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Does Conservation Agriculture Enhance Household Food Security?

Evidence from Smallholder Farmers in Nkhotakota in Malawi

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Abstract

The paper identified factors that influence the adoption and contribution of conservation agriculture (CA) on household food security using household-level data collected in 2010 from Nkhotakota District, Central Malawi where Total Land Care (TLC) a local Non-governmental Organization (NGO) has been promoting CA. To determine factors that influence adoption of CA, a Probit regression model was used. Then, the paper compared estimated production function between adopters and non- adopters of CA. The Probit results show that age and education level of the household head, number of extension visits, and land holding size are important factors that influence farmers' adoption of CA in the study area. Further results showed that CA adopters had more than 50% higher maize production than that of non-adopters from the Cobb-Douglas production estimates. From the findings, there should be improvement in the delivery of extension services in the promotion and dissemination of agricultural technology to foster wider adoption and improve food security status in the study areas. This can be achieved through increased number of extension workers, increase number of demonstrations when introducing CA technology and improved access to formal education. Our overall results show consistently that CA adopters are better off than non-adopters in various aspects such as maize production, per capita maize requirements and meal frequency. As such, the promoting and up-scaling of CA technologies to smallholder farmers should be intensified as an effective strategy for addressing household food insecurity than the promotion of chemical fertilizers use through programs such as the Farm Inputs Subsidy Program, which is not only unsustainable, but also inappropriate for poor resource farmers.

Keywords: conservation agriculture, food security, production function, Probit regression model, adoption, smallholder farmers

1. Introduction

In order to meet growing demand for food arising from the unprecedented population growth, agriculture will have to produce more food sustainably from available land with minimal impact on the environment. The expected increase in population and the associated demand for food, water and other agricultural products will bring additional pressures on agricultural resources. The challenge of agricultural sustainability is becoming more intense with the sharp rise in the cost of food and energy, climate change, water scarcity, degradation of ecosystem services and biodiversity, and the financial crisis (Kassam, Friedrich, Shaxson, & Pretty, 2009). The combined effects of declining soil fertility and soil degradation has contributed to the problems of low agricultural productivity in sub-Saharan Africa (SSA). The development communities together with politicians, policy makers, institutional leaders as well as scholars, scientists and extension workers have been stressing the need for the development of sustainable agricultural systems (Kassam et al., 2009). Productivity-enhancing technologies are therefore needed in net food importing countries especially Africa where the present agricultural practices cannot address food supply shortage facing many countries.

In Malawi, agriculture provides employment for more than 85% of the population, most of whom resides in rural areas (Government of Malawi, 2006). Agriculture generates 83% of foreign exchange earnings, and contributes 39% of gross domestic product (GDP). In contrast, manufacturing sector accounts for only 11% of GDP, of which just over a quarter is from processing of agricultural products. Almost 85% of the households in Malawi are smallholders (Chisinga & O'Brien, 2008). Given this importance, government, some non-governmental organizations and development partners such as the Food and Agriculture Organization (FAO) have been promoting alternative methods of crop production that enhance productivity while conserving soil and water such as Conservation Agriculture (CA). CA is said to be more sustainable cultivation system that can help to restore soil fertility, improve water infiltration, and reduce soil erosion and compaction, while the effects of tillage are replaced by the use herbicides that also reduces labour requirements for tillage (Hobbs, 2007). CA is also a practical method for reducing soil erosion, restoring organic matter, organic matter, conserving soil moisture and soil fertility (IIRR & ACT, 2005).

While CA may be a novel technology, its associated practices have long been employed by farmers for more than three decades and have spread widely across the world. CA has been successfully applied on more than 100 million hectares in different agro-ecosystems and cropping systems in the world (Hobbs, 2007; Giller, Witter, Corbeels, & Tittonell, 2009; Friedrich & Kassam, 2009). In Malawi however, CA dates back to 1940s but has never been integral to agricultural research and development programmes (Mloza-Banda, 1995). CA has been most successful in sub-humid to humid regions of North America, Latin America and selected areas in Asia, where water is not a limiting factor of crop production (Friedrich & Kassam, 2009). In contrast, agriculture in Africa is mostly rain-fed and CA helps to increase agriculture productivity while reducing production costs, maintaining the soil fertility and conserving water (FAO, 2001). It is for this reason that a number of organizations have been promoting CA in many developing countries including Malawi. One such organizations that has been in the forefront promoting CA in Malawi is the Total land Care.

1.1 Total Land Care Conservation Agriculture Project

Total Land Care (TLC) has been implementing a project titled "Chia Catchment Management Project" in Nkhotakota District in the Central Region of Malawi under a big programme called "Management for Adaptation of Climate Change (MACC) funded by the Government of Norway. The MACC is an integrated programme covering five Central Region districts of Nkhata Bay, Nkhotakota, Ntchisi, Salima and Dowa covering a total of 580,154 ha (Bunderson & Jere, 2008). It aims at improving rural livelihoods with emphasis on a number of areas including soil and water conservation, conservation farming, contour and box ridging, vetiver grass hedgerows and gully reclamation.

Under the Chia Catchment Management, TLC has been promoting CA by encouraging farmers in Nkhotakota to plant their crops on old ridges without tilling, use crop residues as mulch to retain soil moisture, and promote the use of herbicides to control weeds. Farmers interested in CA register with the TLC field coordinators in their respective areas where they pay a deposit of USD$ 7.10 each with a commitment to pay the balance in 9 months. This is used for purchasing herbicides costing between USD$ 21.40 and USD $ 25.00 which is enough for 0.4 ha plot. With this, farmers are reported to have benefitted from "Chia Catchment Management Project" through (a) improvement of soil fertility and moisture retention through mulching (b) increased yield hence greater food security (c) stabilization of soil and protection from erosion leading to reduced downstream sedimentation (d) saving labour through no-till and use of herbicides to control and suppress weeds instead of weeding.

Although a number of non-governmental organizations (NGOs) have been promoting CA practices, its adoption levels remain obscure (Williams, 2008). As a result, CA is not widely practiced across the country. As noted by Langyintuo (2005), the challenge of technology adoption to scientists has been to accurately identify factors limiting the uptake of improved technologies. The present paper seeks to address the following questions: What factors that influence the adoption of CA? Does the adoption of CA activities in Nkhotokota increase household maize production and therefore achieve food security among smallholder farmers? Results from this case study could be used when introducing CA not only in parts of the country, but in other countries as well.

2. Methodology

2.1 Conceptual Framework: A Literature Survey

Many factors can influence the participation or adoption of CA technology. For instance, higher output from CA is likely to increase the benefits and improve adoption (FAO, 2001). Limited access to off-farm employment can also increase the chances of smallholder farmers adopting CA as there are only few alternatives of earning income. In instances where a household does not participate in any form of labour market, factors like low agriculture production, poor farming technologies, and land holding size maximize the likelihood of a household adopting the technology. We expect families with high reliance on agricultural production as source of income to be more willing to adopt CA.

In his study, Pretty (1999) indicated that yield (output) is a major factor in farm-level profitability and the most documented in the literature. He argues that yields frequently increase substantially under CA, both in the first year and over time. Pretty, Morison and Hine (2003) noted that for adoption to occur, farmers might not take into account the potential effects on others. Farmers characteristics such as education level and age and gender of the household head are also expected to have a great influence on agriculture and development.

Human endowment factors enable potential adopters to understand and evaluate new information, thus affecting both adoption and diffusion of new technologies (Schultz, 1964; 1975). According to Bhattacharyya et al. (1997), education and experience of the farmer are the variables that capture human endowment. Exposure to education will increase the ability of farmers to obtain, process, and use information relevant to the adoption of new technology. In most adoption studies conducted in low-income countries, the age of the farmer is used to reflect experience. It is therefore, expected that a farmer's age may increase or decrease the probability of adopting the CA technology.

Lwesya (2004) reported that social capital like access to information through extension services from organizations that provide credit services as well as other sources are important factors that may encourage or discourage a household adoption or participation decisions. This is so because luck of knowledge increases chances of failure of activity in which the household is participating. Other household factors such as landholding size (farm size) and potential labour (labour availability) may influence CA adoption. Mbendela (2006) argued that land holding size, being the factor of production, determines not only the output but also adoption of new technology. Potential labour is the labour available to the household, which include both family members and hired members to provide amount of labour input into farm activities given in adult equivalents (Mbendela, 2006). Kankwamba (2010) argued that in a country where farm mechanisation is not commonly practiced which creates a big productivity gap, the only way to fill the gap is intensification of labour use. As CA saves labour, it is an important technology for labour constrained households.

2.2 Analytical Framework for Farmers' Adoption of CA

From the conceptual framework, this paper used the Probit model to assess the determinants of CA adoption. The household decision to adopt CA is influenced by individual, household and institutional factors. Individual factors are those factors that related to the head of the household that may influence household adoption decisions. These include age, gender and education level of the household head. Household factors relates to those that affect the whole household such as availability of labour and land-holding sizes. Institutional factors that might affect CA adoption include access to extension services and information. Other unobservable factors are captured by the stochastic error term, ε.

In this paper, we that household adopts any technology by comparing the net benefit of that technology to the one currently being practised. Benefits of CA may include high yield, which reduces the farmers' vulnerability to food insecurity. The other benefit could be reduced labour that may allow the farmer to allocate his time to other enterprises and income generating activities. Therefore, all things constant, farmers will adopt CA if the net benefits are positive. We assumed a latent variable Y_i^* representing adoption or non- adoption. Here, adoption is defined as a process by which a farmer is exposed to, considers and finally practices an innovation over a period say two or more years. Letting independent variables X_i be factors that affect CA adoption and β be a K-vector of parameters. Then, the decision to adopt a technology can be specified as follows:

$$Y_i^* = \beta X_i + \varepsilon_i \tag{1}$$

Where we observe $Y_i = 1$ if $Y_i^* > 0$ and $Y_i = 0$, otherwise.

$Y_i = 1$ if a household adopts the CA technology and $Y_i = 0$ if a household decides otherwise.

In this case

$$\text{Prob } (Y=1/X) = F(X, \beta) \tag{2}$$

$$\text{Prob } (Y=0/X) = 1- F(X, \beta) \tag{3}$$

Then $F(X, \beta) = X\beta$

Limiting Xβ to (0, 1)

$$\text{Prob}(Y=1/X) \; {}_{-\infty}\!\int^{X\beta} \Phi(t)dt = \Phi\,(X\beta) \tag{4}$$

Such that

$$\text{Prob } (Y = 1) = \Phi\,(\beta X) \tag{5}$$

Where Φ (.) is function of standard normal distribution function.

2.3 Assessing the Contribution of CA on Household Food Security

This paper used maize production as a measure of the contribution of CA on household food security. The underlining reason is that maize is regarded as "food" in the Malawian context. A household without maize stocks would be regarded as food insecure even if that household can have other types of foods such as cassava, rice or potatoes.

The estimation equation considered the rain- fed maize production for both CA adopters and non-adopters. Cobb- Douglas Production function was used. The function was specified as below:

$$A= \beta_0 Lan^{\beta 1}\ Lab^{\beta 2} Fert^{\beta 3} seed^{\beta 4} \mu_i \quad (6)$$

However, the general modified linear logarithmic production function was used. It is expressed as below:

$$lnA_i = \beta_0 + \beta_1 lnLan_i + \beta_2 lnLab_i + \beta_3 Fert_i + \beta_4 lnSeed_i + \mu_i \quad (7)$$

Where: A_i is the expected rain-fed production in (kg)

Lan_i is the land allocated for maize production for each group of farmers in hectors

$Fert_i$ is the amounts of fertilisers used in the production (kg)

Lab_i is household labour units supplied for maize production

$Seed_i$ is the amount of maize seed used in maize production (Kg).

β_s are the parameters to be estimated

μ_i are the stochastic error terms

For each group of farmers a separate production function was estimated as follows:

$$ln\ A_{1i} = X_i \beta_{1i} + \mu_{1i},\ \text{when } Y_i=1 \text{ (adopters) and} \quad (8)$$

$$ln\ A_{0i} = X_i \beta_{0i} + \mu_{0i},\ \text{when } Y_i=0 \text{ (non- adopters)} \quad (9)$$

Where: $X_i s$ are the vectors of variables that are used in maize production such as land, labour, seeds and fertilizer, $Y_i=1$ and $Y_i=0$ represent adopters and non-adopters, respectively as defined in Equation (1). μ_{1i} & μ_{0i} are the error terms.

The T- test was used to test if estimated maize production for two groups were statistically different. We are aware that comparing the yields between adopters and non-adopters just provides an indicative difference in yields but does not measure the impact of CA. There are other methods such as propensity score matching techniques that are appropriate for measuring the contribution of CA to the yield difference. Our sample is not large enough to deploy the propensity score matching techniques to measure the impact of CA. Our aim is just to compare the production efficiencies between adopters and non-adopters.

2.4 Data Sources

Data used in this paper were collected mainly through a survey of 140 farmers comprising 70 adopters and 70 non-adopters of CA in the month of March 2010 in two EPAs of Nkhunga and Zidyana in Nkhotakota district in Central Malawi. This is the area where Total Land Care has been promoting CA. Multi-stage sampling procedure was used to select households for face-to-face interviews. A semi- structured questionnaire was used to obtain farm and household level information from adopters and non-adopters. Statistical Package for Social Scientists (SPSS) and Stata were used to analyze data where descriptive and inferential statistics were obtained. The T-test was used to test the hypothesis and F-test and chi-square test were used to test the overall significance of the models.

2.5 Ethical Consideration

A prior consent was sought from the officials of Total Land Care (TLC) Malawi to assess their project site. Again, smallholder farmers were only interviewed upon giving their consent and willingness to participate in the research. Any information collected from this research was treated with strict confidentiality and was only used for the intended purpose of this research.

3. Results and Discussion

3.1 Descriptive Statistics

This section presents summary statistics, in Table 1 below, comparing adopters and non-adopters. The average age of the farmers was estimated at 41.1 years with the mean age for adopters and non-adopters being estimated at 40 and 43 years, respectively, and was statistically insignificant. Adeoti (2009) also found that that the age of household head was not significantly different for adopters and non-adopters of irrigation technology in Ghana.

Again, there is no statistical difference in the sex of the household heads between CA adopters and non-adopters. Almost 93% of the adopters were male-headed household and only 7% were female- headed households. Likewise, 84.3% of the non- adopters were male -headed household and 15.7% were female headed. Results also indicated that almost 85% of the non-adopters of CA were married and 93% of adopters were married as well. Kankwamba (2010) reported that married couple is in better position to make good decisions through consultations with the spouses and siblings.

Table 1. Characteristics of adopters and non-adopters of CA

Characteristic	Adopters	Non-adopters	%Difference	T-statistic/ Chi^2
Age of household head (years)	43	40	6.98	1.240
Gender of the household head (% male)	92.9	84.3	8.60	0.168 †
Marital status (% married)	93	85	8	6.862 †
Education of household head (years) (highest number of year in school)	7.26	6.07	16.39	1.959*
Household mean income/annum (USD$)	691.59	386.67	44.09	2.488**
Mean household land holding size (Ha)	1.54	1.13	26.60	3.056***
Average number of adults members	4	3	25.00	3.303***
Average number of people hired	3.6	4.4	22.22	-0.515
Potential labour (adults work in field)	7.37	7.2	2.3	0.105

***significant at 1%, **significant at 5%, * significant at 10%, †chi-square value.

From Table 1, the adopters had a mean household annual income of USD$ 691.59, and non-adopters had USD$ 386.67. The percent difference of 44 percent is significant at 5% level of significance. There is also significant statistical difference in education level between the adopters and non-adopters at 10% level. The number of years spent in school was estimated at 7.26 for adopters and 6.07 for non-adopters and is statistically significant at 10% level. The mean land holding size for smallholder farmers for the district was estimated at 1.18 ha per household (GoM, 2010). However, results show that the mean land holding size of adopters was 1.54 ha and that of non-adopters was 1.13 ha. The mean landholding sizes are statistically different at 1% level. The mean land sizes allocated to maize for adopters and non-adopters were estimated at 0.6996 ha and 0.5577 ha, respectively. Finally, the mean potential labour for adopters and non- adopters were 7.37 adults and 7.20 adults, respectively. Overall, the percent difference for potential labour was not significant.

3.2 Determinants of Adoption of Conservation Agriculture

This paper assessed the influence of household head age, gender, level of education, household labour, land holding size and agricultural extension on household decision to adopt CA using Probit regression model. Table 2 shows that the Log Likelihood function is significant at 1% level. This suggests that when independent variables were taken together, they strongly influenced household decision to adopt CA in the study area. Likewise, a χ^2 statistic of 37.91 shows that the overall model was significant at 1% level signifying fitness of the model. This shows that the explanatory variables are relevant in explaining the adoption decision.

The results in Table 2 show that household head education, landholding size, age of the household and access to extension services are important factors in influencing household decision to adopt CA. Household head age positively influences CA adoption and it is statistically significant at 5% level. The marginal effects indicate that an increase in number of years of household head by one year would increase household probability of adopting CA by 6.3%. This is important because older people normally have more land ownership rights than their younger counterparts. In addition, older people are often more experienced and knowledgeable than younger ones (Ellis 1992) and this helps them to make informed decision about CA adoption. These results are consistent with Manjolo (2008) and Adeoti (2009) findings among irrigation adopters in Phalombe District and Ghana, respectively.

Table 2. Probit regression results for the determinants of CA

Variables	Coefficients	Std. Error	Marginal effects
Intercept	-5.915001	1.557236***	
Age (years)	0.1580695	0.0664918**	0.0629582
Age^2(years)	-0.0016009	0.0007308**	-0.0006376
Gender	0.2926189	0.4069502	0.1146684
Education (years in school)	0.3777232	0.177232**	0.1504451
Extension services (access)	1.282543	0.4133991***	0.4299031
Potential labour (adults in field)	-0.0154144	0.0127004	-0.0061395
Landholding size (Ha)	0.2743043	0.1619577*	0.1092539
Log-likelihood	-78.086917		
$\chi 2$	37.91		
Probability of $\chi 2$	0.000**		
N	140.000		

** Significant at 1%, * significant at 10%

Education level of the household head is found to have a positive influence on the adoption of CA and is significant at 5% level. The marginal effects of education shows that if the household head increases education level by one year, there is 15% more chance of adopting CA. Nakhumwa (2004) argued that education helps farmers to analyse alternatives critically and forecast the expected benefits to their activities.

The parameter estimate for household access to agricultural extension shows a positive relationship and is statistically significant at 1% level. The marginal effects indicate that households that have access to agricultural extension services have 43% higher probability of adopting CA than those with no access to extension services. In other words, acquiring knowledge about CA technology enhances household chances of making an informed decision on CA adoption. Increased access to agricultural extension services increases the chances of adoption or participation and builds confidence of adopters to succeed.

Household sex is found to positively influence adoption of CA but it is not significant. While other researchers have also found that males are more likely to adopt sustainable agricultural technologies (Adesina, Mbila, Nkamleu, Endamana, 2000), it is important to underscore the need to avoid generalizing the impact of sex differences on farm technology adoption since the impact of sex on technology adoption is technology-specific. Thus, some technologies that favour males than females and vice versa such as treadle pumps (see Kamwamba-Mtethiwa, Namara, De Fraiture, Mangisoni, & Owusu, 2012).

As expected, further results show that land holding size has a positive influence of household decision to adopt CA at 10% level of significance. The marginal effects of land shows that increase in land by one hectare those that have land has 11% higher chance of adopting CA. Land holding size in this paper was included as a determinant of adoption because households with more land allocated can afford to apportion their land for CA technology. This meant that as land size increased the probability of adopting CA increased as well. From the descriptive statistics, adopters and non-adopters have average land holding sizes of 1.54 ha and 1.13 ha, respectively. The average land holding sizes had a t-statistic of 3.056 with p-value =0.003. Finally, the paper also assessed the influence of household potential labour on the decision for adopting CA technology. Results show that, the labour parameter is not important determinant of CA adoption.

3.3 A Comparative Analysis of Food Security between Adopters and Non-Adopters

The paper assessed the effect of CA on household food security. This constituted comparative analysis of adopters and non-adopters household food security indicators. The first analysis compared maize production estimates from maize production functions of adopters and non-adopters. Finally, the study further analysed compared food security indicators between adopters and non-adopters. These indicators include occurrence of food shortage in household, persistence of food shortage, household coping strategies and amounts of food available to households during the 2009-2010 growing season. The assumption in this assessment was that since both adopters and non-adopters households live and operate in the same area, any differences in household food security status may be due to CA technology.

3.3.1 Estimated Results of Maize Production Functions for Adopters and Non-Adopter

The paper estimated the maize production for both adopters and non–adopters of CA. The results for non-adopters show that, a positive relationship exists between total output and potential labour, land, fertilizer, and seed (Table 3). This implies that as more of these factors of production are employed, there will be an increase in total output of maize. The results chow that coefficients for labour, seed, fertilizer and land have positive influence on total maize yields.

Table 3 below shows a positive relationship between total output and land, labour, and seed. Results show that seed and land are the most significant factors of maize production among CA adopters, though other factors relate positively to the total output. The mean Variance Inflating Factor (VIF) was 1.95 for adopters and 1.64 for non-adopters indicating no multicollinearity of these factors in the data collected since the VIF is less than 5.

The coefficient of potential labour is not statistically significant in influencing maize production for both adopters and non-adopters. Most households use family labour and due to small land holding sizes. As such, availability of labour does not affect maize production in the study area. The coefficient of 0.505 for seed entails that, holding all other factors constant, an increase in seed by one kilogram will results in 0.505 percent increase maize production. For non-adopters, seed does not have any significant influence on maize production.

Table 3. Maize cobb-douglas production function for adopters and non- adopters

Variables	Adopters			Non-adopters		
	B	Std. error	T-value	B	Std. error	T-value
(Constant)	6.312	0.9024	7.00***	5.467	0.6036	9.05***
Potential Labour (Adults)	0.125	0.0877	1.42	0.022	0.0761	0.29
Seed (Kg)	0.505	0.2140	2.36**	0.259	0.1691	1.53
Fertilizer (Kg)	-0.017	0.1440	-0.13	0.227	0.0774	2.94***
Land (Ha)	0.398	0.2199	1.76*	0.484	0.1613	3.00***
RTS	**1.011**			**0.992**		
VIF(mean)		**1.95**			**1.64**	

***significant at 1%, **significant at 5%, *significant at10%.

Further results show that if non-adopters increase fertilizer use by one kilogram, output will increase by 0.227 percent, other things being equal. The negative and insignificant coefficient of fertilizer among CA adopters suggests that adding inorganic fertilizer to the soils where there is CA is being practiced has no effect on maize production. This contracts results from non-adopters where maize production responds to increase in application of inorganic fertilizers. The paper reveals that fertilizer is a significant factor in the production of maize among non-adopters of CA at 1% level. These results strengthen the case for promoting CA technologies in order to reduce the cost of production as well as improving soil health.

For both adopters and non-adopters, land is an important factor of production in the study area. If farmer increases land size by one hectare, maize output will increase by 0.398 percent for adopters. Although increase in land responds high to maize output with 0.484 percent per hectare added for non-adopters, seed does not respond as much as compared to CA adopters.

Finally, from Table 3, the returns to scale (RTS) were also computed. These are the sum of coefficients of input factors of production. Stewart (2008) defines returns to scale as a technical property of production that examines changes in output subsequent to a proportional change in all inputs (where all inputs increase by a constant factor). The return to scale (RTS) estimated as 1.011 for adopters implies increasing returns to scale. Thus, an equal proportionate increase in all factors results in a greater than proportionate increase in maize production. This means that farmers have the potential to increase their production if they increase all factors of production proportionately. Likewise, the returns to scale estimated for non-adopters imply decreasing returns to scale. Thus, an equal proportionate increase in all factors of production results in less than proportionate increase in maize production. The results resonates the findings by Kankwamba (2010) who confirmed that farmers can achieve increased returns to scale only if use of more productive technologies like conservation agriculture and irrigation are intensified. Without these technologies, farmers have to improve efficiency at farm level, which is not the case most of times. Government of Malawi (2010) observed that among factors contributing to the low maize production in the study district (Nkhotakota) is the low adoption levels of new technologies such as CA.

3.3.2 Comparison of Maize Production for Adopters and Non-adopters of CA for Cobb Function Estimates

The analysis also computed the mean maize production estimates from Cobb-Douglas functions for both adopter and non-adopters of CA. The results suggest that the adopters have higher mean maize production of 1983.51 kilograms as compared to that of non-adopter, which was 869.81 kilograms. The mean difference between adopters and non – adopters was 56.15% indicating that maize production is much better for CA adopters than non-adopters. The results are presented in the table 4 below.

Table 4. Mean Maize Production estimates for Adopters and Non-adopters of CA

Status	Mean Production (Kg)	Std. error	[95% Confidence interval]
Adopters	1983.51	1.0516	1794.14 - 2192.86
Non -adopters	869.81	1.0657	766.06 - 987.61
% Difference	**56.15**		

From these results, it is evident that CA has a positive effect on the maize production. Pretty (1999) also found that yields frequently increase substantially under CA, both in the first year and over time. From our findings, the key message is that CA may be a much better strategy for ensuring household food security than the promotion of chemical fertilizer use through programs such as the Farm Inputs Subsidy Program.

3.4 Comparison of Indicators of Food Security Between Adopters and Non-Adopters

This section aimed at comparing the indictors of Food Security between adopters and non – adopters. It looked at number of availability of food throughout the year, number of meals taken by the household per day, and household maize per capita consumption. Table 5 presents the comparative statistics for the selected food security indicators.

Table 5. Indicators of food security

Indicator	Adopters	Non - adopters	% Difference	T -test
Enough food / year (%)	87.1	51.4	35.7	20.978***
Not enough food /year (%)	12.9	48.6	35.7	20.978***
Have two meals/ day (%)	14.3	34.3	20	7.649**
Have three meals/ day (%)	84.3	64.3	20	7.649**
Have >three Meals / day (%)	1.4	1.4	0	
Mean maize consumption per capita (kgs)	247.61	131.95	46.71	6.315***

*** significant at 1%, **significant at 5%.

Food availability in the household partly explains food security status. Again, numbers of meal taken per day by the household members indicate the food security situation. It was assumed in this research that households with more than or equal to three meals a day would be more food secure than those with less than three meals a day do. The research has revealed that 87.1 percent of the adopters and 51.4 percent of non-adopters indicate that they had enough food throughout the year. This difference was significant at 1% level. Similarly, 48.6 percent of non-adopters and 12.9 percent indicated that they had not enough food to finish the year. This difference again was found to be significant at 1% level.

Further results show that not all the household could manage to have three or more meals per day. The results indicated that 84.3 percent of the adopters had had their meals three times a day while 34.3 percent of non-adopters had two meals a day. As shown in the table 5 above, numbers of meals were statistically significant between adopters and non-adopters at 5% level.

The research estimated maize quantity requirements per household member based on the annual maize requirement per capita of 275kg per adult (Government of Malawi, 2002). It has to be mentioned that the figure of 275 kgs usually considers all crops consumed as staples by the household in maize equivalents. However, this paper only considered maize due to challenges experienced in quantifying other crops. The research established that the mean maize per capita consumption for adopters and non-adopters of CA were 241.61 kgs and 131.95 kgs, respectively. The difference in the means was statistically significant at 1% level as shown in Table 5 above.

As already indicated, the mean quantity requirements per household are all below the per capita food requirement. However, CA adopters are better off than non-adopters as far as maize is concerned. However, even if the research had included other crops, the difference would not have been that big to significantly change the results. However, this may look to be under estimation but may give insight of the food security situation in the area. It would not be conclusive to rely on this result alone to assess the food security status. However, if we compare per capita consumption results with maize availability and number of meals taken results above, we see consistence across all the results that CA adopters are generally better off that non-adopters. It is therefore plausible to conclude that CA adoption does improve food security status among adopters. As such, the promotion of CA technologies to smallholder farmers offers promise for enhancing household food security.

3.5 Household Coping Strategies

The paper also collected information on activities that are undertaken by the households when the food stocks last. In case of food shortage, the household would ensure that it is resilient to the shock. From the results, farmers in the study area devise a wide range of strategies to mitigate the food shortage shock. Among others, households do Ganyu (casual labour), reduce number of meals taken per day, sell other crops for the cash value to purchase staples, do business, and sell assets, and others. Figure 1 below presents the copping strategies' results.

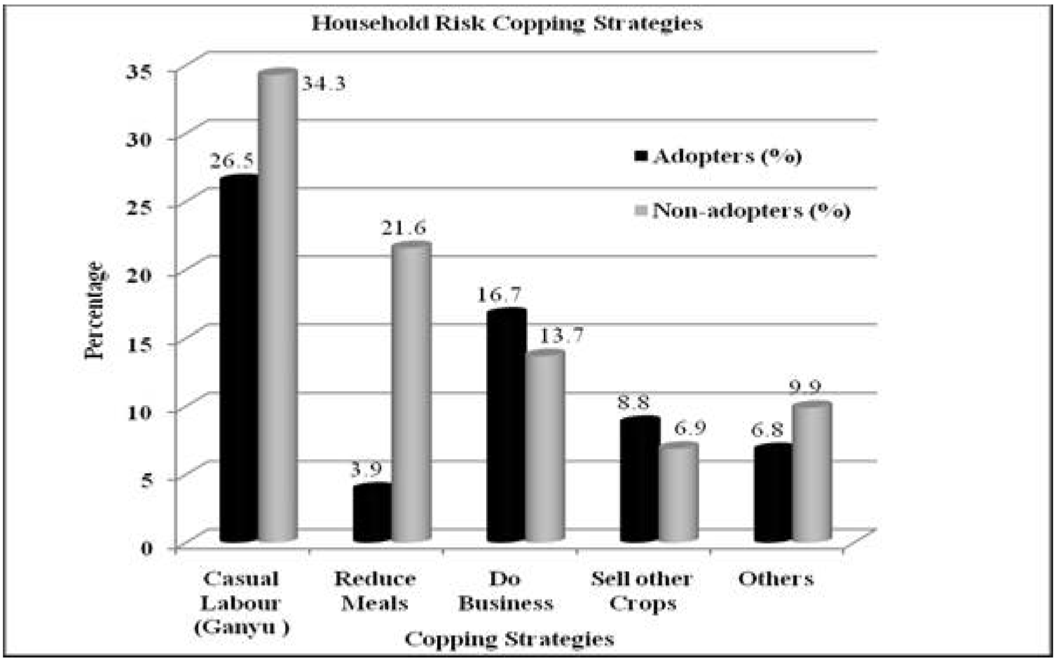

Figure 1. Household risk copping strategies

The paper established that about 34.3 percent of the non– adopters' population do *ganyu* to survive whenever they are confronted with food insecurity problem. Very few (3.9%) adopters' households would reduce their meals as a copping means as non adopters (21.6%) would. Doing business might be a source of income to many. However, we found that farmers in the areas considered it as risk reduction activity. Almost 17% of adopters and 14% of non-adopters would do business whenever they are faced with food insecurity situation. This is in line with the household major sources of income. It was observed that both adopters and non-adopters reported agriculture as one of the major sources of household income as compared to 22% of doing business.

4. Conclusion

This paper assessed the determinants of CA adoption in two EPAs of Nkhunga and Zidyana in Nkhotakota district in Malawi. The socio-economic results revealed that mostly male-headed households irrespective of adoption status in general practice farming. There is no significant age differential between adopters and non-adopters of the CA technology. However, there are significant differences in the number of years of schooling, household land size, income levels and number of adult members in the household. The factors influencing the probability of adoption are age of the household head, education level of the household head, increasing access to extension services and land holding size of the household.

A comparative analysis of food security between CA adoption and non-adopters revealed a positive relationship exist between CA adoption and achievement of food security status. The analysis of production elasticities (coefficients) and the return to scale have demonstrated that maize production among adopters increase with more than proportionate increase in input resources. The contribution of CA adoption on food security is also evident through increased number of meals per day, increased per capita maize consumption and availability of food throughout the year among adopters.

From these findings, extension visits are important in the adoption of CA. Increased relationship of private initiatives like TLC with government institutions such as government extension service could improve access to information about CA technology to farmers. The implication of this is that farmers' access to extension services should be improved when promoting CA technology among smallholders in the areas of study in particular and Malawi in general. Again, the importance of improved access to formal education should not be undermined. This would help the ability of farmers in knowledge acquisition and quick understanding of technology components.

Overall results show consistently that CA adopters are better off than non-adopters in various aspects such as per capita maize requirement, meal frequency and household income. It is therefore fair to recommend that the promotion and up-scaling of CA technologies to smallholder farmers be intensified as an effective strategy for addressing household food insecurity than the promotion of chemical fertilizers use through programs such as the Farm Inputs Subsidy Program, which is not only unsustainable, but also inappropriate for poor resource farmers.

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