_HHs(1) | 0.438 | 1.812 | N/C | N/C | .407 | 1.311 | .167 | .543 | .860 | .904 |
| Weather_inf_HHH(1) | N/C | N/C | N/C | N/C | .226 | 1.557 | .966 | .982 | .802 | 1.155 |
| Farmer to farmer extension (1) | 0.911 | 0.917 | .662 | 1.441 | .084 | .580 | N/C | N/C | .677 | 1.243 |
| Government expert.extension(1) | 0.083 | 0.317 | .784 | .819 | .195 | .637 | .073 | .439 | .070 | .325 |
| Agro_ecol_HHs | 0.473 | | .245 | | .000 | | .028 | | .339 | |
| Agro_ecol_HHs(1) | N/C | N/C | .160 | 6.331 | .000 | 4.262 | .016 | 2.942 | .274 | 1.898 |
| Agro_ecol_HHs(2) | 0.221 | 1.924 | .655 | .742 | .000 | 5.574 | .841 | .890 | .608 | .703 |
| Farm_landsize(1) | 0.049 | 3.666 | .279 | 2.312 | .130 | 1.637 | .011 | 3.149 | .320 | 1.750 |
| TLU-HHs | 0.002 | | | | | | | | | |
| TLU-HHs(1) | 0.001 | 10.1 | N/C | N/C | N/C | N/C | N/C | N/C | N/C | N/C |
| TLU-HHs(2) | 0.028 | 4.696 | N/C | N/C | N/C | N/C | N/C | N/C | N/C | N/C |
| Access to credit | N/C | N/C | .108 | .211 | N/C | N/C | .586 | 1.518 | N/C | N/C |
| Constant | 0.608 | 0.541 | | 3.956 | | | .010 | .020 | .195 | .176 |

Source: Computed based on household survey data, March-October (2016), **Notes**: ***HHH***-*Household head,* ***HHs***-*Households,* ***TLU***-*Tropical livestock unit,* ***N/C***-*Not computed*

**Chemical fertilizers:** Artificial fertilizer is one of the government agricultural input packages in Ethiopia. For this reason, the majority (93.7%) of rural households use fertilizer to their farmland. However, some households did not apply chemical fertilizers due to some barriers. Do not have land/small land size (30.9%) (Because of not all land types use chemical fertilizer), lack of information, preference, and topography of farmland location contributes 4.5% each.

**Irrigation:** In the surveyed households only 18.8 % of households used irrigation as adaptation strategy. The majority (84.6%) of households explained lack of farmlands access to irrigation, and insignificant number of households were; shortage of money (0.6%) and labour (2.5%) to divert and use the water, lack of skills (1.5%) and suitability of their farmland location (0.3%) to use irrigation as adaptation to combat climate change impacts and others did not have /less farmland (10.1%) with no access to irrigation water.

**Water harvesting:** In the context of rural communities, water harvesting is either the collection of run-off during the rainy season or constructing with geomembrane/synthetic membrane for agricultural production purposes. Very few households (10.8%) adopt water harvesting to combat climate change impacts. Households have different barriers to adopt water harvesting. These are; labour shortage (28.3%) to construct it, lack of skills (21.8%), and small land size with the same percentage of (21.8%), suitability and topography problems of farmland location (13.3%) and other insignificant reasons were; shortage of water (6.5%), no land at all (1.8%), lack of money (4.2%) to hire daily labour and/or to buy geomembrane, and others don't have information about water harvesting technology.

**Construction of water pond:** Pond is a body of standing water constructed by rural community households artificially for backyard vegetables and other agricultural practices in the time of inadequate rainfall. Only insignificant number of households (5.5%) pursue water pond to combat climate change impacts. Households explained that, shortage of labour (40.2%), small land size (20.1%) or no space to construct the pond, shortage of money (13.4%) to hire daily labor, lack of skills (11.3%) to construct, location of farmland (9.1%) were barriers to adopt.

### Determinants of households' choice agricultural land management strategies

Determinants of the choice of adaptation strategies were analysed using logistic regression model. The determinant factors model results along with significant levels are presented in Table (2). Analysis was carried out at $p \leq 0.05$.

### Gender of the head of household

Gender (being female headed households) has an inverse relationship (Beta,-1.20) and significant (Sig. =0.012) effect on adopting water harvesting technology. This means there is a decrease in the log of odds by 1.201. The Exp (B) of 0.301 indicates female headed households' are only 0.301 times less likely adopted water harvesting. The inverse of Exp (B) of 0.301 is 3.32 which indicate male headed households are 3.32 times more likely to adopt water harvesting than female headed households. Gender (male household heads are likely to pursue construction of ground water ponds but it has not significant effect.

### Age of the household head

Age, farmland size, and livestock ownership in total livestock unit (TLU) have a significant effect on households' choice of manure-compost as an adaptation strategy (Table 2). Compost is prepared from animal manure, weeds, plant leaves, and crop residues. Age has a significant effect on adopting the application of manure-compost (Sig. = 0.002) at adult household head (HHH1). There is an increase (Beta=+1.356) in the log of odds by 1.356 in adult households head. Adult head households (HHH1) Exp (B) of 3.879 times more likely to use manure-compost than young age (18-35) and old age (>55) household heads. Adult head households (HHH1) has a significant effect (Sig. =0.021) on adopting chemical fertilizer. Age of the household head is assumed to have a close association with farming experience. There is an increase (Beta = +1.837age 36-55) in the log of odds by 1.837. Adult (36-55) head households (HHH1) Exp (B) of 6.280 times more likely use chemical fertilizer than young (age 18-35) head households and old(age>55) household heads (HHH2). Age (36-55 years) has a positive and significant (Sig. =0.043) effect on adopting water harvesting technology. Old headed households have a positive relationship but no significant effect on adopting water harvesting. Age of household head (HHH1, 36-55 years) has an increase (Beta=+1.714) in the log of odds by 1.714. Adult headed households (HHH1) Exp (B) of 5.554 indicates adult headed households are 5.554 times more likely adopt water harvesting than young headed (age 18-35) households and old headed households (HHH2,age>55) to use water harvesting.

### Education

Educational level (Primary and above school) has an inverse and significant (Sig. = 0.004) effect on explaining the application of chemical fertilizer to their farmland. This means the logistic regression result shows households having primary school and above have an inverse relationship on adopting fertilizer (Beta,-2.00). The Exp (B) of 0.135 indicates that households who attend primary school and above are only 0.135times use chemical fertilizer. The inverse of Exp(B) of 0.135 is 7.41 indicates non-educated households are 7.41 times more likely use chemical fertilizer than households who attend primary school and above.

### Farming experience

Farming experience (>30 years) has a positive (Beta, +2.504) and significant effect (Sig. =0.043) on adopting chemical fertilizer as climate change adaptation strategy. This indicates there is an increase in the log of odds by 2.504. The Exp (B) of 12.233 indicates farmers having farm experience >30years (HHH3) are 12.233 times more likely to use chemical fertilizer than farmers having experience of <10years (HHH) and 10-20 years.

### Household Income

Income has a significant (Sig. =0.038 at (HHs1); 0.028 at (HHs2) effect on adopting of chemical fertilizer. Income has a positive relationship (Beta of (HHs1), +1.557, (HHs2), +22.333) with the application of chemical fertilizer. This means there is an increase in the log of odds by 1.557, and 2.333. The Exp (B) of 4.744 and 10.306, indicates income (HHs1) 4.744 times, income (HHs2)10.306 times more likely to use chemical fertilizer than low-income households (<10,000).

**Farmland size**

Farmland size (>1.2hectare) has a significant (Sig. =0.049) effect on adopting manure-compost. There is an increase (Beta=+1.299) in the log of odds by 1.299. The Exp (B) of 3.666 indicates households having farmland size>1.2 hectares are 3.666 times more likely adopt manure-compost than households having <1.2 hectares. Farmland size has a significant (Sig. =0.011) effect on adopting water harvesting. There is an increase (Beta=+1.147) in the log of odds by 1.147. The Exp (B) of 3.149 indicates households having farmland size>1.2 hectares, 3.149 times more likely to pursue water harvesting than households having <1.2 hectares. Farm size (>1.2 hectare) are likely to pursue construction of ground water ponds but it has not significant effect.

**Livestock ownership in total livestock unit (TLU)**

Total livestock unit has significant power in explaining the adoption of manure-compost (Sig. =0.001; 0.028). Total livestock unit has a positive relationship (Beta= (HHs1, +2.313, (HHs2, +1.547). This means there is an increase in the log of odds by 2.313 and 1.547. The Exp (B) of TLU-HHs1 of 10.1 and TLU-HHs2 of 4.696 indicates, households having total livestock unit >6(HHs2) are 4.696 times (much more) likely to use compost than households with TLU<1.

**Agro-ecological setting**

The logistic regression estimate indicated that agro-ecology has positively and significantly determined the use of irrigation to adapt climate change impacts (see Table 2). Agro-ecology has a positive (Beta of HHs1, +1.451, HHs2, +1.718) and significant effect on adopting irrigation (midland, Sig. =0.000, lowland, Sig. =0.005). This means +1.450midland households (HHs1)+1.718lowland households(HHs2) increases in the log of odds by 1.450 and 1.718. The Exp (B) of 4.262 indicates the midland households (HHs1) are 4.262 times use irrigation more likely than highland households. The Exp (B) of 5.574 indicates the lowland households (HHs2) are 5.574 times more likely adopt irrigation than the highland households. Agro-ecology has a significant effect on adopting water harvesting (midland, Sig. =0.016) and the lowland has a positive relationship with no statistically significant effect. Agro-ecology zone (HHs1, midland) in water harvesting has an increase (positive relationships, Beta= +1.079) in the log of odds by 1.079. The Exp (B) of 2.942 indicates the midland households (HHs1) are 2.942 times more likely adopting water harvesting than highland and lowland households. Agro-ecology (midland) is likely to pursue construction of ground water ponds but it has not significant effect.

## DISCUSSION

The rural communities of Dejen district adopt agricultural land management strategies to combat climate change impacts. However, there are barriers to adopt including poor access to water sources, limited knowledge, and skill, shortage of labour, lack of and/or shortage of land, lack of money, lack of information, and inadequate agricultural extension services.

Financial barriers are one of the barriers that restrict implementation of agricultural land adaptation strategies. This implies, every form of adaptation requires some direct or indirect costs. For instance, the use of water harvesting and water pond construction requires money. When geomembrane for water harvesting is available, the price may be prohibiting making it difficult for many rural households to access it. One of the possible causes of financial barriers in the study area could be due to lack of credit facilities to rural communities.

Manure-compost is a process of spreading animal manure and related residues in the field for soil fertility maintenance for enhancing sustainable agriculture. In the study area, the application of animal manure (dry animal faeces) combined with leaves and straws are important for soil fertility management. Adopting organic fertilizers like manures is widely found to have positive effects on the cop yields. For example, Hine *et al.* (2008) found that maize yields increased 100 % (from 2 to 4tones/hectare) in Kenya. The study showed that adult headed households are more likely adopt manure than young and old headed households. This implies adult headed households are more experienced than young household heads and more energetic than old household heads to employ manure-compost. Large farmland size demands the use of manure-compost. One of the drawbacks of the traditional use of manure-compost is that land for manure application is physically limited. Thus, having large farm size is more likely to adopt manure-compost. Farmers having relatively large farmlands might not afford the cost of chemical fertilizer to apply for all of their farmlands. As a result, large farmland owners have the possibility to use manure-compost than small farmland households. Besides, large farmland size of households has the potential to get animal manure, plant leaves, and crop residues for making compost. This implies, having more livestock, households are more likely to pursue manure-compost to increase their soil fertility. Studies on adaptation of climate change technologies indicate that farm size has both negative and positive effects on adoption. The effect of farmland size on technology adoption is inconclusive (Deressa *et al.*, 2009).

However, because of farm size is associated with greater wealth; it is hypothesized to increase adaptation to climate change.

Despite the negative impacts of chemical fertilizers, the current extension system of Ethiopia continues to encourage farmers to use this type of soil fertilization strategy. As a result, the majority of households adopt chemical fertilizer to increase their farm fertility and crop productivity. However, socio-economic and institutional factors determine the adoption of chemical fertilizer. The influence of age on these choices has been mixed in the aspects of the literature. Some studies found that age had no influence on a farmers' decision to participate in agricultural land management activities (Thacher *et al.*, 1996, Zhang and Flick, 2001, Bekele and Drake, 2003). Other studies (eg(Gould *et al.*, 1989, Dolisca *et al.*, 2006, Anley *et al.*, 2007) found that age is significantly and negatively related to farmers' decision to adopt. The study found that adult headed households have a significant effect on adopting chemical fertilizer. Despite the potential disadvantage, artificial fertilizer increases soil fertility by adding nutrients such as nitrogen, phosphors, and potassium. As a result, the very important focus of extension services in Ethiopia is to increase production by using more artificial fertilizer. However, in the study area, some of the elders headed rural community households did not want to use chemical fertilizer. These community groups have the ability to test the crop which was grown with chemical fertilizers and never eats crops grown with chemical fertilizer. This implies that the probability of adopting chemical fertilizer as climate chanage adptaion decreases as the age of household head getting older and vice-versa. Perhaps older farmers may be more interested in using their own traditional strategies.

Head of households who attend primary and above school has a negative relationship on the adoption of chemical fertilizer. Education is identified as one of the most important requirements to improve communities' adaptive capacity through acquiring relevant knowledge and skill (Luk, 2011, Barungi and Maonga, 2011). Better education and more farming experience improve awareness of potential benefits and willingness to participate in local natural resources management and conservation activities. However, Clay *et al.* (1998) found that education was an insignificant determinant of the choice of adoption, while Gould *et al.* (1989)found that education was negatively correlated with such decisions. The study found that head of households who attend primary and above school do not adopt chemical fertilizer to their farmland. The possible explanation would be educated households may realize the negative impact of chemical fertilizer, or it could be determined by other variables. For example, in this study households' income and farming experience has a positive and significant effect on adopting chemical fertilizer. Adaptation of agricultural technologies requires sufficient financial well-being. Studies that investigate the impact of income on adoption found a positive effect, e.g. (Deressa and Hassan, 2009). In this study finding, income has a positive and significant effect on adopting chemical fertilizer. This implies as income of households increases the likely to pursue chemical fertilizer increased. However, the third income category, the so called rich households (income>50,000) have not a significant contribution to the application of fertilizer. This might be that wealth people prefer organic food. In Ethiopia, chemical fertilizer is for the sake of food security by increasing yield of crops to the poor but for those who afford the subsidized cost of fertilizer.

Thus, people in the rich income category might realize the negative effect of chemical fertilizer and use application of both organic and inorganic fertilizer as per their need and preference. It is also argued that higher income farmers may be less risk averse and have more access to information, and a long term planning horizon (Deressa and Hassan, 2009). Irrigation is an important adaptation strategy in drought prone rural communities though its application is determined by several socio-economic and biophysical factors. Irrigation could be adopted by households who have access to water to assist in the growing of agricultural crops during inadequate rainfall. Households located in the lowland agro-ecologies have a significant and positive effect on adopting water harvesting. This implies the lowland households in the study area employed irrigation as the rain is erratic and delay in the expected rain season. Water harvesting is the collection and concentration of rainfall for direct application to the cropped area, either stored in the soil profile for immediate use or stored in a reservoir for future productive use. This can turn the inherent problems of drought and large rainfall variability into opportunities to reverse vulnerability in rain-fed agriculture in Ethiopia. Male headed households significantly affect the use of water harvesting. This implies, as it is expected, water harvesting is the work deserves for males as a culture in the study area as like any parts of Ethiopia. Adult headed households have a significant effect on adopting water harvesting. This study found adult head households and male headed households are characterized by good energy and experience to adopt agricultural land management practices to combat the impacts of climate change. Households who reside in the midland agro-ecologies have demand and ability to harvest the rain water, unlike the lowland households who are in need of water but no ability to harvest water. This is because of the lowland areas are characterized by low and erratic rainfall which lead households not to harvest water for dry spells. Large farm size significantly determines the adoption of water harvesting. This implies farmers who have relatively large farm size require water harvesting so as to diversify crops. In Ethiopia, not all crops grow in the normal rain season. There is also a possibility to use harvested water during dry season. Rural communities having water shortage and rainfall variability use water harvesting as one of climate change adaptation strategies. According to Seyoum (2010), in Ethiopia, rainwater harvesting was started as a response to the 1971-1974 droughts with the introduction of food-for-work programmes through the construction of physical structures and roof water catchment schemes. Households who have faced surface water shortage have extracted water from the deep ground for household consumption, livestock use, and agricultural practices. Excavated ponds are common practices in many dry and semi-arid areas of Ethiopia including the study area.

## Conclusion

Extreme rainfall variability has been one of the major factors to famine and environmental degradation and yield reduction in Ethiopia. Rain-fed agriculture will remain the dominant sources of stable food production and the basis for livelihoods of the majority of the rural poor in Ethiopia. As a result, rural communities adopt agricultural land management practices to combat climate change impacts. Households who did not employ adaptation strategies gave many reasons for their failure to adopt including; poor access to water sources, limited knowledge, and skill, shortage of labour, lack of and/or constraints of land, lack of money, lack of information, and inadequate agricultural extension services. On the other hand, age, gender, farmland size, agro-ecology, income, farming experience, and livestock ownership have a significant effect on the adoption of these agricultural land management strategies. Government policies should strengthen the current adaptation strategies practiced by rural community households and support the adoption of land management strategies. Besides, the less adopted adaptation strategies due to financial constraints should be subsidized by government and aid organizations. This study contributes to the academic discourse on climate change impact adaptations by providing empirical evidence to deepen understanding of the barriers and determinants that confront rural communities in their attempt to implement adaptation strategies.

## Acknowledgments

This study was sponsored by the Pan African University (PAU) a continental initiative of the African Union Commission, Addis Ababa, Ethiopia. The author would like to acknowledge Professor Johnson O. Ayoade, Dr. Ibidun O. Adelekan and, Dr. Menberu Teshome Zeleke for their contribution to supervise the project from inception to end. Further, the author would like to thank the University of Ibadan for hosting the programme, the data collectors and field assistants for their effective coordination, support, and time spent in organizing and conducting successful household interviews.

**Competing interests**

The author declares he has no competing interests.

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