Transformative Engagement Network (TEN)

Building resilience against hunger and climate change in smallholder farming communities through transformative engagement

Masters in Transformative Community Development

Title of Research Paper:
Assessment of Conservation Agriculture Adoption in Bolero EPA in Rumphi District of Malawi

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I have not obtained a Degree in this University or elsewhere on the basis of this Research.

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Abstract

The study assessed factors that influence farmers' adoption of Conservation Agriculture and the challenges that farmers face in implementing Conservation Agriculture in Bolero Extension Planning Area (EPA). Data was collected from one hundred and twenty (120) respondents using a pre-tested structured questionnaire and stratified random sampling technique was used to identify respondents based on two categories that included none doers/none adopters and doers/adopters. The binary logistic regression model was used to examine factors that influence farmers' adoption of Conservation Agriculture and challenges that farmer's face.

The dependent variable (Y) was dichotomized with a value of (1) if respondents have positive adoption and (0) if respondents have negative adoption. Eight (8) predictor independent variables were regressed against the binary dependent variable. The logistic regression model was evaluated using Goodness of fit Hosmer and Lemeshow (H-L) chi-squared, - 2 Log Likelihood, model coefficient chi-squared, and accuracy of prediction; overall. An open-ended questionnaire was also used to support interviews with fifteen (15) Agricultural Extension Development Officers working in the selected EPA. Secondary data were obtained from published and unpublished documents.

The goodness of fit Hosmer and Lemeshow (H-L) test of the model shows 0.047 that is lower than 0.05 suggesting that the model fitted to the data well. The overall analysis of factors showed that out of eight (8) predictor variables, five(5) variables (Gender, marital status, education, income and land ownership) were significant predictors of farmer's adoption ($P < 0.05$). Out of the five significant predictor variables three had positive significant coefficient (Gender, education and income). The research also found out that strong culture of ridge based cultivation, Stover mining, livestock problem and multiplicity of maize Stover usage, scarcity of CA implements and herbicides; long break-even points of CA benefits and lack of clear guidelines for a specific CA practice were the main challenges that farmers face to adopt CA. Perceptions of non-adopters are that CA is generally labour intensive especially when it comes to soil cover where at least 30% cover is the minimum requirement. On the

other hand adopters cited reasons for sustaining the CA as the benefit achieved through reduction in labour requirements; availability of labour for other livelihood activities; increase in yield arising from strict management regime of CA even in years with erratic rainfall and noticeable reduction in the loss of the fertile top soil

This paper shows that adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions. Adaptation often involves a combination of various individual responses at the farm-level and assumes that farmers have access to alternative practices and technologies available in the area which is key to transformative community development where local communities become active participants in influencing responses to climate change for local food production, gender equality, livelihood, health and nutrition.

Problem Statement

Conservation Agriculture (CA) is a climate resilient technology and management system that has demonstrable potential to secure sustained productivity and livelihood improvements for millions of climate-dependent farmers (IFAD, 2011).In Africa, the simultaneous application of the three principles known as CA started recently and has emerged in several places, most notably in South Africa, Zimbabwe, Zambia, Kenya and Tanzania. Conservation Agriculture has spread rapidly in Ghana from a handful of farmers in 1996 to 350 000 by 2002 through the Monsanto and GTZ support. Malawi is beginning to have renewed interest and has currently 47 000 hectares under "some form" of Conservation Agriculture involving 5 407 groups of farmers. Out 47,000 hectares at least 1,000 hectares can truly be said to be under CA in Malawi (FAO, 2009).

Conservation agriculture has had a degree of success in being adopted in Malawi, this is evidenced in the Chia Lagoon watershed project report by Total Land Care and there are reports that conservation agriculture has also had success of being scaled up in other countries. This shows that scaling up agricultural conservation in Malawi is certainly feasible (Williams, 2008). Adoption of Conservation Agriculture as one concept of sustainable agriculture which has been used as an adaptation strategy against climate variability seems to be influenced by several factors and is faced with different challenges that are not clearly defined in Malawi, particularly in Bolero EPA. Climate variability directly or indirectly affects food production. Crop production largely depends on climatic elements like weather, temperature and sunshine which are very varied in the recent past years and can be mitigated by conservation agriculture. Increase or decrease in temperature; increase or decrease in frequency and intensity of rainfall leads to drought and floods that result in reduced livestock and crop production and increased vulnerability of communities to natural hazards, resulting into ecosystem degradation, reduced water and food availability. Non adoption of CA by farmers is attributed to low education level, land holding size, age of the farming house-hold, income of farming house-hold, gender of household head, marital status of the household head, house hold size and land ownership. As found out by Mlamba (2010) that gender of household head, and farmer trainings have significant impact on adoption and continued use

of CA technology. Level of income and first CA inputs acquisition method were found to have significant impact on the retention of CA practice as those who had higher income and made personal investment in the initial inputs were more likely to continue with the CA technology than their counterparts who solely depended on grants. Weed management, access to farm inputs and crop residue management were the main challenges farmers were facing in the implementation of CA.If non-adoption of CA principles will continue in Bolero EPA the effects will be that there will be low per-capita food production that will lead to malnutrition, low incomes, lack of fodder for livestock production and high deforestation rates as farmers are forced to abandon poor soils for virgin lands (Ajayi, 2007).

Despite the reported benefits of conservation agriculture (CA), its wider up-scaling in Sub-Saharan Africa (SSA) has remained fairly limited (Ndah et al, 2013). There is evidence that shows how a newly developed qualitative expert assessment approach for CA adoption (QAToCA) which is a qualitative expert assessment tool for assessing the adoption potential of Conservation Agriculture in Africa; was applied to determine its adoption potential in SSA. It is reported that CA adoption potential is not a predictor of observed adoption rates. Ndah et al (2013) systematically checked relevant factors that may be influencing its adoption. This assessment also agrees with a report by Banda, in Williams, (2007); that despite the benefits that are associated with CA as an adaptation strategy against climate variability, there is still low level of adoption of the technology in Malawi and Bolero EPA in particular hence this study was intended to find out the underlying reasons for this low adoption of CA. The study intends to provide some insights on the reasons behind adoption or non-adoption of CA which will help farmers and agencies to reflect on how best to adapt to climate variability and sustain food production in Bolero EPA.

Research Questions

Overall Objective

- ✓ To determine factors leading to the adoption of Conservation Agriculture by smallholder farmers in Bolero EPA.

Specific objectives

- ✓ To analyse factors that encourages adoption of Conservation Agriculture.
- ✓ To assess challenges farmers face in practicing Conservation Agriculture
- ✓ To determine farmers' perception about Conservation Agriculture principles in Bolero EPA

Research hypothesis

- ✓ Adoption of conservation Agriculture principles in Bolero are influenced by other factors.
- ✓ Farmers have challenges that they face when implementing conservation agriculture principles.
- ✓ There are some farmers' perception about Conservation Agriculture principles in Bolero that influence them to adopt CA or to abandon CA

Literature Review

Qualitative expert assessment approach for CA adoption (QAToCA) delivers an assessment of how suitable conditions "and thus the likelihood for CA adoption" are. Results showed that the high CA adoption potentials exhibited by the Malawi and Zambia case relate mostly to positive institutional factors. On the other hand, the low adoption potential of the Zimbabwe case, in spite of observed higher estimates, was attributed mainly to unstable and less secured market conditions for CA (Ndah et al, 2013). In the case of Southern Burkina Faso, the potential for CA adoption was determined to be high, and this assessment deviates from lower observed figures. This was attributed mainly to strong competition of CA and livestock for residues in this region (Ndah et al, 2013). Lastly, the high adoption potential found in Northern Burkina Faso was explained mainly by the fact that farmers here have no alternative other than to adopt the locally adapted CA farming. Results of this assessment should help promoters of CA in the given regions to reflect on their activities and to eventually adjust or redesign them based on a more explicit understanding of where problems and opportunities are found. Usually farmers lack information and knowledge about innovations, hence the innovation diffusion model, by Negatu and Parikh (1999), which argues that a technology has to be transmitted from a researcher to farmers through competent extension services (Rogers, 2003).

There have been many programs and projects that have been promoting CA in Malawi and Africa as a whole. Valencia & Nyirenda (2003) reported that the total number of farmers participating in the conventional technology across the country was 4,161 farmers and only 273 farmers were participating in CA. Despite this, there is little evidence that is indicating the adoption levels of CA and factors that influence adoption. Nyanga (2012) concluded that smallholder farmers adopt CA but do not relate it to climate change but to incentives that are given by organizations that promote CA such that after the programme ends then the farmers go back to conventional farming.

Land Resources Conservation Department (LRCD) has documented the adoption of CA in Malawi. In the year 2008/2009 LRCD reported that area under conservation farming

registered 18,471 hectares out of the target of 16,789 hectares and participation was 60,758 of the 73,336 farmers planned. For 2009/2010 area under conservation farming registered fell down to 16,028 hectares and the participation was 37,594 farmers comprising 16990 males and 20604 females. For four consecutive seasons; 2006 to 2010 the cumulative hectarage under CA is reported as 102, 363 hactares done by 270,598 farmers of which 151,376 were males and 119,222 females representing 44% female participation.

Mlamba (2010) in a study conducted in Salima ADD supports the suggestion that farmers who buy their own inputs when starting a new technology are likely to continue with the technology than those who solely depend on grants. The study found out that the greater majority of the respondents were aware of CA and its associated benefits, however, awareness in CA alone was found not to be enough to enhance the adoption and continued use of CA. Somewhat unexpectedly in the study results, age of the respondent, household size, level of education, level of land control, and size of the garden were found not to show significant relationships with the adoption of CA. Research has indicated that land control/ownership might have been a significant factor in getting involved in CA, since land tenure has been established as a major factor in encouraging the investments needed for land improvements (McCulloch, et al, 1998; Lastarria-Cornhiel, 2009).

Sirrine et al. (2010) undertook a 10 year, participatory trial on agroforestry adoption with 48 farmers near Zomba in southern Malawi. They found that adoption was based more on immediate livelihood benefits, such as the provision of a secondary food or fuel source, than on long term soil quality or maize yield benefits. Pigeon pea (C. cajan) was the preferred agroforestry system for this reason. However, wealthier and younger farmers, and those with larger landholdings were more likely to adopt the *Sesbaniasesban* (Nitrogen fixing tree) agro forestry system, which has the greatest impact on maize yields via improved soil health.

Thangata and Alavalapati (2003) investigated farm and farmer characteristics that influenced adoption of agroforestry approaches in the densely populated Domasi valley of southern Malawi. The study considered the adoption of mixed inter-cropping of *Gliricidia sepium* (Nitrogen fixing tree) and maize. The results found out that, younger farmers and all farmers with frequent contact to extension staff were more likely to adopt. They also found that larger

households were more likely to adopt, likely due to the higher labor requirements of agroforestry relative to mono- cropped maize. An earlier study by Thangata et al. (2002) addressed the same question but used a linear programming approach and data from Kasungu in central Malawi and found that adoption of improved fallow was driven by available land and labor resources. However, it is hard for female-headed households in Bolero to have more land because of the patrilineal system in the area, especially after the death of a husband or marriage break-ups when women are asked to go back to their home. On the other hand, young farmers in Bolero are concentrating on tobacco farming to raise household incomes even though some are practicing the Conservation Agriculture principles in their gardens as a result of contacts with extension agents. At the same time, it is assumed that younger farmers are the ones to adopt such Conservation Agriculture as a result of labour demands at the initial stages though older and poor farmers could also adopt because they do not have alternatives. Older farmers could also adopt more than younger ones since they have had experience on how changes have occurred in their area over the years. In general, farmers in Bolero are practicing both conventional and conservation agriculture on different plots and gradually convert additional plots, if any, when convinced of the benefits since the majority of farmers in Bolero do combine food and cash crops in their farming systems.

A study by Chinangwa (2006) in Machinga and Zomba districts, southern Malawi looked at farmers' perceptions of soil fertility problems as a driver to adoption of soil fertility improvement technologies such as conservation agriculture. It revealed that majority of farmers perceived soil fertility to be low and that it would continue to decline for their choice on adopting the technologies. However, this could also be as a result of shortage of income for the majority of farmers to perceive low soil fertility since they cannot afford to buy inorganic fertilizers. It is also possible that the study failed to show population trends of the target area in order to show that it was older farmers who perceived soil fertility depletion more than younger ones.

ActionAid (2008) conducted a study in Salima district which showed that a Farmer Field School involving women known as Salima Women's Network on Gender pools together resources to maintain community gardens. Through regular meetings, the women have been able to share tools, seeds and knowledge on diverse farming methods and have been able to

increase yields to more than what they could have grown individually. This supports the study by Kavoi et al. (2014) in Eastern Kenya which sought to determine factors related to low uptake of improved technologies and one of its specific objectives was to identify existing networks in the target area. The findings showed that over 90% of respondents agreed that being a member of more than one group could help farmers interact and share information. However, it is hard to state that the involvement of different stakeholders in Bolero would enhance information flow and uptake of conservation agriculture principles since roles and responsibilities are not clearly defined.

A study in Tanzania and Uganda by Boyd et al. (2000) was aimed at discovering factors for the adoption of low-cost agricultural technologies and it revealed that the majority of crop-dependent farmers practiced soil and water conservation technologies. It also revealed that trade liberalization in Tanzania improved access to markets and increased producer prices, stimulating investment in technologies at household level. Many Ugandan farmers had diversified away from crop production in order to generate cash income thereby neglecting the technologies. Ugandan farmers, as those in Bolero, with limited access to land and work-oxen have invested more in the technologies while farmers' perception of the severity of land and soil degradation such as land shortages and consequent soil depletion were characterized by extensive adoption of the technologies. In other cases, it is those with limited access to land who are engaged in tobacco farming so as to earn cash to be able to buy food at the expense of soil fertility. However, it is different with Bolero, where farmers have contributed a lot to soil fertility decline by diversifying away from food crop production to tobacco farming that relies heavily on inorganic fertilizers in order to generate cash income without thinking of replenishing soil fertility while at the same time encouraging environmental degradation.

Mloza Banda (2003) reported some socio-cultural influence in adoption of Conservation Agriculture principles where he pointed out that in some regions of the country, tradition plays a major role in the type of tillage system practiced. For example, clean tillage was or is regarded as the trademark of the successful farmer, for the ethnic Phokas in Rumphi, Northern Malawi in particular. Socio-cultural influences can make farmers reluctant to accept

new or unusual crop production practices but when properly directed, can also accelerate the acceptance on alternative farming practices.

A survey by Nyanga et al. (2011) in Eastern Zambia, which looked at smallholder farmers' perception of climate change and conservation agriculture in order to understand attitudinal and knowledge-based drivers of adoption, discovered that farmers were aware of climate change and perceptions related to changes in floods and droughts and were significantly associated with adoption of conservation agriculture though mostly attributed this to supernatural forces rather than human activity. There was also widespread expectation of subsidy input packages or material rewards for uptake of technologies. And according to findings of Baudron et al. (2007), 50% of farmers dis-adopt if they no longer qualify for such incentives. In Bolero, farmers are aware of climate change and its impacts and some perceive soil fertility loss as both natural and man-made through tobacco farming. For those farmers who have realized this problem, have adopted the technologies to increase yields, replenish soil fertility and raise incomes, though actions that follow these perceptions might be driven by other different factors such as: Approach to CA (CA message dissemination); subsidies (own acquisition of inputs when starting); age of the farmer; land ownership; household size; education level of the farmer and sex of household head.

Data Collection and Analysis Methods

Study Area

The study was conducted in Bolero EPA that has 12 sections located in Rumphi district of Mzuzu ADD in Northern Malawi. The EPA office is 16 km towards the west of the district headquarters bordered by Mhuju EPA to the east; Katowo EPA to the west; Nyika National Park to the north and Mwazisi Sub-EPA to the south. Its total area is 364 square kilometres. Bolero headquarters is on E 0581360 N 8786019 and stands at an average altitude of 1,099m above sea level. Bolero EPA has a population of 58,550 people that is distributed in 112 villages. Women constitute about 51% of the population. The area has an average of 5 persons per household. It has 12 administrative sections (Figure 1); 112 villages; 11,710 farm families and an average land holding size of 2.7 hectares per family. Bolero is one of the many rural communities in Malawi whose main livelihood activity is subsistence agriculture which accounts for 65% of the income of the rural poor.

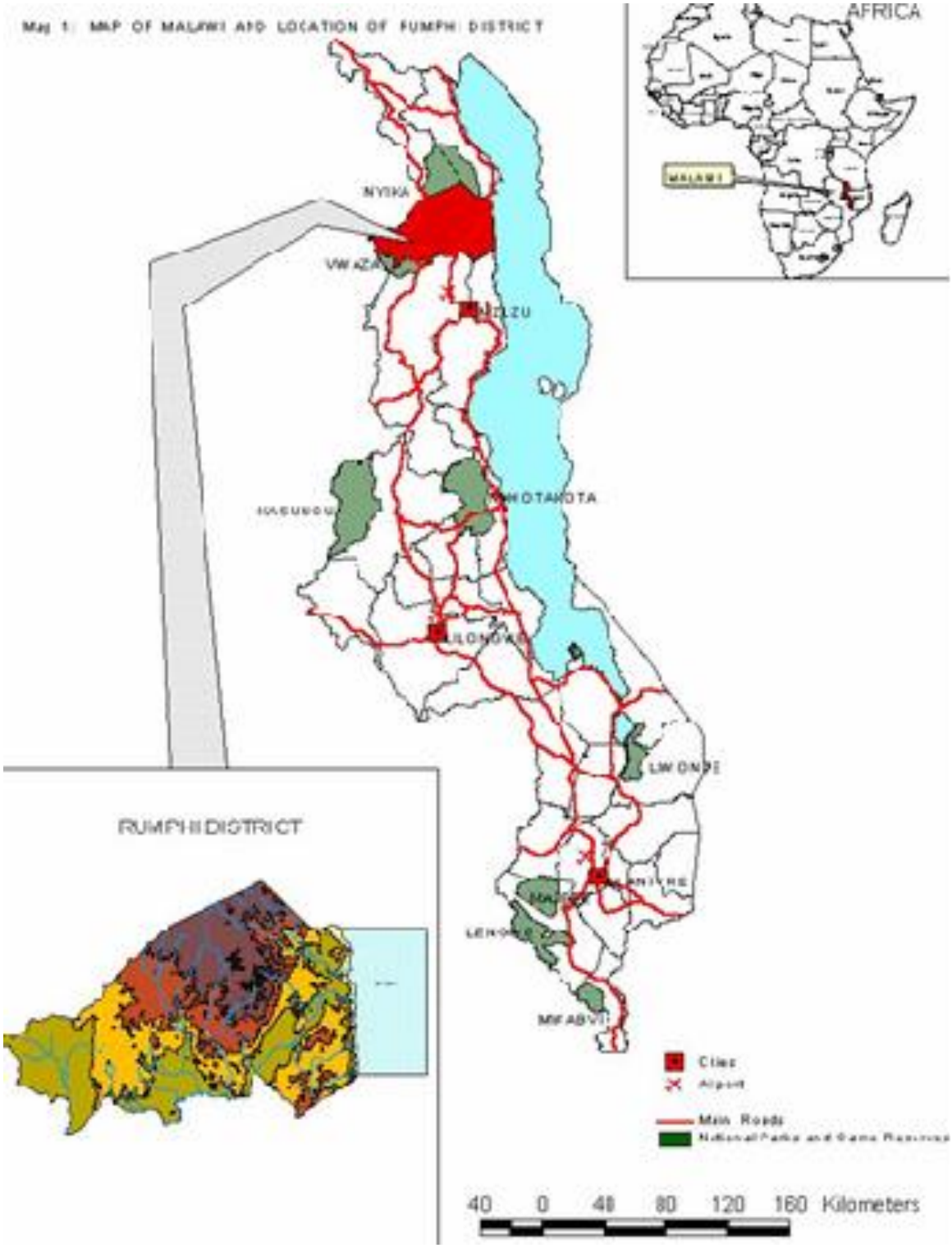

Figure 1: Map of Africa, Malawi and Rumphi
Source: Rumphi District Socio-Economic Profile (2008)

Sampling procedure

The research covered at least 30% of the total 12 sections of the EPA which were randomly sampled after the names of the sections were listed alphabetically and every third section was selected counting from the first section (Bata, Betere, Bolero A, Bolero B, Bumba, Chirambo, Chozoli, Jalira, Kawaza, Lundu, Luviri and Mjuma). This method of random sampling gives each section the same probability of being chosen. This means that Bolero A, Chirambo, Kawaza and Mjuma were sections that were selected for the study which gave more than 30% of the total number of sections. A stratified random sampling technique was used to identify respondents in all the selected sections based on two categories which were farmers who practice CA and farmers who do not practice CA. A list of all farmers who practice CA was obtained from the EPA Office for each section and the names were arranged alphabetically and every n^{th} farmer was selected depending on the number of farmers counting from the first farmer to give at least 30 % of the total farmers as the sample size from each section. Similarly a list of all farmers who do not practice CA was obtained from the EPA Office for each section and the names were arranged alphabetically and every n^{th} farmer was selected depending on the total number of farmers counting from the first farmer to give at least 30 % of the total farmers as the sample size from each section. Fifteen (15) field officers (AEDC/AEDO) from Ministry of Agriculture and Food Security and Field Officers from NGOs working in Agriculture Sector which were more than 30% of the total population of the Field Officers from Bolero EPA were randomly sampled and interviewed using the same technique.

Data collection

The questionnaire that comprised of closed and open-ended questions was administered to farmers and Agriculture Field Officers. An open-ended questionnaire was also used to support interviews with randomly sampled Agricultural Extension Development Officers and Field Officers from Organizations working in Bolero EPA. Secondary data was also obtained from published and unpublished documents; this assisted to triangulate data. The survey administered a pretested structured questionnaire to one hundred and thirty five (135); sixty (60) farmers who do not practice CA and sixty (60) farmers who practice CA. In addition to

the farmers fifteen (15) Field Officers from Ministry of Agriculture and Food Security and Field Officers from NGOs working in Agriculture Sector within Bolero EPA. A questionnaire was designed to collect data on social economic characteristics of the respondents and level of adoption of the respondents. The objective of the case study method is to locate the factors that account for the behavior-patterns of the given unit as an integrated totality (Kothari, 2004). In this case, perceptions and impacts of climate change and conservation agriculture principles being promoted plus factors for adoption or non-adoption were analyzed. This method allows multiple sources of evidence as designed in this study, namely household survey (questionnaire), key informant interviews(Field Officers), documentation reviews and observation (Yin, 1994).

Table1: Sample size of respondents from Bolero EPA

Category of respondents					
Section	**# Doers 2014**	**# Doers interviewed**	**# None Doers 2014**	**# None Doers interviewed**	**Total**
Bolero A	49	15	51	15	30
Chirambo	33	15	48	15	30
Kawaza	42	15	46	15	30
Mjuma	47	15	49	15	30
Total	**171**	**60**	**194**	**60**	**120**

Note: Doers are farmers who have adopted CA and None Doers are farmers who have not adopted CA

Data analysis

Descriptive analysis

Descriptive statistics including frequencies and percentage for various variables were calculated. Cross tabulations were made for the variables that were used in the logit regression model to assess frequency of adoption among the respondents. Chi-square test was

used to determine if the respondents from different categories were significantly different in the adoption of CA.

Logit regression analysis

The binary logistic model was used to examine factors that influence farmers' adoption of CA and challenges farmers encounter when practicing CA principles. Logistic regression sometimes called the logistic model or logit model was used for prediction of the probability of occurrence of an event by fitting data to a logistic function. Like other forms of regression analysis, more predictor variables that were either numerical or categorical were used in the analysis according to Hilbe (2009).

Logistic regression model was considered because it is well suited for describing and testing hypotheses about relationships between a categorical outcome variable and one or more categorical predictor variables (Peng et al., 2001). Logistic regression solves the problems by applying the logit transformation to the dependent variable. In essence, the logistic model predicts the logit of Y from X. Logistic regression is a useful way of describing the relationship between one or more independent variables (e.g., age, sex, education.) and a binary response variable, expressed as a probability that has only two values (Agresti, 2007). The dependent variable (Y) was dichotomized with a value of (1) if respondents have positive adoption (practices principles of CA) and (0) if respondents have negative adoption (does not practice principles of CA). Eight predictor independent variables were regressed against the binary dependent variable of adoption. The binary logistic regression model as specified in equations, 1 and 2, according to Kidane et al. (2005) was used to determine factors affecting respondents' adoption of CA principles. The logistic regression analysis was carried out by the Logistic procedure in SPSS version 20.0 in Microsoft Windows 8.

The probability function of respondents having a negative adoption is given by:

$$P_i = E\left(\gamma_i = \frac{1}{\chi_i}\right) = \frac{1}{1+\ell^{-\left[\beta_i + \sum_{i-1}^{k-n} \beta_{ij}\chi_{ij}\right]}}$$ Equation 1

Where P_i is the probability of respondents *(i)* having positive adoption to CA is the observed resource use status of the respondents.

i, ij are the factors determining positive adoption to CA; *i* and *j* are parameters estimated.

By denoting $\beta_i + \sum_{j=1}^{k-n} \beta_{ij}$ *as* Z , equation (1) can be rewritten to give the probability of positive adoption to CA (i) as:

$$P_i = E\left(\gamma_i = \frac{1}{\chi_i}\right) = \frac{1}{1+\ell^{-Z_i}}$$ Equation 2

which is known as the cumulative logistic distribution function.

On the basis of the general rule of a minimum ratio of 10 to 1, with a minimum sample size of 100, the study met the recommendation because it had a sample size of 120. Therefore, the results reported in this study are considered stable.

Results

Respondents' CA adoption

Variables such as age of respondent, household size and farm size are not significant ($p > 0.05$, χ^2), implying that there are no significant variations in positive or negative CA adoption. The logistic regression coefficients for the determinants of CA adoption of adopters and non-adopters are contained in Table (2.).

Table 2: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	.291	.120		2.419	.017	.053	.530		
Age	.080	.094	.080	.846	.399	-.107	.267	.893	1.120
Income	.073	.096	.072	.761	.448	-.118	.264	.878	1.138
Education	-.044	.098	-.044	-.453	.652	-.238	.150	.849	1.178
Household Size	-.074	.094	-.074	-.790	.431	-.261	.112	.900	1.112
Farm Size	.133	.105	.127	1.269	.207	-.075	.341	.800	1.251
Marital Status	.070	.117	.061	.596	.552	-.162	.302	.765	1.307
Gender	.251	.103	.251	2.449	.016	.048	.454	.757	1.321
Land Ownership	-.536	.358	-.138	-1.498	.137	-1.245	.173	.933	1.072

a. Dependent Variable: CA Adoption status of respondent

Goodness-of-fit statistics assess the fit of a logistic model against actual outcomes. One inferential test and two descriptive measures were conducted. The inferential goodness-of-fit test that was considered is the Hosmer and Lemeshow (H-L) test that yielded Chi-square (χ^2) of 3.848 with 8 degrees of freedom was insignificant (P = 0.481), suggesting that the model fit to the data well. The -2 Log Likelihood shows that the model fits the data at an acceptable level (P = 0.005). Since Sig is .047 which is < .05, for 95% confidence in the ability of the model to explain the dependent variable, this significance implies that we can accept the model. If Sig>.1 then the model was not significant (a relationship could not be found) or "R-square is not significantly different from zero." This could mean that the dependent variable cannot be explained by the independent/explanatory variables.

Influence of significant variables on CA adoption

The marital status of respondents was included in the model to assess if it has an effect in determining CA adoption. The variable marital status shows that it has a negative significant coefficient implying that changes in the variable would be associated with a negative influence on CA adoption i.e. the probability to influence the CA adoption is low. Married group of respondents had negative adoption. The single category of respondents was cooperative in positive adoption implying that they are willing to conserve the declining soil resources of Bolero. The choices of adoption might be attributed to the current challenging household economic needs against household size. The average household size was 5 which were higher than the national figure of 4.4 per household (NSO, 2008). Due to poverty the families may not be able to support all the household members.

The variable level of education was included in the model to assess if it has an effect in determining CA adoption. The variable shows that it has a positive significant coefficient implying that changes in the variable would be associated with a positive influence on CA adoption i.e. the probability to influence the adoption is high. The more educated one is the higher the probability of having a positive adoption. The more educated group is cooperative in resource use (positive adoption) while the less/not educated group is impatient in resource use (negative adoption). Education in that respect helps people to appreciate more values of conserving agriculture. In essence, education would make it

easier for households to comprehend negative externalities and passive user values of natural resources. Ideally, decisions pertaining to CA adoption are expected to be influenced by education level of households.

Statistical tests of individual predictor variables

The statistical significance of individual regression coefficients was tested using the P –value statistic significance. Out of eight (8) predictor variables, five variables (Gender, marital status, education, income and land ownership were significant predictors of farmer's adoption of CA ($P < 0.05$). Out of the five significant predictor variables three had positive significant coefficient (Gender, education and income). This may be inferred that for a given score on the adoption of CA prediction, the probability of the positive significant coefficient to influence the outcome is higher than that of negative significant coefficient. Variables that were insignificant were dropped from the model. The test of the intercept merely suggests whether an intercept should be included in the model. For the present data set, the test result ($P > .05$) suggested that an alternative model without the intercept might be applied to the data.
Variables that were insignificant were dropped from the model thus the final model contains the following independent variables; Gender, marital status, Literacy, Income and land ownership.

Therefore, the model can be estimated as:
Logit (Y) = Gender + Marital status + Education + Income + land ownership.

Two additional descriptive measures of goodness-of-fit are R^2 indices, defined by Cox and Snell (1989) and Nagelkerke (1991), respectively. Cox & Snell R^2 of .217 can be interpreted as 21.70% fewer errors were made in predicting the adoption of CA. Negelkerke`s R^2 of .289 can be interpreted as 28.9% fewer errors were made in predicting the adoption of CA. In linear regression, R^2 has a clear definition: It is the proportion of the variation in the dependent variable that can be explained by predictors in the model. Attempts have been devised to yield an equivalent of this concept for the logistic model. None, however, renders the meaning of variance explained as argued by Menard (2000). Furthermore, none corresponds to predictive efficiency or can be tested in an inferential framework (Menard,

2000). For these reasons, the two R^2 indices can be treated as supplementary to other, more useful evaluative indices, such as the overall evaluation of the model, tests of individual regression coefficient and the goodness of fit test statistic.

Discussion

Adoption of CA practices among smallholder farmers in Bolero

It was well established from the study that most of the farmers were aware of CA and the majority of extension workers were trained on CA. These activities had a bearing on imparting knowledge, skills and empowerment for the target farmers to practice CA in their own fields. The most important impact of this work has to be adoption/practice of CA technologies. In this study adopters are defined as *farmers that have been using one of the three principles for two years or more with or without input support (seeds/fertilizer)*. The adoption paradigm illustrates that adoption of an innovation is not a characteristic of an individual alone but encompasses a set of phases or levels, such as cognitive, normative and action-oriented that govern it (Prager et al. 2011). The recognition of these levels will aid in understanding the prerequisites necessary for successive steps that ultimately lead to sustainable adoption of a technology.

Current practice of conservation agriculture principles

Soil cover and minimum tillage were the most popular CA principles being practiced by farmers in Bolero. However, during discussions with farmers, it was observed that retention of crop residues as surface mulch is hampered by fear of termites eating mulch, rodent hunting and fire attacks among others. Crop rotation and intercropping were practiced by a small proportion of farmers in the study area. In general a very small percentage of the farmers interviewed were practicing all three principles of CA in their fields. As most respondents had heard of CA, there was little difference in practices between those who had heard of CA and the whole set of respondents. It is interesting to note that for those who had practiced CA at some point very few had stopped practicing. This suggests that farmers can see the benefits of the technology, once they have practiced it. The implementation of CA should encompass all three principles so that the benefits are realized. Adoption of CA should then improve based on observed benefits (FAO, 2010). Respondents were asked why they did not practice CA; it is interesting to note here that 24% claimed that they did not understand what CA was about. This is broadly in line with responses from farmers on whether they have heard of CA, where just under 22% of respondents stated that had never heard of CA. Waiting for, or perceiving that inputs are needed as well as extension workers promoting other techniques were also significant reasons for not practicing.

Given the significance of this constraint to practicing CA it would be interesting to follow up on this. It is proposed that the behavior change approach used extensively in water and sanitation and health programmes could be used. Specifically, the Barriers Analysis (BA) tool, which assesses the key determinants for why people ***do*** or ***do not*** do a particular behavior, could be used to understand this better.

Respondents who ceased practicing CA were also asked why they no longer practiced it. The reasons given during FGDs for stopping CA practices were broadly in line with the survey results: stopped receiving support, too much work, and lack of crop residues for mulching. Incentives, such as inputs (i.e. seed and fertilizer) may induce farmers to practice CA by demonstrating over a couple of seasons that the technology works at least that is the theory. It is widely perceived that stopping inputs is a decisive factor in farmers ceasing to practice CA.

In FGDs with farmers, it was mentioned by lead farmers that most of the farmers are no longer practicing CA after withdrawal of incentives. A report by FAO (2010) also highlighted this as a grey area to CA adoption with questions of sustainability being put on inputs which could also be acting as a disincentive to those in the community that do not receive the inputs. On the other hand, incentives can effectively reduce farmers' risks associated with a new innovation. For incentives to work as an empowerment package for the adoption of CA beyond the project period, NGOs and other international development agencies must ensure that inputs are not used as bait to attract farmers and that there is clear messaging around the benefits of the principles of CA. Success of CA must not be perceived to be due to improved inputs alone.

The expanded use of CA would have economic and environmental impacts on farmers in Malawi, including the potential for reduced labor days, soil erosion, and production costs (Ngwira et al. 2014). The proportion of farmers that have expanded the area under CA in their fields from the initial plots is 34% of all farmers practicing CA. Results show that in general, respondents who received inputs were more likely to expand their plots than those who did not.

Factors affecting adoption of CA

Marital status

The variable marital status shows that it has a negative significant coefficient implying that changes in the variable would be associated with a negative influence on CA adoption i.e. the probability to influence the CA adoption is low. Married group of respondents had negative adoption. The single category of respondents was cooperative in positive adoption implying that they are willing to conserve the declining soil resources of Bolero.

Sex of the household head

The study involved a total of 120 households divided into 3 categories of 40 households each. The first group was composed of farmers who had been practicing conservation agriculture for a minimum of two years, the second group comprised farmers who once practiced CA but had stopped, and the last category consisted of farmers who have never practiced CA. Seventy per cent of the households interviewed were male headed while the remaining 30% were women headed. Chi-square (x^2) analysis of sex of the household head and adoption of CA was conducted and the results support the idea that male-headed households were more likely to adopt CA than those headed by females at 95% confidence interval and 2 degrees of freedom (df). Mazvimavi and Twomlow (2009) found similar results in a study carried out in Zimabmbwe.

Age of the household head

Thirty five per cent (35%) of the farmers who are practicing CA and those who were no longer doing it were in the age category of 18-44, as compared to 30% of those who had never practiced CA. No relationship was found between age of the respondents and adoption of CA. Studies in the literature has come up with conflicting results. Knowler and Bradshaw (2007) also found it difficult to link adoption of CA and age of a farmer in their review and analysis of recent research on farmer's adoption of conservation agriculture. Likewise

Mlamba (2010) again found it difficult to link adoption of CA and age of a farmer in their review and analysis of recent research on farmer's adoption of conservation agriculture.

Size of the Households

More than 65% of the respondents involved had households of greater than 4.4, which is the national average. No statistical correlation was found between household size and CA adoption, but those who had never practiced CA, or had given it up were more likely to have larger families than those who did practice it.

Education

It is assumed that the ability of the household head to understand technical aspects of conservation agriculture would be dependent on their educational level. A positive relationship was expected between educational level and adoption as farmers with higher education are expected to have more access to information on the dangers of not following recommended soil and water conservation technologies. In this study, no overall correlation was found between the adoption of CA and the household head's level of education.

Land Ownership

Land is one of the important factors of production; it assists the farmer in budgeting what and how much to produce. It also helps the farmer in deciding the production system to follow. In this study it was assumed that farmers with larger gardens would be able to adopt CA more easily because they can follow all the principles of CA, including crop rotation.
All the households who participated in the study owned a piece of land ('garden'). Overall, 91.8% of the farmers were farming on customary land while the remaining 8.2% were cultivating on public land. All the farmers who were using customary land had obtained it through inheritance, while those under public land obtained it from government under settlement scheme programme.

Land Holding Size (Size of the Gardens)

The minimum land holding size in the study area was 1.5 ha, while the maximum was 6.4 ha, and 75%, 60% and 50% of the farmers who were practicing CA, who once practiced CA and those who had never practiced CA, respectively, had pieces of land of greater than one hectare. The study found no statistical correlation between farm size and adoption of CA, but half who did not practice CA (50%) owned less than 1 hectare, while most who did practice it (65%) owned more than 2 ha.

Level of Income

Household income is the aggregation of income both in cash and/or kind that accrues from economic activities performed by household members on a regular basis (NSO, 2005). The assumption in this study was that higher income would have a positive influence on adoption of CA because the higher the level of income the higher the chances that the farmer can invest in conservation technologies. Data for income distribution among the three categories of farmers indicate that the majority of respondents were poor. Going by the 2010-2005 Malawi Integrated Household Survey (which puts MK16, 165.05 per person per year as a poverty line and 4.4 persons per household as national average) it means that more than 70% of households in the study area live below the poverty line. Additional information recovered during the survey revealed crop production contributing over 80% of the total income from agriculture while the remainder came from livestock.

Challenges to Conservation Agriculture Adoption

Strong culture of ridge based cultivation

Conventional agriculture is characterized by continuous tillage through ploughing and ridging, monocropping, burning of crop residues and inadequate nutrient application (Mloza Banda, 2002). During the colonial and post independence era, farming system changed gradually to the ridge based system. Most CA demonstration farmers have only allocated small plots of their land holding to CA demonstrations without significantly increasing. This

indicates that the demo farmers have not been "transformed" enough in spite of the CA benefits over non-CA plots. Sosola *et al.* (2010) found out in a baseline study that 100% of the smallholder farmers possessed a hoe used for land preparation and other hoe based tillage including ridging. The same authors found that the reasons for using ridging cultivation were that farmers learnt it from their parents, they use it as a soil and water conservation and that is the only cultivation practice that they know. This shows it is very difficult to transform farmers like these.

Stover mining, livestock problem and multiplicity of maize Stover usage

Most CA stakeholders promote maximum soil cover but the practice encourages "Stover mining" from non-CA fields because usually maize Stover from CA fields are never adequate to cover the soil in the recommended amounts of 30% cover. The maize Stover spreading across the CA fields soon after harvest is fed on by roaming livestock that are set loose after harvest. CA farmers lamented on feeding their Stover to other farmers' livestock and of livestock damaging their planting basins. Under smallholder agriculture system, ownership rights do not extend to crop residues but is rather limited to crops produce. Maize Stover is often taken away by fellow farmers to be used for fuel wood, fumigating tobacco nurseries, construction purposes and feeding livestock. Most demo farmers have CA plots close to the village where close supervision is guaranteed. This alone would affect the scaling out of CA by the participating farmers to distant fields in fear of theft of Stover. It is feared that farmers would start selling maize Stover due scarcity of maize Stover and its multiple uses.

Scarcity of CA implements and herbicides

Following CFU's CA methods, there is a shortage of chaka hoes, jab planter and other support implements. Other CA stakeholders promote the use of the standard hand hoe for constructing planting basins. ICRAF, CARE Malawi, WALA consortium and NASFAM did not promote the use of herbicides in their respective projects whereas FAO, CRS, TLC and Concern Universal provide packages of herbicides. Farmers complained about the price and scarcity of the herbicides on the local markets.

Long break-even point of CA benefits

Research findings indicate that SOM changes in the early stage of CA but bulk density and porosity did not change significantly though over a period of four years or more would lead to physical soil improvements (Mloza-Banda and Nanthambwe, 2010). Farmers are used to "instant" or "click" technology of improved seed, chemical fertilizer, herbicides and others which yield immediate results. Any technology that takes a relatively longer period of time to yield results would be regarded as a waste of time and resources. A similar syndrome befell agroforestry sector whereby most trees require a longer period of time for the farmers to benefits from soil health improvements (Sosola *et al*., 2010).

Lack of clear guidelines for a specific CA practice

The survey results show that most of the stakeholders do not have clear guidelines for promoting of CA practice as regards to suitability to agro-ecological zone. CA is not a blueprint technology to be promoted as a "one-size-fits-all" approach. Under Evergreen Agriculture project of ICRAF, farmers used both old ridge approach and planting basins depending on the topography and dryness of the areas. The dimensions of the planting basins and the spacing between the basins and rows are not uniform amongst CA stakeholders. FIDP and Government of Malawi promoted that the basins should be staggered to capture water more efficiently as opposed to regular patterned basins. This lack of clear guidelines for a specific CA practice confuses farmers and discourages them in the long run.

Farmers` perspectives on CA

The benefits of CA are usually long term. Focus group discussions, key informant interviews and anecdotal evidence revealed that CA reduces crop vulnerability to dry spells and results in an increase in maize yield. The reasons cited for sustaining the practice were: the benefit achieved through reduction in labour requirements; availability of labour for other livelihood activities;
Increase in yield arising from strict management regime of CA even in years with lean rainfall and noticeable reduction in the loss of the fertile top soil. However non-adopters believe CA is

generally labour intensive especially when it comes to pit digging and soil cover where at least 30% cover is the minimum requirement as well as long break-even point of CA benefits.

Conclusions

CA adoption is a process which can be broken down into the four stages of Knowledge/Persuasion; Practice/Decision; Implementation and Confirmation. It is important to note that about 95% of those who claimed to have practiced CA at some point started it in the last three years. Given this figure is so large it might be expected that after just three years of concerted effort on CA, little progress will have been achieved on actual adoption. It is also clear that as farmers move from one stage to the next, roughly half the farmers are being lost at each stage. Currently, knowledge is not translating into practice and practice is not translating into implementation/adoption. There is ample evidence to indicate that CA works in Malawi in general and Bolero in particular. There is also a compelling case for CA as a technology to increase not only food production, but also the resilience of smallholder farmers in Malawi. The perennial question remains – ***'so why are farmers not adopting?'***

The study shows that the vast majority of farmers have been exposed to CA, while 88% claimed to have heard about CA, 21% could not name any of the principles. However, just about 13% of those who had heard about CA could name all three principles. This indicates that CA is not being systematically promoted as a package of principles by practitioners. The emphasis is only on soil cover/mulching and minimum till with little emphasis on rotation. It has also been shown that while extension workers are knowledgeable on both the principles of CA as well as the rationale for each principle, this is not translating into practice. Only 11% of respondents still practicing CA are implementing all three principles, whereas 54% are practicing two of the three. When considering the total population, these figures drop to just 2.2% and 11.2% respectively. Of the 60 respondents not practicing CA, 24% stated it was because of a lack of knowledge and a further 21% stated they were waiting to see if it works. This would seem to make a strong case for awareness raising through farmer field days, demo plots and farmer to farmer exchange. However, this is already widely practiced and this 'knowledge of CA' (by either extension staff or farmers) is not translating into practice. For example 72% of respondents were able to name soil cover/mulching as a principle of CA but only 24% are actually practicing it; while on the other hand 96% of extension staff were able to state that rotation/association is a key principle of CA yet less than 3% of farmers are practicing it. Very few (3%) of all respondents currently practicing CA have expanded their plots. The few who have expanded are those who have been

doing CA for two or three years. There are a number of stakeholders that promote CA in Malawi; as such there is urgent need to synergize efforts in CA development and to advocate for radical change in tillage system.

The study has proved the hypothesis that adoption of conservation Agriculture principles in Bolero are influenced by other factors; farmers have challenges that they face when implementing conservation agriculture principles and there are some farmers' perception about Conservation Agriculture principles in Bolero that influence them to adopt CA or to abandon.

Recommendations

Much more work is required on the extension methodology to ensure that it is effective. Some suggestions for improvements on the extension methodology are to start from a problem analysis conducted with farmers. This will enable the extension staff to introduce CA as a solution to problems faced by farmers, rather than a top down ***("do this") ("this is how it is done")*** approach. This will also effect a move away from the one size fits all model, which will not work; all three principles should be promoted together where possible; we must demonstrate that the technology works and treat CA adoption as behavior change and integrate barriers analysis into extension work so that extension workers can better understand why some farmer ***do*** or ***do not*** adopt and can adjust their approach/messaging accordingly.

The deficiency of information persists despite some adaptive research on CA. Adaptive research is needed so that local communities become active participants in influencing responses to climate change for local food production, gender equality, livelihood, health and nutrition as a way of transformative community development to develop practices appropriate for the various farm and agro-ecological conditions. CA should not be practiced as a "one-size-fits-all" as such may be counter-productive to CA advocates in the long run if the practical realities of the farmers' are not properly assessed and incorporated in the promotion of CA.

Input acquisition is a challenge to smallholder farmers as the desired inputs are sometimes not available or most farmers cannot afford to buy them at the current market price. This is particular true of herbicides. The lack of purchasing power can be attributed to the fact that the majority of farmers live below the poverty line, and deliberate action therefore needs to be taken to enhance farmers' access to inputs. This has previously been done by supplying materials as grants, but this has encouraged farmers to apply who are only interested in the inputs rather the CA technology being promoted. Such practices create a dependency syndrome, which is counter-productive to the goal of building self-sufficiency. Grants also bring discontent among the farming community as not everybody is covered, and the criteria used in selection of beneficiaries are often questionable. In some cases farmers who are left out of grants programmes shun away from participating in other agriculture programmes. It also creates an impression that any new technology cannot be implemented without external assistance.

Alternatively, provision of loans on a cost-recovery (i.e. no-interest) basis to smallholder farmers who show interest in CA. Previously the Malawian government issued agriculture inputs as loans accessible through Farmer Groups, but with individual recipient farmers repaying to the government through the Agricultural Extension Workers. This is no longer the case, but government grants can still be given to a Farmer Group to set up a revolving fund with repayment to the Group. Farmers who show interest in CA should be asked to pay a deposit to the Farmer Group account as proof of their commitment, and this would put off farmers who were only interested in the grant rather than the technology. TLC (2007) recommends that loans to farmers and small-scale enterprises must first involve a thorough assessment of capabilities to undertake the intended practice, along with ability to repay the loan. To reduce the risk of defaults, and to ensure that beneficiaries are committed to the endeavour, a minimum down-payment should be demanded.

Many people are still tentative on working with conservation agriculture because the government has no official agricultural policy that incorporates this technology therefore there is need to draft and approve a policy with clear guidelines for a specific CA practice.

Coming up with a deliberate policy that would result in reduction of the current market price of herbicides may also increase CA adoption, and this can be achieved through reducing the domestic tax on herbicides, which is currently at 21% (Tchale and Keyser, 2010). However, not all farmers could afford herbicides even with the provision of loans or a reduction in price. Therefore, it is imperative that it is demonstrated to farmers that CA is not synonymous with herbicide application. This assumption had been established by the fact that very few proponents of CA in Malawi have done it without herbicides. However, there is literature support for the idea that CA can be done without herbicides as long as adequate soil cover is provided to suppress weeds (FAO, 2008). Doing this would be more labour-intensive, but would enable farmers to fight the weed problem more cheaply.

Finally, after making sure the current farmers are stable and experienced, we can look to scaling up and plan the implementation of conservation agriculture throughout the rest of the Country. A clear vision of what conservation agriculture should look like in Malawi is the first step, and then a plan that addresses the principles of development should be compiled. This is not a simple process, and should be done in conjunction with all partners and input from farmers themselves—if this process belongs to a single person/organization, it is bound to fail.

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