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Abstract

The study identified factors that influence the adoption and contribution of conservation agriculture (CA) on household food security among smallholder farmers. To determine factors that affect the adoption of CA among smallholder farmers, a probit regression model was used. Then, the study compared estimated production function between adopters and non- adopters of CA. From the descriptive statistics, there are significant difference in the number of years of schooling, household land size, income levels and potential labour availability. From the probit regression results, age, education level of the household head, increase in the number of extension visits and land holding size are important in influencing the adoption of CA in the study area. Further results indicate that adoption of CA technology increases household maize production. Cobb-Douglas production estimates showed that CA adopters had more than 50% higher maize production than that of non-adopters. In addition, there are greater than proportionate unit increase in maize production with unit increase in all input factors of production among CA adopters. The paper recommends that there should be improvement in the delivery of extension services in the promotion and dissemination of agricultural technology to improve adoption rates and improve food security status in the study areas. This can be achieved by increasing number of extension workers operating in the areas and increase number of demonstrations when introducing CA technology to farmers. Again, access to formal education should be improved to enhance knowledge acquisition and understanding of CA technology components.

Key words: *Conservation Agriculture; food security; production function.*

Introduction

The agricultural sector is the backbone of Malawi's economy. It is responsible for the employment of more than 85% of the population, most of which 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 processing of agricultural products. Almost 85% of the households in Malawi are smallholders (Chisinga and O'Brien, 2008).

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 et al, 2009). The expected increase in population and the associated demand for food, water and other agricultural products will bring additional pressures on agricultural resources. 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).

It is against this background that alternative methods of crop production are being promoted which enhance productivity while conserving soil and water. One such technology is conservation agriculture (CA). CA is a farming innovation that aims at producing high yields while reducing production costs, maintaining the soil fertility and conserving water (FAO, 2008). It involves practical methods to reduce soil erosion, restore organic matter and conserve soil moisture and soil fertility (African Conservation Tillage, 2005). However, Langyintuo (2005) found out that the challenge of technology adoption to scientists has been to accurately identify factors limiting the uptake of improved technologies such as CA for the design of appropriate intervention strategies.

In Malawi, Conservation Farming dates back to 1940s but has never been integral to agricultural research and development programmes (Mloza-Banda, 1995). Different non- governmental organizations (NGOs) have been promoting farmers in the country to adopt CA practices. However, the adoption levels remain obscure (Williams 2008).

One of the notable non-governmental organization (NGO) is Total Land Care (TLC). Its work is centered on the need to increase the production and income levels of small-scale farmers in the country through improved agricultural practices with sustained conservation and management of the natural resources base. CA under TLC entails planting on old ridges, use of crop residues and weed control using herbicides.

A key focus of TLC programs is to improve 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. TLC has been implementing a project around Chia Lagoon (the Chia Catchment Management Project). The project provided for an expanded programme "Management for Adaptation of Climate Change (MACC): An Integrated Model for the Central Watersheds of Lake Malawi" covering ten Extension Planning Areas in five Districts: Nkhata Bay, Nkhotakota, Ntchisi, Salima and Dowa covering a total of 580,154 ha (Bunderson and Jere, 2008).

The fundamental principles entail an integrated holistic approach with a three-point thrust: To reduce risks and vulnerability from erratic and unpredictable changes in climate; to improve food security, nutrition, and general well-being of rural communities; and to assist farm households in making the transition from subsistence survival to a business oriented mind-set that promotes self sufficiency and growth.

TLC in Nkhotakota has CA demonstration programme in partnership with the International Maize and Wheat Improvement Centre (CIMMYT) where farmers get to observe the method and results of CA. Farmers interested in CA do 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 for herbicides, which costs about USD$ 21.40 to USD $ 25.00 per 0.4 ha plot. These deposits are used to estimate demand of chemicals, which are purchased centrally by TLC and distributed to Farmers. According to TLC officials, the repayment has been good estimated at about 90% and is used as a revolving fund to support farmers on CA the following season.

According to TLC officials, there are more potential benefits in all the areas they are working in than what is invested in CA in long term. These benefits include: Improvement of soil fertility resulting in sustainable crop production, high retention of moisture in the soil due to adequate mulch, increased yield hence greater food security, there is stabilization of soil and protection from erosion leading to reduced downstream sedimentation, labor is saved, no hard pan that hampers root penetration into the soil, improves soil properties – physical, biological and chemical, control and suppressing of weeds, and risk aversion.

Though a number of CA adoption studies have been conducted in the country, there was no evidence to accurately answer the following questions: Does the adoption of CA activities in Nkhotokota increase household maize production? In addition, does CA adoption help to achieve food security among smallholder farmers?

The study therefore, aims at assessing factors that influence the adoption of conservation agriculture and its contribution on food security among smallholder farmers. Specifically, the study seeks to determine factors that affect the adoption of CA among smallholder farmers and to assess the contribution of CA to household food security. This study therefore provides better information to support policies that promote adoption CA practices.

Methodology

Conceptual frame work: 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, 2008). 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 the instances where the household does not participate in any form of labour market, factors like low agriculture produces, 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 et al (2003) reported that for adoption, 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), the variable used to capture human endowment is education and experience of the farmer. 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. Farmers' age can breed or wear down confidence; hence, they become more or less risk averse to new technology. It is therefore, expected that a farmer's age can increase or decrease the probability of adopting the CA technology. Gender of the household head is again important in adoption studies.

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 participation. This is so because lucky of knowledge increases chances of failure of activity in which the household is participating.

Institution 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 far from being attained which creates a big productivity gap, the only way to fill the gap is intensifying labour use.

Analytical Framework for Farmers' Adoption of CA

From the conceptual framework, household decision to adopt CA depends on a number of factors like land holding size, access to extension services and information, household characteristics (such as age of household head, and gender), availability of labour and unobservable factors explained by the stochastic term, ε. This study used the probit model to assess the determinants of CA adoption.

In this study, it was assumed that household adopts any technology by comparing the basic benefit of that technology to the current one. 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. Where adoption means the process by which a particular farmer is exposed to, considers and finally practices an innovation. Independent variables X_i be regarded as 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:

$$Y_i^* = \beta X_i + \varepsilon_i \quad \text{………………………………………………………………..…………(1)}$$

Where:

We observe $Y_i = 1$ if $Y_i^* > 0$ and $Y_i = 0$ if otherwise.

Y =1 if the household adopts the CA technology and Y=0 if the household decides otherwise.

In this case Prob (Y=1/X) = F(X, β) …………………………………………… (2)

Prob (Y=0/X) = 1- F(X, β) ………………………………………….. (3)

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

Limiting Xβ to (0, 1)

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

Such that $\text{Prob}(Y = 1) = \Phi(\beta X)$...…………………………………………………… (5)

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

Assessing the Contribution of CA on Household Food Security

This study used maize production as a measure of the contribution of CA on household food security. The underlining reason was, maize is regarded as staple food and that without it in a household is considered as lack of food.

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

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

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

$$\ln A_i = \beta_0 + \beta_1 \ln Lan_i + \beta_2 \ln Lab_i + \beta_3 Fert_i + \beta_4 \ln Seed_i + \mu_i \quad \text{………………………..(7)}$$

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)

Labi is household labour units supplied for maize production

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

Bs 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:

$\ln A_{1i} = X_i\beta_{1i} + \mu_{1i}$, when A=1 (adopters) and …………………………..(8)

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

Where: X_is are the vectors of variables that are used in maize production such as land, labour, seeds and fertiliser

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 differences 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.

Study design and data

The study was carried out mainly through a survey of 140 farmers comprising 70 adopters and 70 non-adopters of CA in the month of March 2010. Multi-stage sampling procedure was used to select households for data collection. 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.

Results and discussion

Descriptive statistics

This section presents summary statistics, in table 1 below, comparing adopters and non-adopters. Results of the research show that the average age of the farmers is 41.1years. It was found that the mean age of adopters was 43 and that of non-adopters was 40. The difference between the ages is not significant. 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.

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 of the household head Married (%)	93	85	8	6.862 †
Mean Education of Household Head (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***
Household Adults (mean)	4	3	25.00	3.303***
Number of people Hired (mean)	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

The study found that there was no significant difference in the gender of the household heads. 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.

The study revealed that the adopters had a mean household annual income of USD$ 691.59, and non-adopters had USD$ 386.67. The percent difference of 44 was significant at 5%. There is a significant difference in education level between the adopters and non-adopters at 10%. It was found that mean number of years spent in school were 7.26 for adopters and 6.07 for non-adopters. The mean land holding size for smallholder farmers for the district is 1.18 ha per household (GoM, 2010). The study has shown 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%. The mean land sizes allocated to maize for adopters and non-adopters were 0.6996 Ha and 0.5577 Ha respectively.

The study also showed that 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. However, household size, practically the availability of adult members was statistically significant in the adoption of CA technology at 1% level.

Determinants of CA adoption

This study 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 model. The Log Likelihood function significant at 1% also shows 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 showed 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 are summarised in the table 2 below. The results showed that household head education, landholding size, age of the household and access to extension services were important factors in influencing household decision to adopt CA.

Household head age positively influenced CA adoption and it was statistically significant at 5%. The marginal effect indicated that increase in number of years of household head by one year would increase household probability of adopting CA by 6.3%. The parameter was more important because older people had 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 helped 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.

Education level of the household head was found to influence positively towards adoption of CA and was significant at 5%. The marginal effect of education showed 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 showed a positive relationship and was statistically significant in influencing household decision to adopt CA at 1%. The parameter’s marginal effect indicated 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, increase in acquired knowledge about CA technology increased household chances of making an informed decision for CA adoption. Increased agricultural extension services access increases chances of adoption or participation and builds confidence of adopters to succeed.

Household gender was found to positively influence adoption of CA but was not significant. The marginal effect of gender shows that when household is male headed has almost 11% higher chance of adopting CA compared to the female headed counterpart. While other researchers have also found that male-headed households are more likely to adopt sustainable agricultural technologies (Adesina et al. 2001), it is important to underscore the need to avoid generalizing the impact of gender on farm technology adoption, emphasizing that the impact of gender on technology adoption is technology-specific.

Table 2: Probit Regression Results of 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		
$\chi2$	37.91		
Probability of $\chi2$	0.000**		
N	140.000		

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

In the study, land holding size was found to be positive and statistically significant at 10%. This meant that households that have large land sizes are likely to adopt CA than those have less land sizes. Again, the marginal effect of land showed that increase in land by one hectare those that have land have 11% higher chance of adopting CA. Land holding size in the study was a determinant of adoption because the households with more land allocated more part of their land to CA technology. This meant that as land size increased the probability of adopting CA increased as well. Adopters and non-adopters had sample 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 indicating significance.

The study also assessed the influence of household potential labour on decision for adoption of CA technology. In the study, the parameter was not important factor for CA adoption. The marginal effect of labour depicted that increase in potential labour by one adult would reduce the chance of adopting CA by .01%.

A Comparative Analysis of food security between adopters and non-adopters

The study assessed the Contribution of CA on household food security. This constituted comparative analysis of adopters and non-adopters household food security indicators. Finally, the analysis compared maize production estimates from maize production functions of adopters and non-adopters. Again, the analysis compared food security indicators between adopters and non-adopters. These indicators included, 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 would be attributable to CA technology. Specifically, the results in this section will lead to either reject or fail to reject the hypotheses stated earlier.

Maize production functions for adopters and non-adopter

The study estimated the maize production for both adopters and non–adopters of CA. The results for non-adopters showed that, a positive relationship exists between total output and potential labour, land, fertilizer, and seed. This implies that as more of these factors of production are employed, there will be an increase in total output of maize. The results coefficients indicate that labour, seed, fertilizer and land have positive influence on maize yield. Again, the study reveals that fertilizer and land are significant factors for production of maize among non-adopters of CA. Fertilizer and land were both significant at 1%. The potential labour coefficient of 0.022 implying that increase in labour by one adult member in production of maize will only increase output by 0.022 percent.

Though 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. If non-adopters increase fertilizer use by one kilogram, output will increase by 0.227 percent. This entails that fertilizer is useful in convention farming to improve maize production. Variance Inflating Factor (VIF) of 1.64, which is less than five indicating no multicollinearity of these factors in the data collected.

Again, table 3 below shows the production function of maize for adopters of CA. The results indicate that a positive relationship exist between total output and land, labour, and seed. In this function, seed and land were significant factors of production among CA adopters though other factors relate positively to the total output. The coefficient of 0.505 for seed entails holding all other factors constant, increase in seed by one kilogram will surely increase maize production by 0.505 percent. If farmer increases land size by one hectare, maize output will increase by 0.398 percent for adopters. Results are summarised in Table 3 below.

Table 3: Coefficients - Maize Cobb-Douglas Production Function for Adopters and Non- adopters

	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%

The coefficient of potential labour of 0.125 implies that if a household increases its labour use by one member, maize output will increase by 0.125 percent. The negative and insignificant coefficient of fertilizer entail that in conservation agriculture, as the time goes, increase in fertilizer input by one kilogram would not have impact on the maize production. In other ways, fertilizer in not a major factor of production among CA adopters though is needed. 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.

From the production functions presented in table 3 above, 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 proportionately. Likewise, the returns to scale estimated for non-adopters imply decreasing returns to scale. Thus, an equal proportionate increase in all factors results in less than proportionate increase in maize production. The results can be justified by looking at what Kankwamba (2010) observed. In his study, Kankwamba (2010) found out that farmers could achieve increased returns to scale only if use of more productive technologies like conservation agriculture and irrigation are intensified. Without these, farmers have to improve efficiency at farm level, which is not the case most of times. Government of Malawi (2010) observed that the reasons why there is low maize production in the district (Nkhotakota) is among others things due to low adoption rate of new technologies such as CA.

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 had 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 CA adopters are better that non-adopters in terms of maize yield. 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**		

Source: Researcher’s computations

From these results, it is evident that CA has a positive contribution on the maize production. The results are in line with what Pretty (1999) reported. Pretty (1999), found that yields frequently increase substantially under CA, both in the first year and over time. This research therefore concludes that maize productions for farmers that adopt CA are greater than that for non-adopters.

Indicators of food security

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.

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. This subsection assumed 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 indicated that they had enough food throughout the year. This difference was significant at 1%. 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%. Table 5 below summarises the 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%.

The study further showed that not all the household could manage to have three or more meals a 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, the numbers of meals were statistically significant at 5%.

The research tried to establish maize quantity consumed per household member. This was done considering that the annual maize requirement per capita is 275kg per adult (Government of Malawi, 2002). It has to be mentioned that the figure of 275kgs usually considers all crops consumed as staples by the household in maize equivalents. However, this study only considered maize due to challenges in collecting quantities of other crops. The research established that the mean maize per capita consumption for adopters and non-adopters of CA were 241.61Kgs and 131.95Kgs respectively. The difference in the means was statistically significant at 1% as shown in the table 5 above.

As already indicated, the means are all below the per capita food requirement partly because only maize was used as food. 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 of the results. The research therefore is justified to benefit from this analysis.

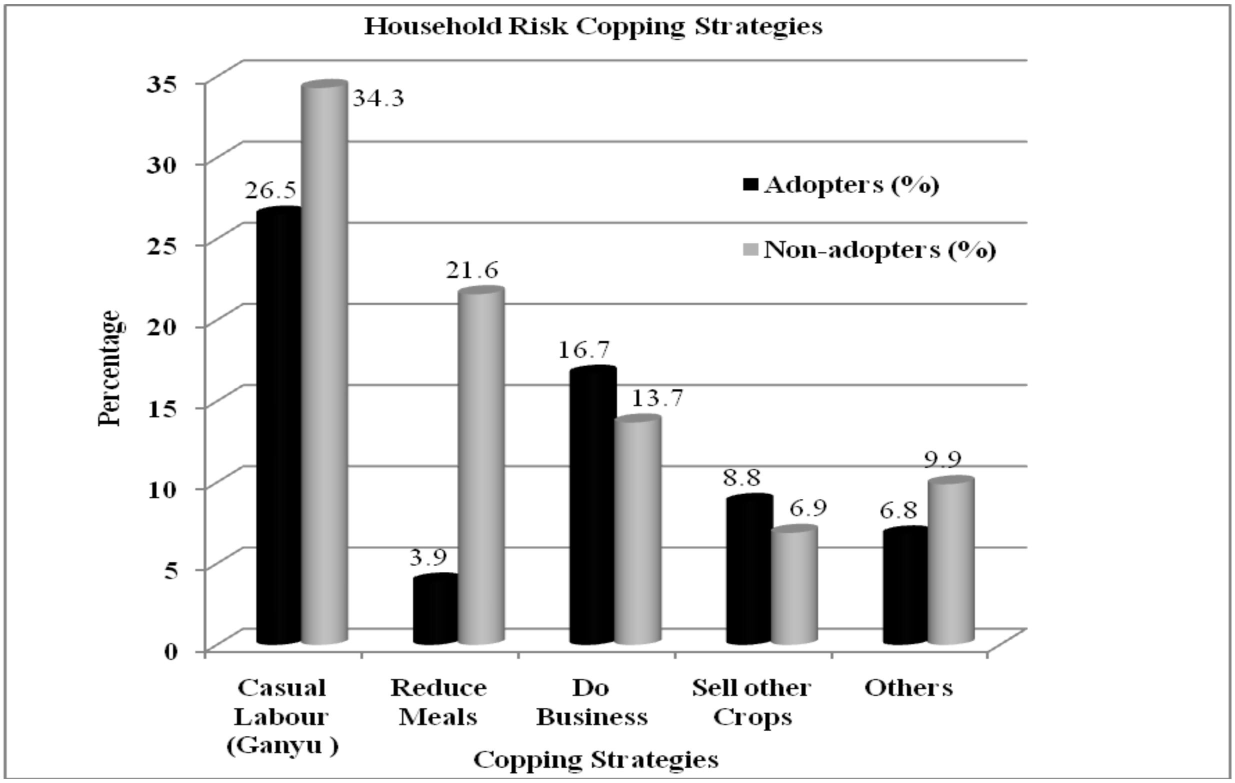
Basing on the results from maize availability, number of meals, and per capita maize consumption, the research observes that adoption of CA has an influence on food security status. Since all the results were statistically significant, the research therefore concluded that, CA adoption does improve food security status among smallholder farmers.

Coping Strategies

The study 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. The study found out that there is a range of activities that farmers in the areas of study do 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 summarises the copping strategies' results.

The study established that about 34.3 percent of the non – adopters' population would 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 do. Doing business might be a source of income to many but this study found out 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 worried of their food security 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.

Figure 1. Household Risk Copping Strategies



Summary and Conclusions

This study assessed the determinants of CA adoption in two EPAs of Nkhunga and Zidyana in Nkhotakota district in Malawi. The socio-economic analysis 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.

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