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Does Adoption of Climate Smart Agriculture (CSA) Technologies Reduce Household Vulnerability to Poverty?

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Abstract
Climate variability is one of the limiting factors to increasing per capita income and food production among smallholder farmers in Africa. This study investigated if the adoption of climate smart agriculture (CSA) technologies reduce household vulnerability to poverty by differentiating crop yields and income between adopters and non-adopters. This study used a mixed methods approach; both qualitative and quantitative techniques. A multi-stage stratified random sampling was applied, with 619 respondents interviewed in the districts of Nsanje and Balaka in southern Malawi during 2014-2015 cropping season. There was an increment of 26%, 37%, 9% and 26% in maize yield by farmers who adopted portfolio diversification, soil and water conservation, soil fertility improvement and irrigation and water harvesting technologies respectively. About 42% of the adopters had food throughout the year compared to 26% non-adopters. Adopters had 47%, 42%, 60% and 36% more in their crop revenues from portfolio diversification, soil and water conservation, soil fertility improvement and irrigation & water harvesting respectively, than their non-adopters counterparts. The study confirms the importance of agriculture technology adoption for increased household revenue and the need to take steps to reinforce existing adoption strategies.
Keywords: Climate smart agriculture, effectiveness, smallholder farmers, Malawi.

1.0 Background

It is estimated that more than 70% of the arable land in Malawi is allocated to maize production (GoM, 2006). According to Dorward et al. (2008), the share of farmers growing maize varies from 93% to 99% in the country's main maize production regions. The puzzle is that even though maize is the dominant crop among smallholder farmers in Malawi, over the last two decades maize productivity has been erratic. Only 10% of the maize growers are net sellers while about 60% are net buyers (World Bank, 2010).

Smallholder cropping systems in Malawi are characterized by mixed cropping strategies and incorporation of climate smart agriculture (CSA) technology. The CSA technologies do increase both the net value of the production and the net return to labour. Farming systems based on CSA technology do extend the harvesting period and also help to alleviate seasonal food shortages, thus enhancing the stability of household food access; they can also reduce erosion risks by providing increased soil cover and additional crop residues for use as green manure and mulch (FAO, 2007).

Adaptation to current or expected climate variability involves adjustment in natural and human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001). These may include both on and off farm activities. At the farm level, there are a wide range of strategies that may contribute to adaptation which include modifying planting times and changing to resistant varieties, changing the farm portfolio of crops and livestock (Howden et al., 2007); improved soil and water management practices including conservation agriculture (Kurukulasuriya and Rosenthal, 2003) and shifting to non-farm livelihood sources (Morton, 2007). Despite growing interest in CSA technologies and some productivity enhancing practices for agricultural development and sustainability in Malawi and other regions, the adoption rates are generally quite low sometimes leading to stagnant or worsening yields (Wollni et al., 2010). The question that arises is whether these CSA technologies are actually effective adaptation strategies in the specific circumstances of Malawian farmers. This study was focused on determining the effectiveness of CSA strategies and tried to answer the question, "does adoption of CSA technologies reduce household vulnerability to poverty?" The argument is that CSA technologies does improve farmers' productivity and profitability.

2.0 Literature summary

Escaping poverty traps in many developing countries depends on the growth and development of the agricultural sector (World Bank, 2008). Agricultural growth and development is not possible without yield enhancing technological options because merely expanding the area under cultivation to meet the increasing food needs of growing populations is no longer sufficient. Research and adoption of technological improvements are thus crucial to increasing agricultural productivity and reducing poverty, while sustaining the agro-ecosystems that support livelihoods (World Bank, 2008).

Climate variability may affect food systems in several ways ranging from direct effects on crop production (changes in rainfall leading to drought or flooding, or warmer or cooler temperatures leading to changes in the length of growing, increased pest and disease incidences.), to changes in markets, food prices and supply chain infrastructure (Fuhrer, 2003). Examples of changes in climatic conditions that influence crop systems include: rainfall quantity and distribution, and consequently water availability; extreme events, such as floods and droughts; higher temperatures; and shifting seasons (Allara et al., 2012). Adaptation is about decreasing the dangers posed by climate variation to people's lives and livelihoods. It refers to responses by individuals, groups and communities to actual or expected changes in climatic conditions or their effects (FAO, 2010).

In the recent past most smallholder agricultural livelihood decisions in Malawi have been undergoing change. In response to observed changes in weather and to the perceived impacts of climate variability, farmers are changing the dates for planting their crops and making use of selected seed for shorter cycle crops (Total Land Care, 2012). In another respect, smallholder farmers clear land and plant their crops closer to streams and other water bodies. Another strategy is adoption of conservation agriculture (e.g., mulching). Conservation agriculture has been demonstrated to be an effective practice to conserve soil moisture and to increase crop yields, particularly during periods of erratic or reduced rainfall and on soils with lower clay content (Total Land Care, 2012). In terms of planting and harvesting strategies, farmers are compensating for climate-driven lower yields by increasing their cultivation of improved, drought resistant varieties (USAID, 2013). Many smallholder farmers have adopted no-till agriculture in order to conserve soil moisture, and increase investment in dry season irrigated vegetable gardens (Oxfam, 2008).

FAO (2010), defined "CSA" as the agriculture adaptation methods that sustainably increases productivity, resilience, reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals. CSA seeks to maximize benefits and minimize negative trade-offs across the multiple objectives (food security, development, climate variability adaptation, and mitigation). CSA technology practices can be integrated into a single farming system and provide multiple benefits that can improve livelihoods and incomes, for smallholder farmers. CSA provides opportunities to attain greater food security, increased income and greater resilience which is more important. However, there are other climate smart practices that cannot be integrated locally because they impact upon other elements of the

3.0 Study description

This study was carried out in two districts of Balaka and Nsanje (Figure1). The districts were purposively chosen because they are prone to climate variability (droughts and flooding). Balaka District is in the Southern Malawi, located 150 00'S latitude and 350 00'E longitude (Balaka SEP, 2010).

Nsanje District, on the other hand, is situated at the southern tip of the country within the Lower Shire valley, located 160 45'S latitude and 350 10'E longitude (Nsanje SEP 2010).

A reconnaissance survey was conducted prior to the cross-section household survey to determine CSA technologies that are commonly promoted in the study areas. The survey focused in the CSA technologies categorized in five broad groups; portfolio diversification, soil and water conservation, soil fertility improvement, irrigation/rain water harvesting and zero or no adaptation. (Table 1).

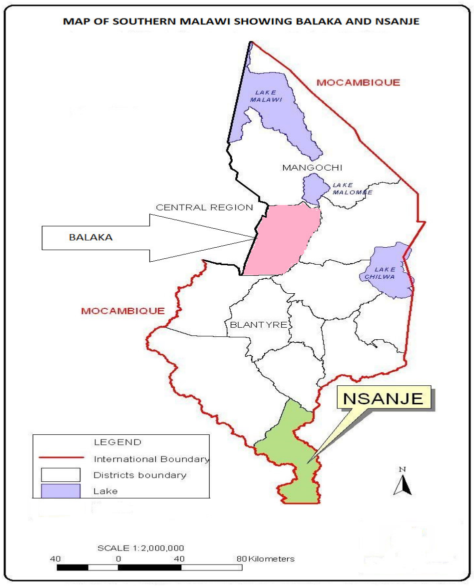

Figure 1: Map of Southern Malawi

3.1 Data analysis

This study used a mixed methods approach; both qualitative and quantitative techniques involving focus group discussions and a cross-sectional survey were used. Data from the household survey was analysed using descriptive statistical methods to generate frequencies, percentages, and to conduct explanatory factor analysis. Apart from the descriptive statistics, the study employed paired t-test statistics to compare responses between the two farmer groups, adopters and non-adopters.

Table 1: Definitions of CSA technologies under study

CSA Technology	As defined in this study
No / zero adaptation	Farmers not using any adaptation method to counteract the negative impact of climate variability
Soil fertility improvement	Agroforestry, applying fertilizer and organic manure
Irrigation/rain water harvesting	Involving storage and supplying water to the farm
Portfolio diversification	Using improved crop varieties, intercropping, different crop varieties that survive in adverse climatic conditions
Soil and water conservation	Farmers' use of mulching, planting of cover crops, minimum tillage operations (conservation agriculture), full tillage operation and digging ridges across slopes

4.0 Results

Adopters in the study were lead farmers of different CSA technologies, while follower farmers and any other farmer were categorized as non-adopters. However, it was revealed in the study that some lead farmers were involved in other multiple technologies (Table 2). Non adopters were in 273 households in total with Nsanje (130) and Balaka (143).

Table 2: Percentage distribution of CSA Technologies by household

CSA Technologies by household	Nsanje n =219	Balaka n = 127	Total n =346
	%	%	%
Portfolio diversification	37.1	43.0	39.7
Soil and water conservation	37.7	23.0	31.3
Soil fertility improvement	40.6	41.5	41.0
Irrigation and water harvesting	28.6	12.6	21.6

Percentages are accounting for multiple CSA technology adoption

4.1 Crop production by CSA technology adoption category

The mean yield by different CSA technology adopters tested against their non-adopter counterparts in each category using t-statistics (Table 3) shows some significant differences at different levels in several variables. There were significant differences in the maize and tobacco yields for those practicing portfolio diversification. For those in soil and water conservation, maize, tobacco and sweet potatoes were significant different. However, the t-statistical analysis on irrigation and water harvesting did not give any mean yield statistical differences on all crops of interest.

Table 3: Comparative household average crop estimates by technology

Crop (Kg)	Portfolio Diversification	Soil & water conservation	Soil Fertility Improvement	Irrigation & Water Harvesting
Maize	830.9*(77.7)	906.1***(78.3)	717.7(73.1)	827.9(66.3)
Millet	101.8(16.4)	93.8(13.66)	119.5**(16.76)	77.7(14.65)
Tobacco	74.4***(17.5)	61.4***(13.8)	65.6**(13.9)	49.5(16.3)
Cotton	120.1(26.9)	120.6(20.7)	92.8(20.8)	109.2(26.2)
Sweet potato	145.2(31.4)	86.3**(23.2)	143.7(37.8)	164.3(35.9)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 Household income comparison by CSA technology adoption category

The mean crop revenue was statistically different only for soil fertility improvement technologies and not the other technologies. The mean income from non-farm sources was statistically different for the adopters of soil and water conservation, soil fertility improvement and those in irrigation and water harvesting (Table 4).

Table 4: Comparative household average revenue estimates by technology

Revenue (MK)	Portfolio Diversification	Soil & water conservation	Soil Fertility Improvement	Irrigation & Water Harvesting
Crop revenue	43055 (6252)	41635 (4229)	47126**(6911)	39979 (4089)
Livestock Rev.	14547 (2033)	15814 (2458)	13000 (2547)	18253 (3119)
Tot. Agric. Rev.	57603 (6607)	57449 (4814)	60127 (7268)	58232 (5173)
Non-farm Rev.	165528 (14729)	183130*15923)	206310** (26535)	199245**(22529)
Tot. Rev.	223131(16419)	240580**(16623)	266437*** (27715)	257477***(23394)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Household expenditure comparison by technology

We note with interest that, the mean agriculture cost and the mean expenditure on other expenses (capital and food expenditure) is t-statistically different in all the CSA technologies under study (Table 5).

Table 5: Comparative household average expenditure estimates by technology

Expenditure (MK)	Portfolio Diversification	Soil & water conservation	Soil Fertility Improvement	Irrigation & Water Harvesting
Agriculture Cost	37764***(5223)	30325**(4052)	43603***(6628)	33571**(5185)
Capital Exp.	2252(862)	2599(759)	3482*(1214)	2610(688)
Clothing Exp.	29488**(3052)	26593(2624)	28491(3365)	29768**(2665
Other Exp.	41527**(3716)	39236***(3592)	44552.8**(4409)	436809***(3469)
Total Exp.	189753*(12110)	193295**(11753)	213190***(15627)	212671***(12607)

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.4 Household output, revenue and expenditure increase in percentage by technology

The percentage increase of different output variables after CSA adoption (Table 6), shows that when the base technology (zero adaptation) is compared with any CSA technology adopted there was a marked difference.

Table 6: Percent household crop, revenue expenditure increase by CSA technology

Production, Income and expenditure	Portfolio Diversification	Soil and water conservation	Soil Fertility Improvement	Irrigation & Water Harvesting
	%	%	%	%
Maize (Kg)	26.1	37.5	8.9	25.6
Millet (Kg)	12.0	3.2	31.5	-
Crop revenue (Mk)	46.6	41.7	60.4	36.1
Tot. Agric. Rev. (Mk)	27.1	26.7	32.6	28.4
Non-farm Rev. (Mk)	14.8	27.0	43.1	38.2
Agriculture Cost (Mk)	146.6	98.1	184.8	119.3
Capital Exp. (Mk)	83.2	111.5	183.3	112.4
Other Exp. (Mk)	53.6	41.9	56.8	798.4

Our basis of comparison is on zero technology adopters not shown in this table

4.5 Period taken before food stocks run out in the household

A total of 35% of the respondents, stated that they have enough staple food (maize) to last the whole year, the rest usually had food stocks taking them 4-7 months (May to November) or less. Further analysis to find out the specific severely deficit months of food revealed that most households experience acute food shortages during the months of December, January and February (Figure 2), for both adopters and non-adopters. Disaggregating food shortage by adoption status, 42% of adopters had food throughout the year followed by non-adopters who had 26% only.

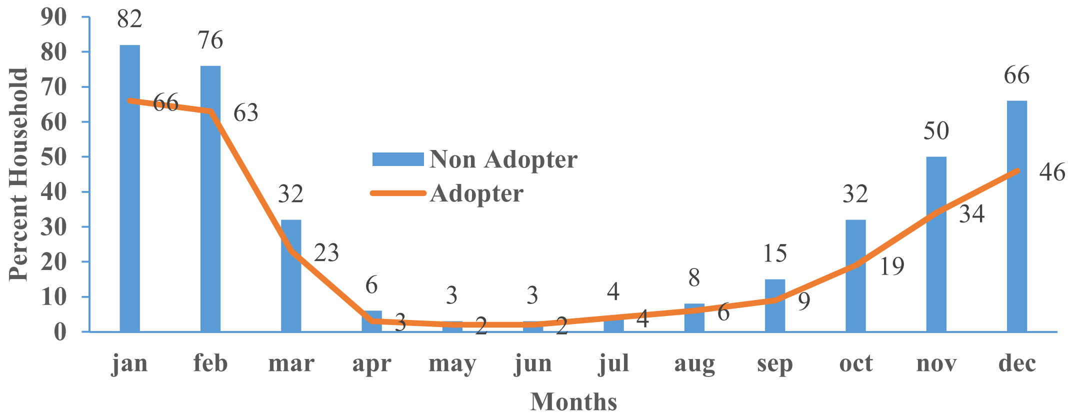

Figure 2: Household experiencing monthly food shortages in percent over the year

5.0 Discussion

Environmental stresses have always had an impact on crop production. Farmers have always looked for ways to manage these stresses. Climate variability adaptation requires more than simply maintaining the current level of performance in agricultural sector. It also requires developing a set of responses that allow the sector to improve performance under the changing conditions brought about by climate variability. Since, agricultural production remains the main source of income for most rural communities, adaptation of the agricultural sector to the adverse effects of climate variability is imperative for protecting and improving the livelihoods of the poor and ensuring food security (FAO, 2012).

The study reveals that the contributions of CSA technology adoption on smallholder household food production in Malawi is significant. Users of CSA technologies had their plots performing better than plots without CSA technologies. When differentiating means of adopters and non-adopters, CSA technology adopters were well off in the mean values of the following variables crop incomes, livestock incomes, total agriculture revenue, non-farm income, total income, non-food expenditures, and in their total expenditure.

This has confirmed the earlier studies by Sidlin (1975) and Olayide (1980) which stated that adoption of innovations resulted to increase in output and income of small-scale farmers. For instance, in this study, there was 26%, 37%, 9% and 26% maize yield improvement if farmers did adopt portfolio diversification, soil and water conservation, soil fertility improvement and irrigation and water harvesting technologies respectively. Similarly millet and cotton production had increased in plots with CSA technology. These results, however, must be interpreted with caution because crop productivity and expenditure pattern may also be influenced by plot and household characteristics, apart from adoption of technologies (Asfaw et al., 2014). The fact that we did not control these characteristics may affect the results.

6.0 Conclusion

CSA technologies has resulted in higher crop yields and increased incomes among smallholder farming households. Since the relationship between agricultural technology and poverty is complex. The potential for increasing rural incomes through the diffusion of CSA technology in this study is substantial. To explicitly make reference to the causal relationship between CSA technology and household wellbeing, is a challenge, which is definitive, and relates to how best to conceptualize its linkage to poverty. Never the less, the study has shown that, CSA technology can reduce poverty through direct effects on output levels, food security, incomes and overall socioeconomic welfare.

7.0 Acknowledgement

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