Makerere University Journal of Agricultural and Environmental Sciences
Vol. 8. pp. 1 - 19, 2019
Printed in Uganda.
ISSN 1563-3721

Climate smart agriculture practices by rural women in Akwa Ibom State, Nigeria: Adoption choice using Multinomial Logit Approach

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Abstract

Women who farm in rural communities of Nigeria are typically poor and are vulnerable to events of climate change. An understanding of the Climate Smart Agriculture (CSA) practices engaged by these women is required to strengthen and improve their adaptive capacity to cope with climate change events. An empirical study was, therefore, conducted to investigate the factors influencing rural women's choice of CSA practices. Through the multistage sampling procedure, 280 rural women in Akwa Ibom State, Nigeria were selected as representative farmers. Data were collected using a semi-structured questionnaire. Multinomial Logit Model was employed to analyze the data. Analysis revealed that the most critical factors influencing rural women's choice of adopting CSA practices were age, education, frequency of extension contact, membership in a cooperative and farm size. Findings further showed that age of women farmers significantly influenced the probability of choosing to adopt crop residue mulching and improved high yielding varieties ($p<0.01$). Results also revealed that the educational level of women had a positive and significant ($p<0.05$) influence on choice of efficient use of fertilizer. Results of the study further revealed that the choice of non-adoption, cover cropping and crop residue mulching was significantly influenced by the size of farmland. Women's decision to choose agroforestry was significantly ($p<0.05$) influenced by the terrain of farmland, as farmers with steeper and slopy lands had a higher probability of choosing agroforestry. Improving women access to educational opportunities would be rational policy option for adoption of CSA practices.

Key words: Adoption, agroforestry, climate smart approaches

Introduction

Climate smart agriculture (CSA) is an integrative approach to address the inter-linked challenges of food security and climate change. Climate change is a serious challenge to sustainable crop and livestock production, and food security. According to Mutoko (2014), climate change poses new challenges to fight against poverty and achieve sustainability of agrarian livelihood in sub-Saharan Africa (SSA). Changes in rainfall patterns and increasing temperatures have impacted agricultural production. Studies by Kurukulasuriya and Rosenthal (2003) and Kurukulasuriya *et al.* (2006) suggest that climate will adversely affect agricultural production in SSA through declining crop yields and livestock productivity caused by rainfall variability, rising temperatures and increased pest/disease incidences. An empirical study by Lobell *et al.* (2011) also corroborate that losses in crop yields arising from climate change may negatively impact and thereby threaten the survival of smallholder farmers in SSA.

Though the effects of climate change are expected to vary geographically (Jost *et al.*, 2016), the poor and vulnerable smallholder farmers particularly rural women are reported to be at higher risk of negative impacts from climate change (Kakota *et al.,* 2011; Goh, 2012; Jost *et al.,* 2016). This may be connected with the fact that household responsibilities such as child care and the collection of firewood and water makes women particularly climate sensitive since they take on more agricultural work as men migrate for labour even in the face of less access to agricultural resources such as land extension services and input (Petermann *et al.,* 2010; Doss, 2011; FAO, 2011, Kakota *et al.,* 2011; Wright and Chandari, 2014). But the increasing role of rural women in small holder agricultural production provides an important opportunity to positively impact food production and security in a changing climate (Carvajal-Escobar *et al.,* 2008).

It is estimated that if rural women had equal access to agricultural resources as men, output could be increased by 20-30% and the total number of hungry people globally could be reduced by 12-17% (FAO, 2011). Farm level studies by Ghathala *et al.* (2011), Khatri-chhetri *et al.* (2011) and Sapkota *et al.* (2014) also suggest that adoption of CSA technologies can improve crop yields, increase input use efficiency and net income, and reduce green house gas (GHG) emissions. But despite the various benefits of CSA techniques (Palaanisam *et al.,* 2015), rural farmers are yet to take full advantage of CSA practices.

With a population of 150 million, Nigeria's agriculture must undergo a significant transformation to meet the challenges of over population, climate change, poverty, and food insecurity. According to James *et al.* (2015), climate should be part of the solution in addressing the problem. Therefore, focusing practices and attention on women is an important strategy for effective decision making on the choice of adoption of these practices. Given the role of rural women in agricultural production, the constraints faceds in adopting new technologies and the challenges of climate change, it becomes imperative to study the factors influencing rural women's choice of practices. This study was conducted to empirically estimate the determinants of adoption choice of practices by rural women in southern Nigeria.

Methodology

The study was conducted in Akwa Ibom State of Nigeria. The state is in the rainforest belt and lies between latitude 4°33' and 5°53' North and longitude 7°25' and 8°25' East. The total land area in the state is 7,249 square kilometers and it has an estimated population of 3.9 million (National Population Commission, 2006). The state has 31 Local Government Areas. There are six Agricultural Project Development (ADP) zones in the state namely; Uyo, Abak, Oron, Etinan, Eket and Ikot Ekpene. Akwa Ibom State is characterized by heavy rains and the annual precipitation ranges between 2000-3000 mm. There are seasons – the rainy season of March to October and short dry season of November to February.

Selection of interviewees

Multi stage sampling technique was used to select a total of 280 rural women farmers used for the study. First, out of the 6 ADP zones were randomly selected. Secondly, villages were randomly selected per ADP zone to make a total of 4. Thirdly, 70 women were selected per village to give 280 rural women. Primary data were obtained from a cross section of the rural women using questionnaire and focus group discussion among young and adult women.

Theoretical model

To model the determinants of adoption choice of Multinomial Logit Model (MNL) was used. The model is used to analyze the factors influencing choice of CSA practices among rural women in Akwa Ibom State, Nigeria. The model was preferred because it permits the analysis of decisions across more than two categories in the dependent variable; hence it becomes possible to determine choice probabilities for the different

CSAs practices. On the contrary, the binary probit or logit models are limited to a maximum of two choice categories (Maddala, 1983). The MNL was preferred for this study due to its simplicity in computation. This MNL model was used by Ayuya *et al.* (2011).

The MNL model is expressed as follows:

P(y-/j/x) - /exp(Xbj)/[1+$\sum_{n=}^{j} \exp(x\beta_n)$j/1, 2, j].. Eq. 1

Where: y denotes a random variable taking on the values (1,2, ….j) for a positive integer j and x denote a set of conditioning variables. X is a 1 x K vector with first element unity and b_j is a KX1 vector with j = 2, ….j. In this case, y denotes Climate Smart Agriculture Practices or categories while x denotes specific household and farm characteristics of the rural women. The inherent is how changes in the household and farm specific characteristics affect the response probabilities P(y=j/x), j = 1,2,….,j. Since the probabilities must sum to unity, p(y=j/x) is determined once the probabilities for j=1,2,…., j are known. For this study, the CSA used in the study area were characterized, after which the most adopted practice by farmers (or decision categories) were identified.

The parameter estimates of the MNL model only provide the direction of the effect of the explanatory variables on the dependent (choice) variable, thus the estimates represent neither the actual magnitude of change nor the probabilities. Instead, the marginal effects are used to measure the expected change in probability of a particular technique being chosen with respect to a unit change in an independent variable from the mean (Greene, 2000). To obtain the marginal effects for the model, Equation 1 is differentiated with respect to the independent as shown in Equation 2.

$\frac{\delta P_j}{\delta X_k}$ =$P_j(\beta_{jk} - \sum_{J=1}^{J-1} P_j\beta_{jk})$.. Eq. 2

It has also been observed that the marginal effects and respective coefficients may be different (Hassan and Nhemachena, 2008) since the former depends on the sign and magnitude of all the other coefficients.

The empirical specification for examining the influence of explanatory variables which are described in Table 1 on the choice of CSA (Y) is given as follows:

Y = 1….j -/b_0+ b_1 (Age) + b_2 (Edu) + b_3(Farm Size) + b_4(Farming Exp) +b_5 (Extension) +b_6 (Land Tenure) +b_7 Terrain + $_8$ (Membership) +b_9 (Household Size) + m.. Eq. 3

Table 1. Variables used in the Multinomial Logit Model and their expected signs

Variables	Definition and measurement of variables used	Expected Sign
Age	Age in years of the farmer (continuous)	±
Education	Number of years of formal education (continuous)	±
Farm size	Size of farmland available in hectares (continuous)	±
Farming Exp.	Number of years of experience in farming (continuous)	±
Extension contact	Number of visits by extension agent (Within one cropping season) (continuous)	±
Land Tenure	Land ownership by title deed (1=owned by title deed, 0 =otherwise)	±
Terrain	Topography of the land (1=slopy & steep, 0 if otherwise)	±
Membership	If a farmer belong to an agricultural related group (1=belong to a group, 0 = otherwise)	±
Household size	Number of household members (continuous)	±

Where:

y denotes a random variable taking on the values (0,1,2,3,4) for non-negative integer j.

Y_0 = Choice of no climate smart agriculture practice
Y_1 = Choice of crop residue mulching
Y_2 = Choice of improved high yielding varieties
Y_3 = Choice of cover cropping
Y_4 = Choice of efficient use of fertiliser
Y_5 = Choice of agro forestry

Test for collinearity of variables used in the model

Multi-collinearity is one of the important econometric problems of cross sectional data analysis. It is a state of very high inter-correlations or inter-associations among the independent variables. To ensure the consistency, unbiaseness and reliability of inference about the multinomial logit model estimates, multicollinearity was tested using the variance inflation factor (VIF). The VIF has a minimum possible value of 1. Value greater than 10 indicates a probably of collinearity problem between the independent variables under consideration. VIF was estimated using the formula stated below:

VIF; $1/\{1 - R_j^2\}$

Where:

R_j^2 is the multiple correlation coefficient between the independent variable under consideration.

Results and discussion

Collinearity among specific variables

Table 2 presents the VIF result for multicollinearity between the explanatory variables used in the multinomial logit equation. No multicollinearity problem was detected. Result implies that the estimates of the multinomial logit model have minimum variance, were consistent, unbiased and statistical inference made about the data are reliable.

Socioeconomic characteristics of women

Most of the women farmers (57.14) were within the age of 20-40 years, indicating that they were within the economically active and productive age. This result is synonymous with earlier empirical studies by Edet and Etim (2014) and Etim *et al.* (2017) in their study of urban farming and its potentials for waste recycling.

About 14.29 percent of women were single as shown in Figure 2, whereas 85.71 percent were married. The result implies that by reason of marriage, most women lost their decision making ability to their husbands who take decisions to adopt agricultural technologies.

The educational background of the rural women is shown in Figure 3. The result revealed that most farmers (35.71 percent) had attained primary education and 42.86 percent had attained secondary education. This is an indication that the rural farmers were literate and therefore were faster in the adoption of innovations.

Table 2. The variance inflation factors (VIF) test result for multi collinearity of variables used in the analysis

Variable	VIF estimates
Age	1.032
Education	3.015
Farm size	2.009
Household size	1.387
Farming experience	3.020
Farming size	2.588

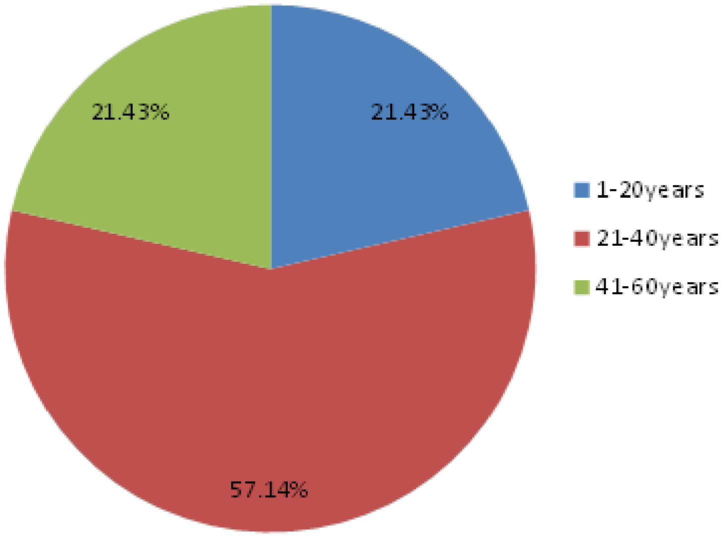

Figure 1. Age of farmers.

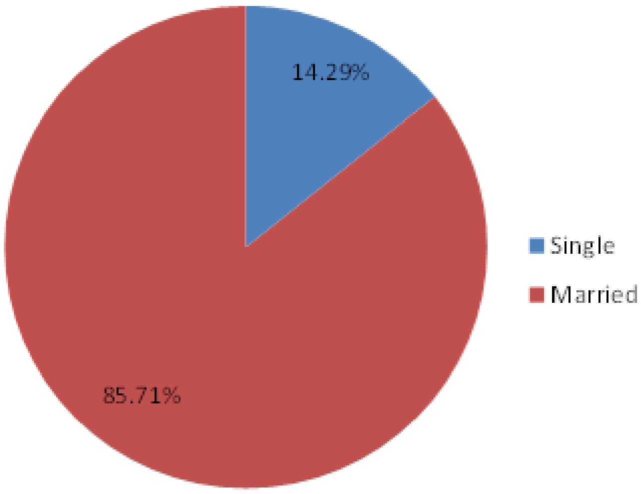

Figure 2. Marital status of farmers.

Majority of the farmers (78.5 percent) had between 11-20 years experience in farming whereas 12.5 percent had 6-10 years experience in farming (Fig. 4). About 8.93 percent had between 1-5 years experience in farming. The result implies that most women had long years of experience about successes and failures of technologies in agriculture. Overtime, experience would support overcoming challenges either by sticking to the technology or seeking new technologies for the purpose of trying them out.

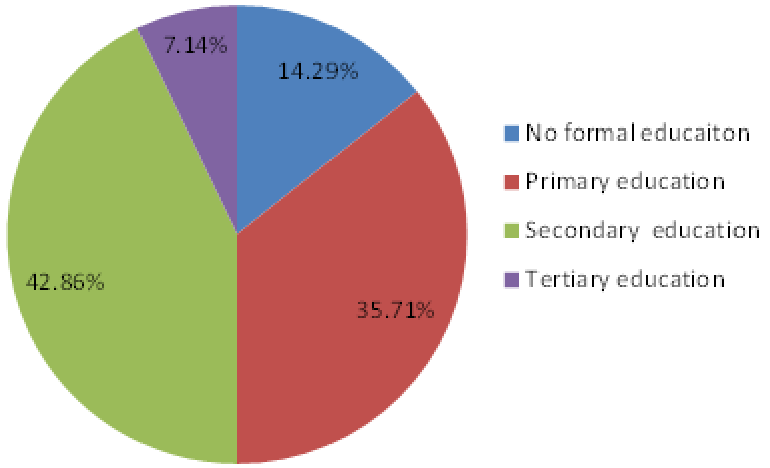

Figure 3. Educational status of farmers.

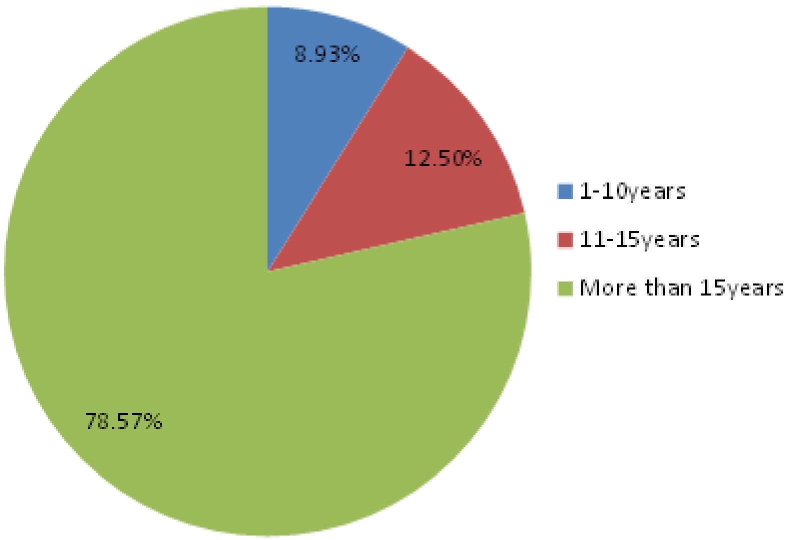

Figure 4. Farming experience of women

Figure 5 revealed that 64.29 percent of women had between 11-15 years membership in social organisation; whereas 12.5 percent had between 1-10 years membership in social organisation. About 23.21 percent of the women belonged to social organisation for more than 15 years.

The farm size of the women is shown in Figure 6. Most of the women (78.57 percent) cropped farmlands less than 1 hectare, whereas 17.86 percent cropped farms between 1 to 1.2 hectares. Only 3.57 percent of the women cultivated more 2 hectare of land. This result suggests that majority of respondents were subsistence farmers who cultivated small farm holdings mainly for family consumption. This result is in

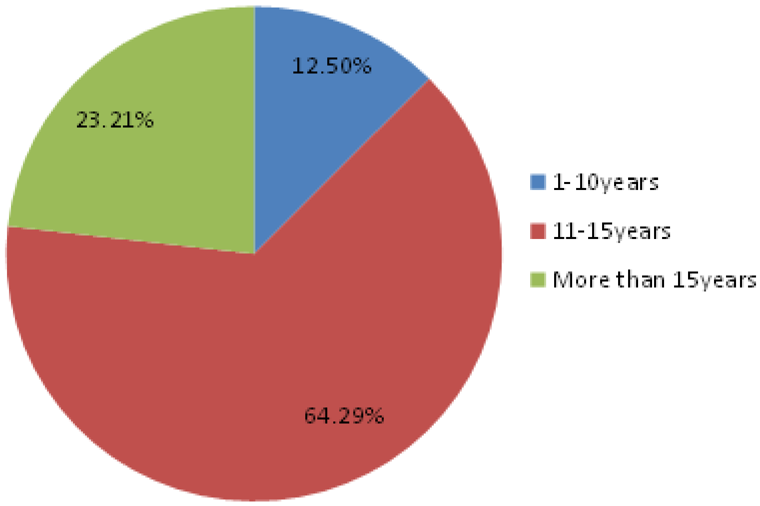

Figure 5. Membership of social organisation

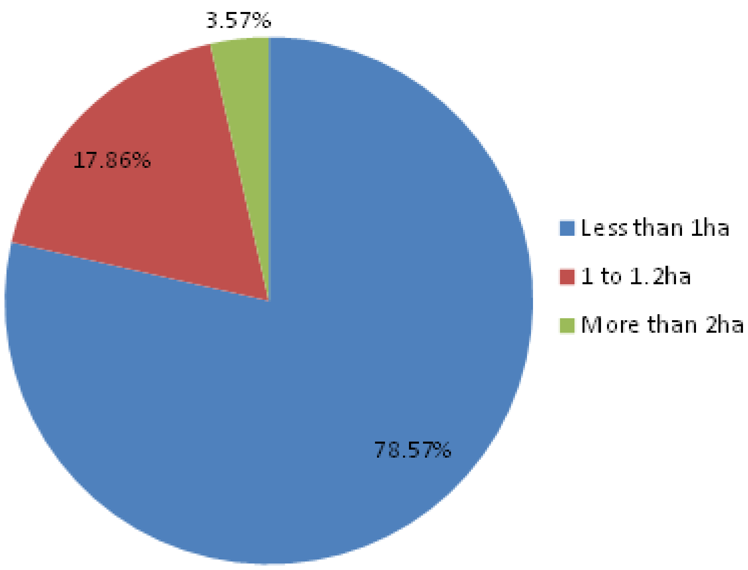

Figure 6. Farm size.

conformity with earlier empirical findings by (Etim *et al.* (2017) in their study of adoption choice of soil enhancing materials by arable crop farmers in Nigeria.

Rate of adoption of CSA practices by rural women

Figure 7 revealed the rate of adoption of the different CSA practices. From the figure, 42.86 percent of the women chose to adopt improved high yielding varieties, 17.86% choose cover cropping whereas 17.86, 15 and 17.14% of the rural women choose to adopt crop residue mulching, efficient use of fertiliser and agro forestry, respectively.

Sources of information

Figure 8 showed the different sources of information on CSA to rural women, 35.71 percent of the rural women received information on CSA through radio broadcasting, 17.86 percent in meetings and conferences, 32.14 percent through friends, relatives

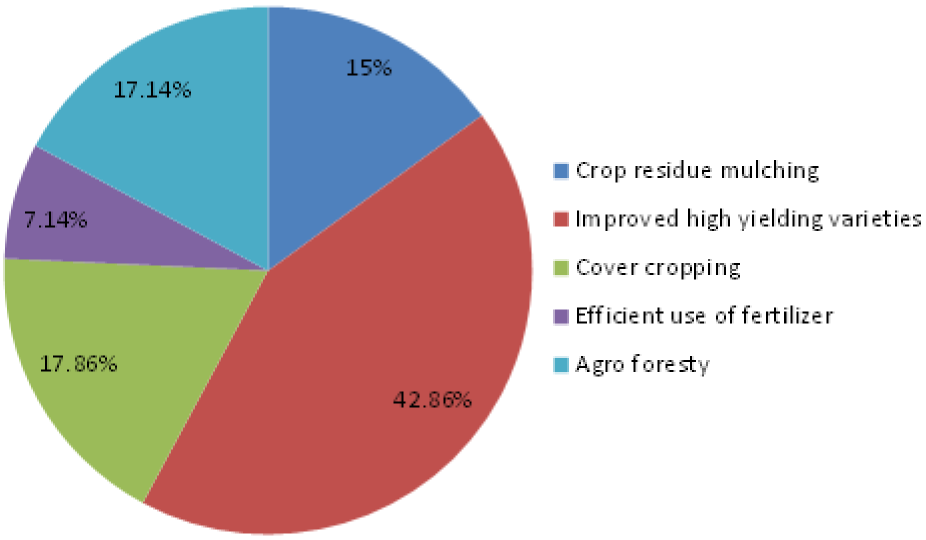

Figure 7. Rate of adoption of climate smart agriculture practice.

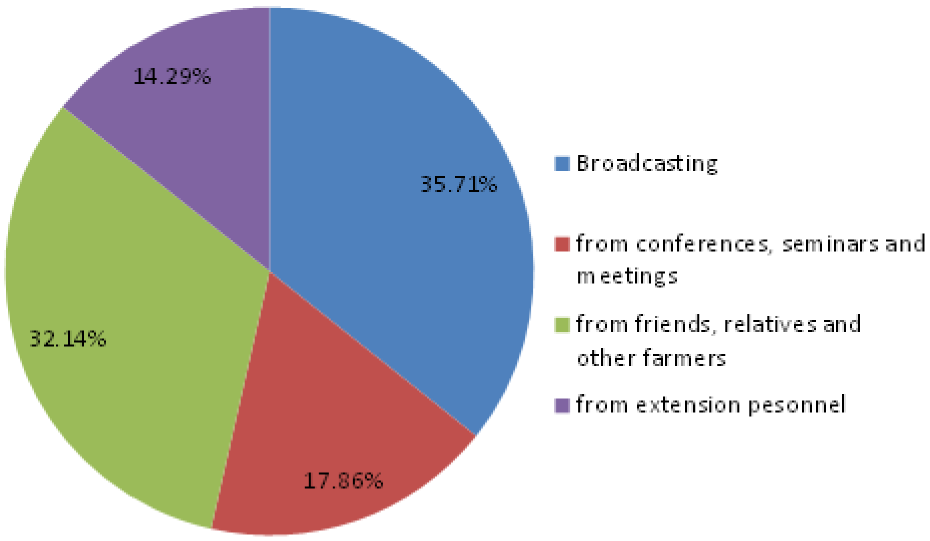

Figure 8. Sources of information on climate smart agriculture (CSA) practice.

and other women farmers, whereas 14.29 percent received CSA information from extension personnel.

Figure 9 identifies the constraints to the adoption of CSA practices by rural women. From the figure, 42.86 percent of the rural women lacked adequate CSA information, 35.71 percent lacked adequate planting materials/inputs whereas 21.43 percent lacked capital.

Figure 10 shows the perceived benefits from the adopted CSA practices. About 50 percent, 31.43 percent and 18.57 percent of rural women perceived increase in household income, improved food supply and security and better environment as benefits of adopting CSA practices, respectively.

Result of marginal effects

Table 3 presents the result of the marginal effects of multinomial logit model. The result showed that age of the household head positively and significantly influenced the probability of choosing crop residue mulching and improved high yielding varieties by 3.88 and 1.18%, respectively. Result implies that older women farmers are more interested in trying out new ideas because of their risk taking behaviour. This result is contrary to earlier empirical study by Etim (2015) that younger farmers are more likely to try and adopt new agricultural technologies.

Educational level of the women farmers was significant and had a direct effect on choice of efficient use of fertilizer. Raising the level of education , increased the

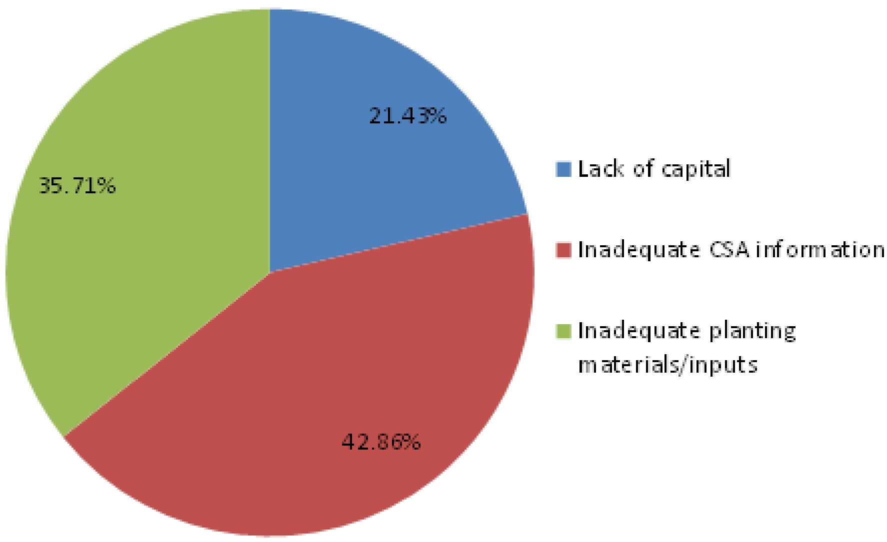

Figure 9. Constraints to the adoption of CSA practices by rural women.

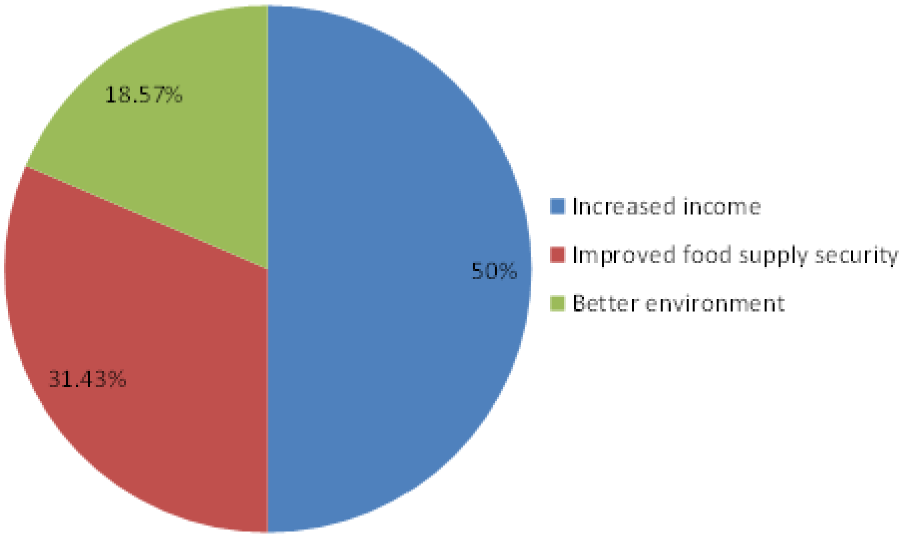

Figure 10. Perceived benefits from the adopted climate smart agriculture practices.

probability of choosing to use fertiliser efficiently by 1.35 percent. Result is in conformity with earlier empirical findings by Feder *et al.* (1985); Udoh and Etim (2006); 2008; Etim and Okon (2013); Etim and Edet (2013); Etim (2015) and Etim *et al.* (2017) who found that education empowers farmers to interpret and respond to new ideas much faster than their counterpart with lower education. The fact that human capital plays a direct role in the acquisition and evaluation of innovations is supported by this result. Ba.cha *et al.* (2001) and Zegeye (2001) in Ethiopia, Chirwa (2005) in Malawi, Chianu and Tsujii (2004), Etim (2015) and Etim *et al.* (2017) in Nigeria obtained similar results. Maddison (2006) also agree that education may increase an individuals ability to acquire and absorb information on climate change and various farm management practice.

Membership of social organisation positively influenced the choice of improved high yielding varieties at 10 percent level of significance. Women farmers who were members of agriculturally related social organisations had a higher probability of choosing improved high yielding varieties by 8.18 percent. This is not unconnected to the fact that with socialisation, women farmers are exposed to a wide range of ideas, knowledge and information. Nkamleu (2007) in earlier studies reported that membership in social groups exposed farmers to a broad range of innovations and improved their access to information through training and regular contact which eventually changes their attitude to innovation positively. This result also conforms to earlier empirical findings by Nchinda *et al.* (2010), Ayuya *et al.* (2012) and Etim *et al.* (2017).

Table 3. Marginal effects from the Multinomial Logit on the choice of climate smart agriculture practice

Explanatory variables	No adoption	Crop residue mulching	Improved high yielding varieties	Cover cropping	Efficient use of fertiliser	Agro forestry
Sex	0.7604(0.5100)	0.0070(0.2010)	0.3888(0.0010)	0.7990(0.0107)	0.3306(0.0089)	0.2097(0.0076)
Age	0.0078(0.0016)	0.0388(0.0027)	0.01802(0.0221)	0.0100(0.0500)	0.5106(0.0700)	0.031(0.1803)
Education	0.1062(0.0911)	0.1102(0.0187)	0.0051(0.0138)	0.6010(0.0302)	0.0135(0.0017)	0.2108(0.3030)
Farming experience	0.0830(0.0160)	0.2106(0.0133)	0.8100(0.0156)	0.2302(0.0241)	0.0800(0.0011)	0.1755(0.0020)
Extension contact	-0.0281(0.0091)	0.1662(0.0810)	0.1720 (0.0810)	0.0970(0.0200)	0.0109(0.0088)	0.1907(0.0333)
Household size	0.1102(0.2818)	0.4473(0.0251)	0.3021(0.0117)	0.5507(0.0111)	0.0607(0.1001)	0.3939(0.0310)
Membership of cooperative	0.5006(0.3003)	0.5220(0.0707)	0.0818 (0.1010)	0.7108(0.00011)	0.0800(0.3010)	0.0309(0.5000)
Land tenure	0.2771(0.1130)	0.6331(0.0068)	0.1799(0.0031)	0.6500(0.0224)	0.0903(0.0610)	0.8001(0.0014)
Farm size	0.0311(0.1500)	0.3103(0.0708)	0.8007(0.0038)	0.0833 (0.0108)	0.0308 (0.0011)	0.3088(0.1010)
Terrain	0.0200(0.6133)	0.1709(0.0113)	0.0085(0.0004)	0.0908(0.0025)	0.0818(0.0010)	0.1576 (0.0405)

Note:*** ,**, and * are significance at 1, 5 and 10%, respectively. Figure in parenthesis are p-values

The choice of agro-forestry was influenced by the terrain. Women farmers who cropped on steeper slopy lands had a higher probability of choosing agro-forestry by 15.16 percent. The adoption of agro forestry as a CSA practice is not unconnected to the fact that agro-forestry improves the quality of farms by it allows producers to make the best use of their land and is a very important practice in food supply of small holder farmers (Asten *et al.,* 2011).

The choice of efficient use of fertilizer was positively and significantly influenced by the size of farms. Increasing the farm size by one hectare raises the probability of choosing efficient use of fertilizer and cover cropping by 3.08 and 8.33 percent, respectively. This result suggests that smaller farm discourage technology use. Larger farms often give room for the experimentation on a small plot of land (Small Plot Adoption Technique) without compromising family food supply and security. Zepeda (1994) reported that the benefits desirable form large scale adoption of innovations is higher for larger farms. Similar empirical findings on the positive effect of increasing farm size on technology adoption were reported (Onyenweaku *et al.,* 2010; Etim and Edet, 2014; Etim, 2015; Etim *et al.*, 2017).

The frequency of extension contact influenced women's choice of non-adoption. This suggests that an increase in extension contact by one visit, decreased the probability of choosing not to adopt any CSA practice by 28.10 percent. Increasing the visits by extension personnel, raised the probability of using improved high yielding varieties by 17.20 percent. Findings by several aythors (Adesina *et al.*, 2000; Abdulai and Huffman, 2005; Tixale, 2007; Yirga, 2007; Menale *et al.*, 2009; Etim *et al.*, 2017) agree with this notion frequency of extension contacts being a proxy for farmer's access to agricultural information positively affected adoption of innovations.

Conclusion

The adoption choice of CSA practices by rural women identified were crops residue mulching, improved high yielding varieties, cover cropping, efficient use of fertilizer and agro forestry. The most critical factors identified as influencing the rural women's choice of adopting CAS practices included age, education, frequency of extension contact, membership of social organisation, farm size, and terrain of land. Polices to encourage the education of rural women and increase their access to land should be pursued.

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