

AgWater Solutions Project Case Study

Adoption and Outscaling of Conservation Agriculture in Tanzania

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The AWM Project

The AgWater Solutions project was implemented in five countries in Africa and two states in India between 2008 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, NGOs and small-scale farmers.

The leading implementing institutions were the International Water Management Institute (IWMI), the Stockholm Environment Institute (SEI), the Food and Agriculture Organization of the United Nations (FAO), the International Food Policy Research Institute (IFPRI), International Development Enterprises (iDE) and CH2MHill.

For more information on the project or detailed reports please visit the project website <http://awm-solutions.iwmi.org/home-page.aspx>.

Disclaimer

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Table of Contents

Abbreviations _____	iv
1. INTRODUCTION _____	1
1.1 Background _____	1
1.2 Objectives _____	1
2. METHODOLOGY _____	2
2.1. The study areas _____	2
2.2 Data collection _____	3
2.3 Data analysis _____	3
3. RESULTS AND DISCUSSION _____	3
3.1 Importance of conservation agriculture and its adoption _____	3
3.1.1 Role of CA technologies in improving yields and food sufficiency _____	3
3.1.2 The extent of adoption of CA technologies in Arusha and Dodoma _____	5
Crops grown using different CA technologies _____	6
Yields of crops under different CA technologies _____	6
Types of farmers who adopt conservation techniques _____	8
3.1.3 Estimates of the spread the CA technologies in Tanzania _____	9
Local level _____	9
Districts within Arusha and Dodoma Regions _____	9
Regional spread _____	10
3.1.4 Labor inputs, investments and gross returns _____	10
3.2 Factors contributing to adoption and up-scaling of CA technologies in Tanzania _____	13
3.2.1 Technological and economic factors _____	13
3.2.2 The roles of change agents _____	13
3.2.3 Inputs and equipment suppliers _____	15
3.2.4 Market interventions and communication infrastructure _____	15
Markets and buyers _____	15
3.2.5 Policies and bylaws at local scale _____	17
3.2.6 Policies at national scale _____	18
3.3 Successful CA interventions _____	18
3.3.1 Successful projects in the study areas _____	18
3.4 Constraints that limit CA technologies adoption and up-scaling _____	19
3.4.1 Perception of limitations for CA adoption _____	19
3.4.2 Technical, biophysical, and economic constrains _____	20
3.4.3 Legal and institutional framework _____	20
3.4.4 Markets and communication constraints _____	20
3.4.5 Socio-economic constrains _____	21
3.4.6 Credit, inputs, and equipment _____	21
3.4.7 Change agents _____	21
3.5 Adoption constraints at national level _____	22
3.5.1 Inadequate funding of sustainable land management activities _____	22
3.5.2 Conflicting sector policies _____	22
3.5.3 Weak implementation of new land law _____	22
3.5.4 Lack of recognition of indigenous land management systems _____	22

3.5.5 Inadequate capacity	22
3.6 Steps for promoting adoption and up-scaling of CA technologies in Tanzania	22
4. SUMMARY AND CONCLUSIONS	23
4.1 Summary	23
4.2 Conclusions	24
Appendix 1: Successful AWM technologies and degraded land	25

Abbreviations

AWM	Agricultural Water Management
BMGF	Bill and Melinda Gates Foundation
CA	Conservation Agriculture
CARMATEC	Centre for Agricultural Mechanization and Rural Technology
CA-SARD	Conservation Agriculture for Sustainable Agriculture and Rural Conservation
DADPs	District Agricultural Development Plans
DALDO	District Agricultural and Livestock Development Officer Development
FAO	Food and Agriculture Organization of the United Nations
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
IWMI	International Water Management Institute
LVIA	Lay Volunteer International Association
MALDO	Municipal Agricultural and Livestock Development Officer
MVIWATA	Muungano wa Vikundi vya Wakulima Tanzania (Union of Farmers Groups)
NAVIS	National Agricultural Input Voucher Scheme
NFRA	National Food Reserve Agency
RECODA	Research, Community and Organizational Development Associates
RELMA	Regional Land Management Unit of Sida
SACCOS	Savings and Credit Co-operative Societies
SARI	Selian Agricultural Research Institute
SCAPA	Soil Conservation and Agroforestry Programme in Arusha
SEI	Stockholm Environmental Institute
WADEC	Women's Agriculture Development and Environmental Conservation
TZS	Tanzania shilling; valued at 1,500 to USD one in this report

1. INTRODUCTION

1.1 Background

The Agricultural Water Management (AWM) Solutions project is a three-year research program funded by Bill and Melinda Gates Foundation (BMGF). The overall objective of the project is to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders including policy makers, investors, NGOs and small-scale farmers.

The project is being implemented in several countries in Africa and Asia. The leading implementing institutions are the International Water Management Institute (IWMI), Stockholm Environmental Institute (SEI), and Food and Agricultural Organization (FAO).

For Tanzania, the results obtained from the situational analysis carried out through a stakeholders' forum, prioritized three AWM technologies: conservation agriculture, water lifting devices, and communal managed irrigation schemes. The main focus of this part of the study is on conservation agriculture.

The first part of the study focused on reviewing conservation agriculture (CA) practices in Tanzania with particular emphasis on the extent of adoption, cost of implementing the technologies, benefits that can be derived, and identifying possible investment pathways for outscaling. A literature review on the different technologies revealed several information gaps. Technologies such as terraces, conservation tillage and pits and trench farming showed potential to increase yields in places where they have been practiced. Conservation tillage had limited literature, especially on the costs and benefits and adoption and non-adoption factors. Most of the available literature is from researchers and change agents who were involved in promoting conservation tillage. Literature on pits and trench farming is even more limited. Therefore, a case study was required to advise on investment pathways for scaling-out conservation tillage, pits and trench farming. The second part of the study focused on field work to gather primary data on adoption and outscaling of conservation agriculture in Tanzania.

1.2 Objectives

The main objective of the study was to identify and recommend investment areas in conservation agriculture with the greatest potential to improve incomes and food security for poor farmers. The specific objectives were to:

1. Determine the extent of adoption of various conservation agriculture technologies in the case study areas and the estimated spread of the same in Tanzania.
2. Investigate the elements contributing to project or intervention success and approaches that can be used to replicate the same in other areas in Tanzania.
3. Investigate the constraints that limit adoption of conservation agriculture technologies.
4. Recommend steps to be used in promoting adoption and up-scaling of CA technologies in Tanzania.

2. METHODOLOGY

2.1. The study areas

The study was conducted in Arumeru District, Arusha Region, and Chamwino and Dodoma Urban districts in Dodoma Region (Figure 1). Arusha's elevation of 1,400 amsl on the southern slopes of Mount Meru keeps temperatures relatively low and alleviates humidity. Cool dry air is prevalent for much of the year. The temperature ranges between 13 and 30 degrees Celsius, with an average of around 25 degrees. It has distinct wet and dry seasons with average annual rainfall of 654 mm.

Dodoma is 486 kilometers (west of the former capital city of Dar es Salaam, and 441 kilometers south of Arusha. It covers an area of 2,669 square kilometers. Dodoma features a semi-arid climate with relatively warm temperatures throughout the year. The region averages 570 mm of precipitation per year, the bulk of which occurs during its short wet season between December and March. The remainder of the year comprises of the dry season.

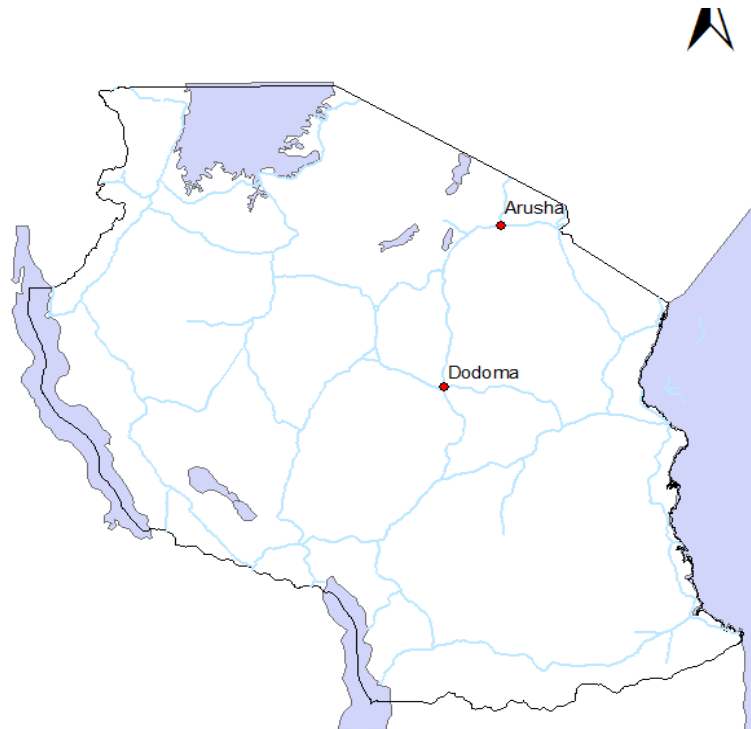


Figure 1: Map of Tanzania showing case study wards and villages in Arusha and Dodoma.

2.2 Data collection

This study was carried out using mainly structured questionnaire surveys and key informant interviews. A total of 200 randomly selected respondents were interviewed in Arumeru, Dodoma Urban and Chamwino Districts. Within each district two to three wards were chosen where villagers practice the identified CA technologies. In Arumeru District the three wards chosen were Musa (Likamba village), Olturumet (Ilkuishen and Ekenywa villages) and Oldonyosambu (Oldonyoas village). In Dodoma Urban District, the ward chosen was Kikombo (Kikombo and Chololo villages). In Chamwino District Msamalo ward was chosen (Mnase and Mgunga villages).

Key informant interviews were conducted to fill gaps from the questionnaire survey and verify the results. People interviewed at village level were village chairpersons, village executive officers, and village extension officers. At ward level, the ward councilor and ward extension officers were interviewed. The district agricultural development officers (DALDO) along with land use officers and district extension officers were interviewed at district level. One NGO in Dodoma (INADES) and another in Arusha (RECODA) were also interviewed.

2.3 Data analysis

Descriptive analyses were used to determine factors that influence adoption. A total of 200 farmers were interviewed from the eight villages. The data was analyzed using SPSS statistical package and MS Excel software. Results from the analysis were interpreted and gaps were addressed through interviews with key informants.

3. RESULTS AND DISCUSSION

3.1 Importance of conservation agriculture and its adoption

3.1.1 Role of CA technologies in improving yields and food sufficiency

Perceptions of farmers on the role of a particular technology in sustaining their livelihood were assessed by analyzing their replies on losses they would incur if the technologies were not introduced. Results from Arusha and Dodoma Regions (Figure 2) imply that the adoption of CA technologies had helped increase yields on their farms. Farmers felt that yields would be affected without CA technologies. The yield losses rank from less than 25% to 100% yield loss, with a majority of farmers indicating yield losses of about 50%. Farmers indicated that terraces, minimum tillage, large pits and cover cropping have had impacts on crop yields.

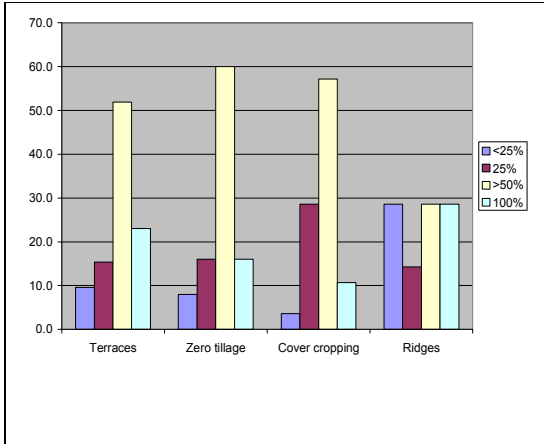


Fig. 2a: Loss in yield due to lack of technology in Arusha

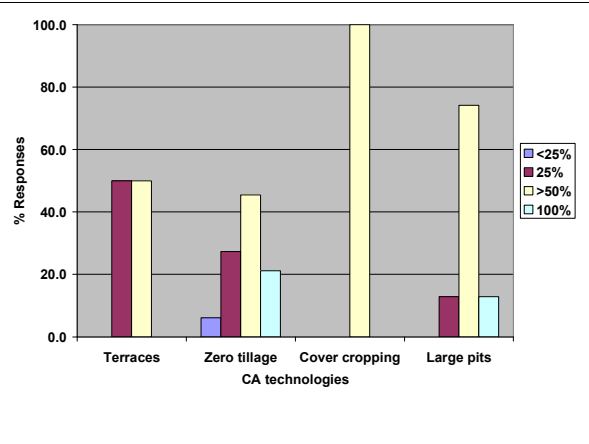


Fig. 2b: Loss in yield due to lack of technology in Dodoma

Figure 3 shows household food sufficiency in terms of production and purchasing power. Results show that the majority of respondents in Arusha are able to producing between 50-75% of their household requirements and to some extent they can also afford to purchase food in case of deficits. This group is followed by that able of producing 75-100% of their food and with good purchasing power in case of deficit or crop failure. This is in contrast to respondents in Dodoma, where the majority can produce between 25-75% and can afford to some extent to purchase food in case of deficit or crop failure. This information signifies the importance of improving agricultural practices geared towards increasing production, such as the use of CA technologies, especially in Dodoma where a majority are not producing enough and have weak purchasing power.

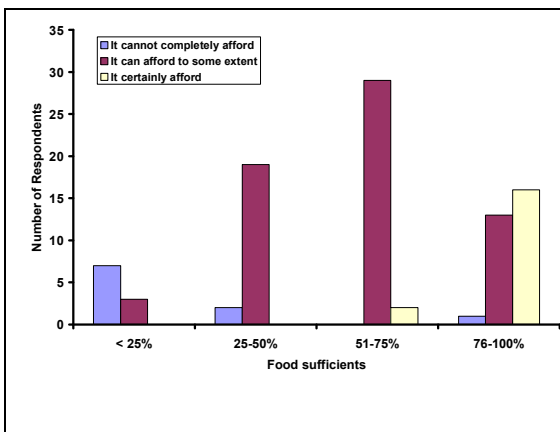


Fig. 3a: Household food sufficiency in Arusha

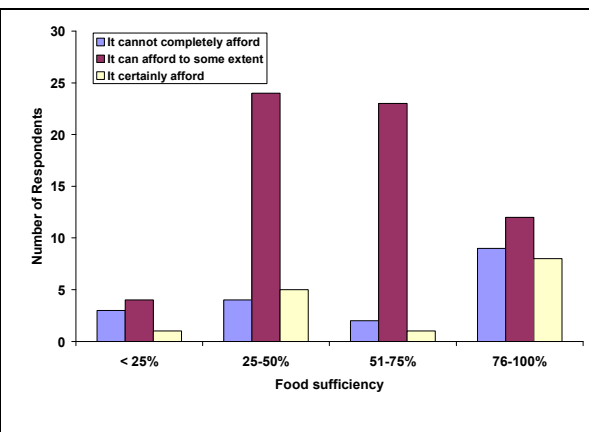


Fig. 3b: Household food sufficiency in Dodoma

3.1.2 The extent of adoption of CA technologies in Arusha and Dodoma

Improved or new soil and water conservation techniques used in the study areas in Arusha and Dodoma are terraces, minimum tillage, cover cropping, large pits and, ridges. Other techniques include mulching and micro-basins (*jaruba*). Investigation of the widely adopted conservation agriculture technology was done to identify the extent of adoption.

Adoption of improved or new soil water conservation techniques was analyzed in terms of proportion of farmers undertaking the techniques as well as the crops grown using the different technologies. Survey results indicate that the number of farmers adopting different CA techniques varied from place to place depending on biophysical characteristics of the farm areas. In Arusha Region, terraces had the majority of adopters (52.1%) (Figure 4a). Minimum tillage, which comprises all methods that do not involve land disturbances such as zero tillage, ripping, and minimum tillage, was adopted by almost 29.1% of the respondents. However, there was little adoption of mulching and *jaruba* with a combined percentage of 1.1%.

In Dodoma, the majority of farmers have adopted conservation tillage (29.1%) and large planting pits, often referred to as large pits and locally known as *chololo* pits (26.2%). The wider practice of conservation tillage is due to the use of rippers pulled by ox plows, a farming technique widely used in the area. Large pits are gaining in popularity due to their ability to conserve soil moisture when the rains are infrequent and the slope is steep for other cultivation methods. Ridge cultivation (1.0%) and terracing (2.9%) are unpopular technologies in Dodoma Region since they cannot easily be made by ox plowing, which is a popular farming technique in the region.

Terraces in Arusha were reported to have been practiced on sloping lands and in areas where land degradation was high. This was confirmed by key informants who reported the intervention of the SCAPA program, which was aimed at reducing soil degradation, improving soil fertility through improving water retention, and increasing soil organic matter.

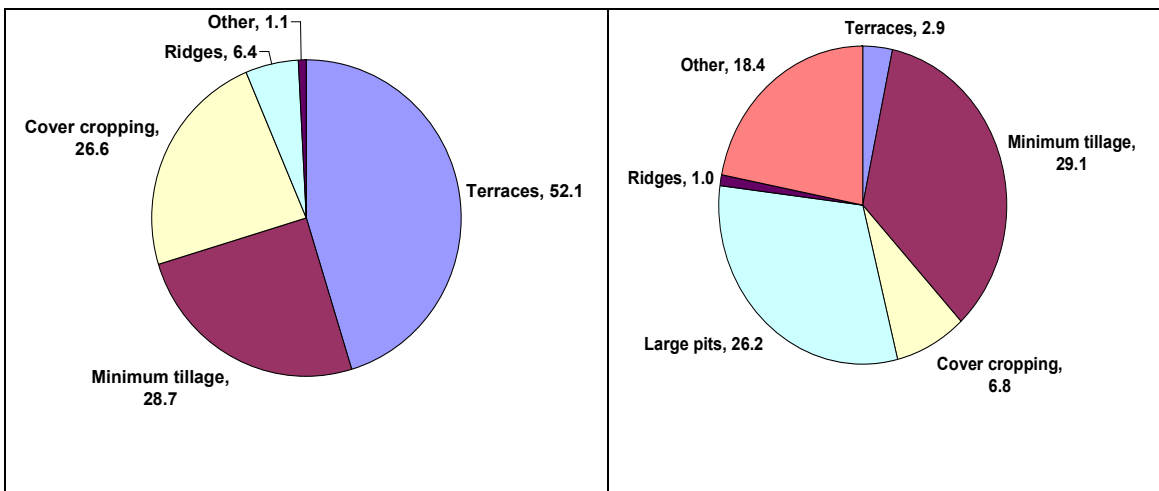


Fig. 4a: Adopters of different technologies in Arusha region.	Fig. 4b: Adopters of different technologies in Dodoma region.
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Crops grown using different CA technologies

The study also investigated the types of crops grown using different types of CA technologies. The results of CA technologies with corresponding crops are shown in Table 1. In Arusha, maize was planted using all the CA technologies. This indicates the importance of the crop for both food and cash in the region (Table 1a). Almost 55% of all the farms had maize planted, followed by beans (29%) and lablab (6%). Interviews with key informants supported the findings that farmers find maize a crop with a good return value compared to others, and would employ the most trusted technology for the production of maize. This is shown by the high numbers who used terraces and minimum tillage and a combination of the two technologies to grow maize. Beans, although they have a good market value, the harvest has been declining in recent years. One farmer, Simon Kutingala in Ekenywa village (Kilimapunda CA group) in Arusha, said during interviews that *“maize has a good market value because it is used by the majority as a food crop, but crops like lablab is mainly bought by traders from the neighboring country. Beans have a good market value, but the yield has been decreasing in recent years”*.

Table 1a: Types of crops grown on different CA technologies in Arusha.

CA Technology	Maize	Beans	Vegetables	Lablab	Other
Terraces	60.0	32.7	1.8	1.8	3.6
Minimum tillage	51.1	31.9	8.5	4.3	4.3
Cover cropping	47.2	33.3	0.0	2.8	16.7
Ridges	55.6	27.8	11.1	0.0	5.6
Terraces & min. tillage	54.9	33.3	2.0	2.0	7.8
Terraces & cover crop	60.0	13.3	0.0	26.7	0.0
Average	54.8	28.7	3.9	6.2	6.3

Sorghum is the dominant food crop in Dodoma Region, cultivated using almost all the technologies (38% of all the crops, Table 1b). It is a drought resistant crop suited to the semi-arid climate of Dodoma (300 -500 mm annual rainfall). For large pits, sorghum makes up about 75% of the crops grown. Also, terraces and minimum tillage are employed in the cultivation of sorghum. Cover cropping and a combination of terraces and cover cropping or minimum tillage are mainly employed in groundnut cultivation.

Table 1b: Types of crops grown using different CA technologies in Dodoma.

CA Technology	Maize	Sorghum	Groundnuts	Lablab	Others
Terraces/ridges	15.4	46.2	15.4	23.1	0.0
Minimum tillage	14.1	46.9	21.9	12.5	4.7
Cover cropping	27.8	11.1	44.4	11.1	5.6
Large pits	17.5	75.0	7.5	0.0	0.0
Terraces & min. tillage	15.6	23.3	36.7	18.9	5.6
Terraces & cover crop	9.3	25.6	30.2	34.9	0.0
Average	16.6	38.0	26.0	16.7	2.6

Yields of crops under different CA technologies

The yields for different crops in the study area are generally lower but typical of dryland areas in Sub-Saharan Africa (Table 2). This underscores the rationale for promoting CA technologies to improve productivity. On average, terracing performed better than other technologies with regard to maize yields (Table 2). Other CA technologies under which at least a ton of maize per hectare was realized were large pits and ridges. However, only terracing attained yields of one ton per hectare. As the median is not affected by outliers compared to the mean, it is an ideal statistic presenting a typical situation in a particular population.

Table 2: Yields of crops under different CA technologies (ton/ha)

Crop	Statistics	CA technology						
		Cover crop	Terrace	Minimum tillage	Large pits	Ridges	Terrace + min. till**	Terrace + cover crop
Maize	n*	16	34	24	7	11	42	11
	Mean	0.8	1.3	0.8	1.1	1.0	0.9	1.0
	Std. Dev.	0.6	1.2	0.8	1.0	0.7	0.9	0.7
	Median	0.8	1.0	0.6	0.4	0.8	0.6	1.0
Sorghum	n	2	2	24	30	3	18	9
	Mean	0.3	0.5	0.5	0.4	0.3	0.5	0.6
	Std. Dev.	0.1	0.0	0.4	0.5	0.2	0.5	0.4
	Median	0.3	0.5	0.3	0.3	0.3	0.3	0.8
Beans	n	12	17	8	-	5	17	2
	Mean	0.4	0.2	0.8	-	1.5	0.5	0.7
	Std. Dev.	0.3	0.3	0.6	-	1.3	0.4	0.3
	Median	0.3	0.1	0.6	-	1.3	0.3	0.7
Groundnuts	n	7	-	11	3	-	27	8
	Mean	0.1	-	0.3	0.1	-	0.2	0.2
	Std. Dev.	0.1	-	0.2	0.1	-	0.3	0.1
	Median	0.1	-	0.3	0.1	-	0.1	0.2
Lablab	n	2	-	7	-	2	17	18
	Mean	0.9	-	0.3	-	0.3	0.6	0.4
	Std. Dev.	0.9	-	0.2	-	0.0	0.5	0.4
	Median	0.9	-	0.3	-	0.3	0.5	0.5

* n = number of observations (valid cases), ** min. till. = minimum tillage

Ridge technology had much better results on yields of beans. However, only a few farmers practiced ridging bean production. The yield levels of sorghum, groundnuts, and lablab were typically low across the CA technologies. These four are among the crops promoted in the dryland farming areas of Tanzania including the study sites. Sorghum and groundnuts are common crops grown in Dodoma and across other regions in the semi-arid central part of Tanzania. Lablab is widely grown across the semi-arid northern Tanzania mainly for export to neighboring countries.

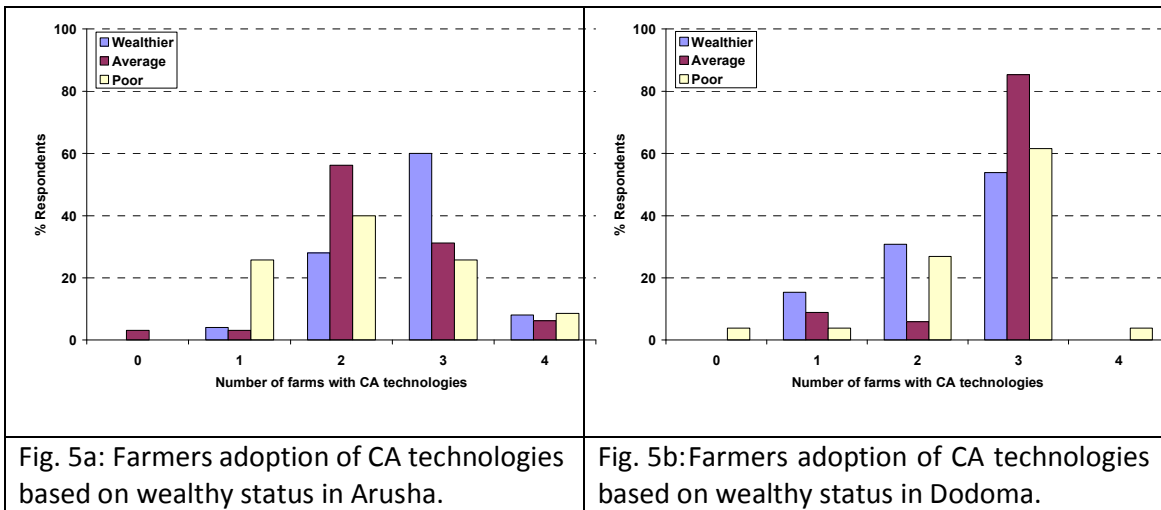
The relatively better yields (at median) of sorghum were attained under terracing. However, considering minimum tillage as a control, the typical increment in yield gain (0.2 ton/ha) may not likely cover the costs of terracing in terms of monetary investments and labor.

There is no difference in using large planting pits or minimum tillage in sorghum cultivation. However, farmers have indicated that they are likely to lose up to 50% of the crop if they don't practice CA technology as already indicated in Figure 2. Probably the difference could not be found because farmers were asked about the previous season's (2010) yield and maybe the rainfall amount was sufficient for the crop. It has been found that in a good year, there is significant difference in yields between conservation tillage and conventional tillage (Mkoga *et al.*, 2010). Lablab is a cover crop and hence is self-provisioning in terms of benefits of cover crop use. The results indicate that other CA technologies did not result in yields of lablab higher than just growing the crop as a cover crop.

Types of farmers who adopt conservation techniques

Results indicate that the decision to adopt conservation technologies varied according to wealth status. Wealth status was ranked in three groups, poor, average and wealthy. Wealthy indicators used for ranking were roofing, floor and wall materials of the main house, and possession of a motorbike, cell phone and bicycle.

In Arusha, the poor have two technologies on their farms. This is contrary to farmers in Dodoma where most have adopted three technologies regardless of their wealth status (Figure 5b). The reason for this pattern might be due to the fact that Dodoma is a drier area and farmers had to adopt various technologies for capturing and retaining water.



Results on gender role in household decisions to adopt conservation agriculture technologies are presented in Figure 6. In the case of Arusha, husbands make adoption decisions with regard to ridges and terraces (>50% of respondents). For minimum tillage and cover cropping, both husbands and their spouses make the decisions to adopt equally.

In Dodoma over 60% of the respondents indicated that husbands make the decision to adopt large pits and minimum tillage. However, the decision to adopt cover cropping is made by both husbands and wives equally. This shows that men have an upper edge to decide to adopt technologies that are labor intensive over those which do not require as much labor such as conservation tillage and cover cropping.

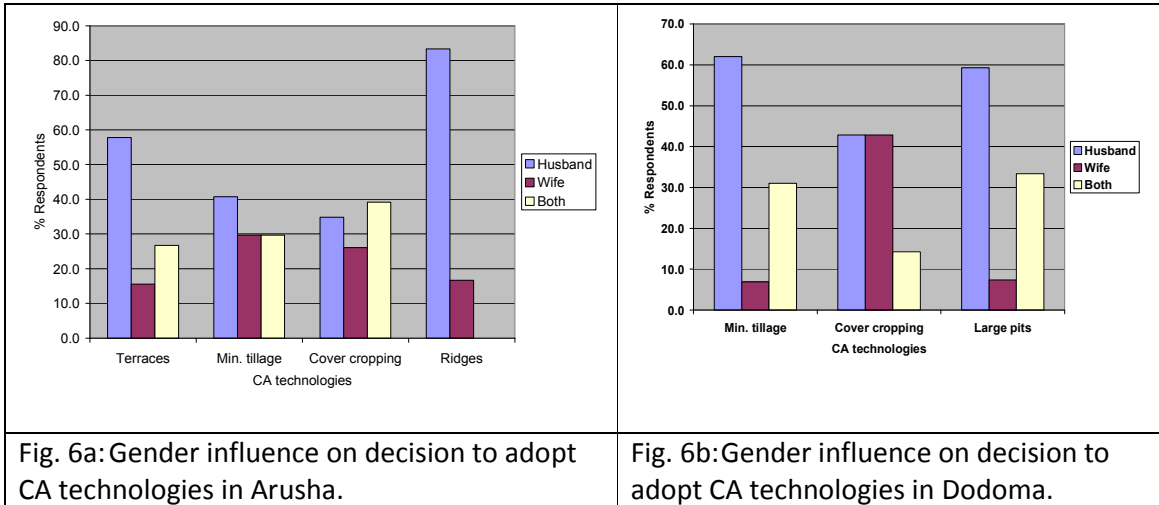


Fig. 6a: Gender influence on decision to adopt CA technologies in Arusha.

Fig. 6b: Gender influence on decision to adopt CA technologies in Dodoma.

3.1.3 Estimates of the spread the CA technologies in Tanzania

Local level

This section provides estimates of adoption and spread on the studied CA technologies at district and national scales. The primary focus for the Dodoma case study was to investigate the adoption and diffusion of *chololo pits*. According to key informant interviews, at the moment a farmer group with 25 members is practicing *chololo pit* farming and about 45 to 50 other farmers not in the group are also practicing it in the studied villages. The limitation of the technology is that it can only be practiced in heavy soils and sloping areas. The majority of the village farm lands are located in flat loamy soils that are not suitable for *chololo pits*.

The spread of CA technologies in the study areas has been facilitated by groups through which training is conducted by different stakeholder change agents. In Arusha, key informants recalled that groups were formed in villages and farmers were given training on CA technologies. *“Our group started with 19 members and this is a third year we are practicing CA, many farmers in the village have adopted and the number of those practicing CA has reached more than 50 households in the village, even a primary school within the village has started practicing CA”* said Godwin Sanare, a farmer in Ilkuishen village. CA technologies started with one group in the Olturumet ward in 2005, but now four CA groups (*Merikinoj, Kilimapunda and Tuamke Tuamke and Olorishi village*) have been formed. Another farmer from *Ekenywa* ward reported that from a group of 26 farmers, CA has continued to be adopted by other farmers to more than 80 farmers and many more are adopting. It was also reported that about 300 households in a village of 1200 have adopted CA. There are also CA groups in other areas such as Nduruma and Enyorata.

Districts within Arusha and Dodoma Regions

Conservation agriculture technologies have been adopted by farmers in places where interventions were promoted. Change agents played a great role in the adoption of CA technologies. In Arusha, early efforts are credited to a SCAPA project which started in the late 1990s. Efforts by NGOs such as RECODA, WADEC, and World Vision in collaboration with Selian Agricultural Research Institute (SARI) through a CA-SARD project funded by FAO and the district have promoted the adoption of CA in most wards in the district. Interviews with

key informants from NGOs and extension agents revealed that CA technologies have spread to 11 out of 21 wards of Arumeru District. The wards are Olturumet, Oldonyo Sambu, Musa, Namayala, Mlangarini, Maroroni, Kisongo, Nduruma, Manyire, Oljoro, and Oltoroto.

The technology of chololo pits was invented by inventor farmers in 1997 in Chololo village. Thereafter it was promoted by various NGOs such as INADES, LVIA, and MVIWATA. In Dodoma urban and Chamwino Districts has spread in the wards of Handali, Msamalo, Kikombo, Ng'ong'ona, and Makulu. In these wards, 60 innovator farmers were trained by INADES on the chololo pit technology. Each of the trained farmers went to form their own group. Conservation tillage (ox plowing) technology is commonly practiced in Msamalo, Ikoa, Igandu, Handali, Kikombo, and Buigiri wards.

Regional spread

Apart from villages and wards in Arumeru District, there have been successes in spreading CA in other districts of Arusha and Manyara regions. Key informant interviews revealed that Karatu and Babati Districts were one of the early adopters of CA technologies, thanks to efforts by SARI in support of GTZ, and through a CA-SARD project. Interviews with farmers, extension agents and NGOs indicated that Karatu and Babati were locations where different groups were taken for study tours and field visits to learn about CA. RECODA, an NGO dealing with the promotion of CA, are also promoting CA in Kilimanjaro and Tanga regions. CARE International together with Selian Agriculture Research Institute is also promoting adoption of CA technologies in Morogoro Region and in Kilindi District in Tanga Region. Intervention by ARI Uyole promoted the adoption of CA technologies in the Southern Highlands in Mbeya and Njombe Regions.

The *chololo* pit technology got more publicity when it was entered into a competition of best farmer innovations within East Africa by the UNDP and won third place. Interviews with the DALDO of Chamwino District and Municipal Agricultural Development Officer (MALDO) of Dodoma Urban District indicate that *chololo* technology is now being practiced in six districts of Dodoma Region (Dodoma Urban (1), Kongwa (2), Kondoa (3), Chamwino (4), Bahi (5), and Mpwapwa (6)). Discussion with INADES officials indicated that the main source of spread is through farmers who visited areas where the technology is being practiced. Also the INADES has been proposing adoption of *chololo* pits in their respective districts. Discussion with INADES officials indicated that potential regions where *chololo* pits can be promoted are the semi-arid areas of Morogoro, Singida, and Shinyanga, Kilimanjaro, Mwanza, and Manyara. These are the regions with slopping highland areas and heavy soils suited to the technology.

3.1.4 Labor inputs, investments and gross returns

The household questionnaire survey included the objective of determining the labor and financial investments and gross returns. The labor component includes the number of person-days provided by the household, hired or by the community through reciprocity. The aspects considered under investments are the cost of materials, hired labor and community in-kind contributions. The investment aspect covers both initial investments and operating costs for long-term CA technologies such as terraces.

Results in Table 3 indicate that ridging was the most labor intensive technology (with median person-days of 65) compared to other types of CA. At median, ridges and large pits

were the relatively expensive CA technologies. At median and average, minimum tillage was the least expensive technology. Apparently, the magnitude of labor and investment requirement seems to be in affordable ranges to smallholder farmers. The median is a good measure of central tendency especially when the dataset has outliers.

Table 3: Labor input and investment in CA technologies

CA Technologies	Labor input (hours/acre)					
	n	Min.	Max.	Mean	Std. Dev.	Median
Terraces	36	1	140	36	36	24
Minimum tillage	29	1	432	45	89	4
Cover crops	17	1	252	68	92	16
Large pits	18	3	420	36	97	7
Ridges	6	14	121	69	47	65
	Investments (Tshs/acre)					
Terraces	31	3,000	440,000	68,968	102,506	25,000
Minimum tillage	14	2,000	220,000	36,679	55,685	19,250
Cover crops	8	8,000	441,000	89,375	146,267	25,000
Large pits	12	6,000	435,000	78,333	124,936	29,500
Ridges	3	6,000	360,000	133,667	196,546	35,000

n = number of observations (valid cases)

The gross returns to land indicate the level of overall income and benefits from the use of different CA technologies in crop production. The gross returns do not take into account the costs of production. They are a simple valuation of entire farm output reported by the respondents for the season ending 2009/10. The gross returns can be compared with overall investments and labor input in Table 4 to figure out the returns to investment for different CA technologies.

Considering the median, which is a relatively good measure of data dispersion, terracing and a combination of the same with cover crops had more financial returns to land. The associated differential returns were around TZS 90,000 to 100,000 over minimum tillage and were realized from maize grown under terracing without and with cover crops respectively. A farmer needs to incur a median investment and operating cost of TZS 60,000 to terrace one hectare (Table 4). This leaves a farmer with a net of TZS 40,000 in the first year of investment and a possibility of higher returns over time before terraces have to be reconstructed. Maize is used as our case crop because it forms the national food basket and widely grown or both food and cash. The majority of farmers living in the semi-arid areas still prefer to grow maize and have resisted sorghum and millet.

Table 4: Gross returns to land for different crops under CA technologies (Tshs/ha)

Crop	Statistics	CA technology						
		Cover crop	Terrace	Minimum tillage	Large pits	Ridges	Terrace + min. tillage	Terrace +cover crop
Maize	n	16	34	24	7	11	42	11
	Mean	214,646	321,984	205,062	231,071	219,508	266,619	247,159
	Std. Dev.	175,357	300,982	211,651	195,923	166,454	277,354	177,524
	Median	206,250	237,500	150,000	100,000	187,500	168,125	250,000
Sorghum	n	2	2	24	30	3	18	9
	Mean	81,250	155,000	117,613	87,350	76,111	112,659	167,082
	Std. Dev.	28,284	28,284	120,956	123,913	43,703	118,791	129,439
	Median	81,250	155,000	91,875	60,625	62,500	61,250	183,750
Beans	n	12	17	8	-	5	17	2
	Mean	242,259	132,255	190,799	-	927,500	303,593	228,375
	Std. Dev.	242,856	217,422	157,983	-	1,195,120	362,391	186,146
	Median	165,000	50,000	150,000	-	350,000	187,500	228,375
Groundnuts	n	7	-	11	3	-	27	8
	Mean	47,722	-	80,017	40,000	-	137,535	91,972
	Std. Dev.	33,074	-	79,186	20,000	-	144,785	60,171
	Median	30,000	-	61,250	40,000	-	90,000	78,125
Lablab	n	2	-	7	-	2	17	18
	Mean	1,795,313	-	146,675	-	86,250	859,387	562,361
	Std. Dev.	1,703,685	-	85,617	-	37,123	1,257,566	518,266
	Median	1,795,313	-	150,000	-	86,250	346,500	354,167

Returns to land from sorghum grown under terracing alone and the same technology in combination with a cover crop were higher compared to other CA technologies. These gross returns were also higher than the costs of investment and operating a unit of land under terracing. The median costs and labor for terracing a hectare of land was estimated at around TZS 60,000 and 60 person-days, respectively (Table 4). Based on the survey results, the median price of sorghum was about TZS 245,000 per ton, yielding incremental returns of TZS 49,000. This means a farmer producing sorghum would lose TZS 11,000 per hectare if he decided to move from minimum tillage to terracing.

The bean enterprise registered impressive gross returns across different CA technologies with the highest under ridging. Groundnuts grown under a combination of terracing and minimum tillage had more financial reward to farmers than other CA technologies. However, the realized median returns would not recover the required investment costs for terracing one hectare of land.

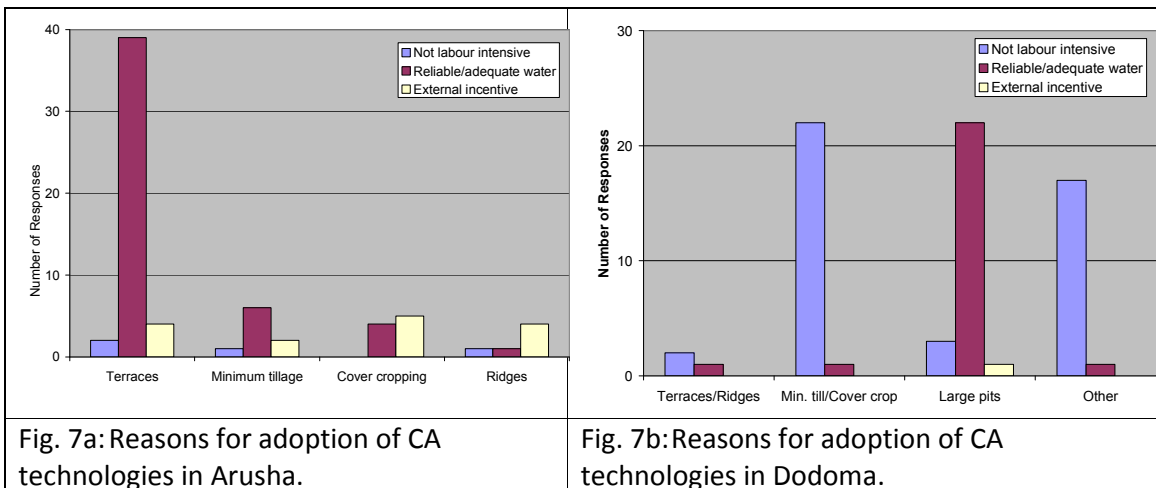
When lablab is grown as a cover crop it appears to be more profitable than when it is grown under other CA technologies. Other CA technologies such as terracing and ridging are water-conserving. The lablab crop requires minimum water especially after establishing which is

why it is increasingly grown in drier semi-arid environments.

3.2 Factors contributing to adoption and up-scaling of CA technologies in Tanzania

3.2.1 Technological and economic factors

Various factors have contributed to the adoption of CA technologies by farmers (Fig. 7). The ability of the CA technology to conserve soil moisture was the main factor for adopting terraces and conservation tillage in Arusha and large pits in Dodoma. Technologies with less labor intensiveness were also favored in Dodoma Region as is the case with minimum tillage and cover cropping. The presence of external incentives such as provision of subsidized farm inputs (e.g. lablab and pigeon pea seeds provided by RECODA and SARI in Arusha), and provision of training on the use of draught animal power at subsidized costs in Dodoma were also contributing factors for farmers to adopt new technologies.



3.2.2 The roles of change agents

It was hypothesized that the intervention of change agents and the messages they carry is also a factor that brings wider adoption of technology. This was investigated by asking respondents about the number of visits by the various change agents and the type of messages they passed over. Figure 9 shows the frequency at which change agents were visiting farmers. It is quite clear that more were in contact with farmers than the other three groups (researchers, NGOs and private sector). The intervention by extension agents is relatively higher in Arusha than in Dodoma with exception of one case by the NGOs, which indicates that the “more than twice” visit by NGOs in Dodoma was higher than in Arusha.

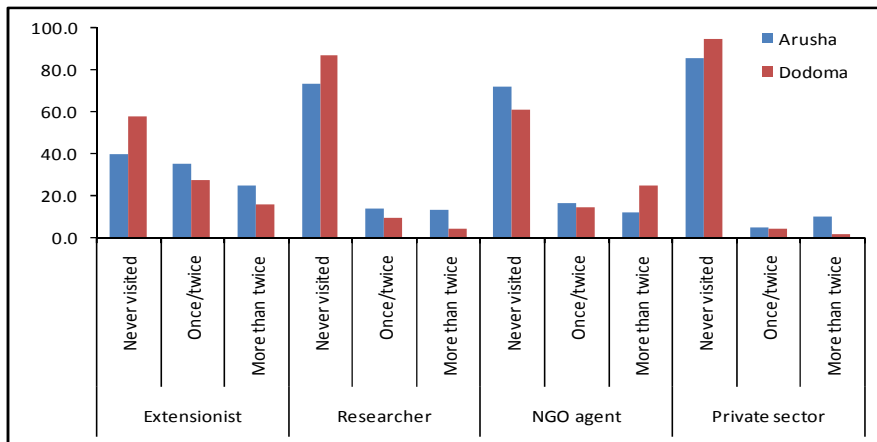
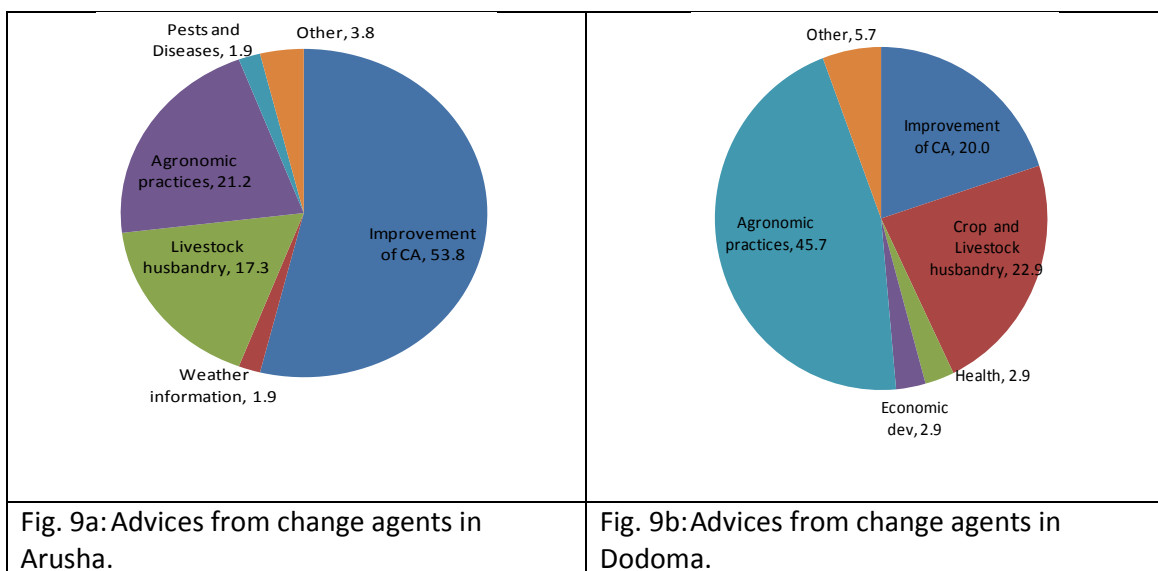


Fig.8: Frequency of contact of farmers by the change agents.

The advice from the change agents delivered to farmers included agronomic practices, pests and diseases, livestock husbandry, CA technologies and others. In the study area in Arusha, 53.8% of the advice was on CA technologies while advice on agronomic practices and livestock husbandry was 21.3% and 17.3, respectively (Figure 9). In Dodoma, the advice was a higher percent compared to others on agronomic practices (45.7). Advice on CA technologies came third at 20.0%. Farmers in Arusha were receiving more advice on CA technologies than in Dodoma.

In the key informants interviews it was found that the promotion of CA technologies in Arusha started in the 1980's by SCAPA. This project provided training, formation of groups, demonstration of plots and other support. However, during the interviews with farmers in Mnase Ward in Dodoma, farmers indicated that the government was not supportive of their efforts in adopting CA technologies and especially *cholo* pits.



3.2.3 Inputs and equipment suppliers

Input and equipment suppliers have helped to bring agricultural inputs and equipment close to the farmers thereby facilitating the adoption and up-scaling of CA technologies. Interviews with ward extension officers indicated that in Dodoma Region an NGO called LVIA successfully promoted conservation tillage using rippers pulled by oxen by conducting training and issuing a set of oxen and ox plows at a subsidized price. Farmers were supposed to pay in three installments after they sold their harvest. The government, also through village extension officers, has been distributing improved seeds to farmers at a reduced price so that a majority of the farmers can afford and adopt improved seeds.

Interviews with farmers revealed that farmer organizations (SACCOS) have helped by bringing farm inputs such as fertilizers, pesticides and seeds in godowns located within villages thereby making them easily accessible. Figure 10 shows a godown where farmers store their produce in one of the study villages.



3.2.4 Market interventions and communication infrastructure

Markets and buyers

Analysis of places where farmers sell their produce indicated that in Arusha, farmers sell mostly dried maize and beans in a nearby township (Figure 11). Village sales were the leading markets in Dodoma compared to neighboring villages and nearby townships. The leading crops in Dodoma are Sorghum/millet, groundnuts, and mesia (improved sorghum variety).

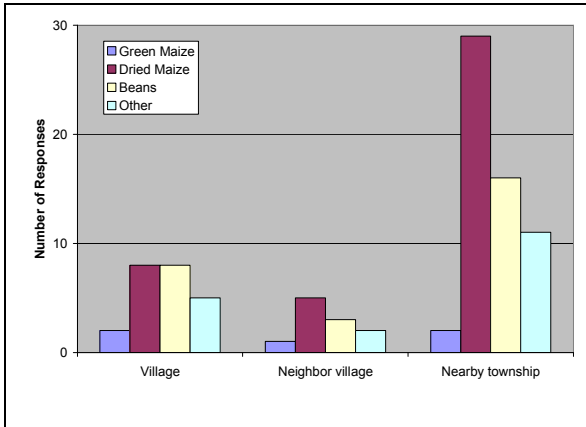


Fig. 11a: Markets for farmers to sell their produce in Arusha.

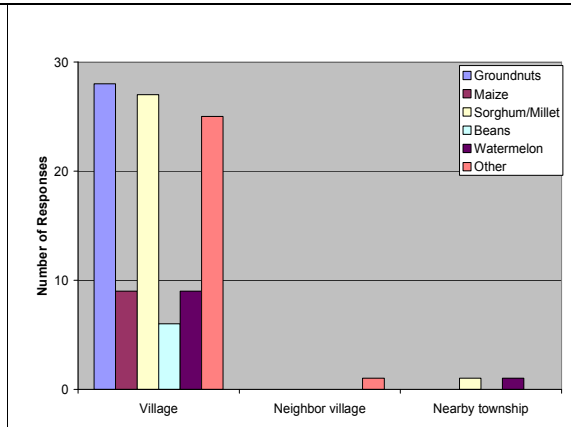


Fig. 11b: Markets for farmers to sell their produce in Dodoma.

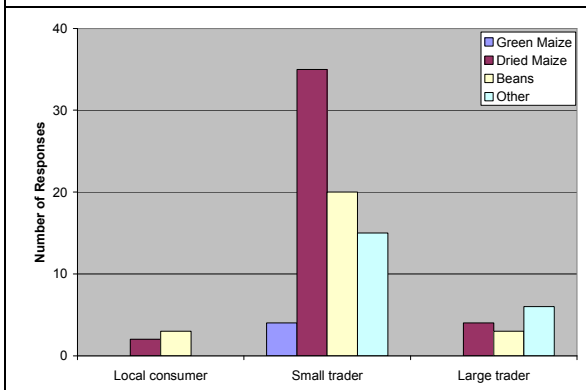


Fig. 12a: Buyers of farm produce in Arusha.

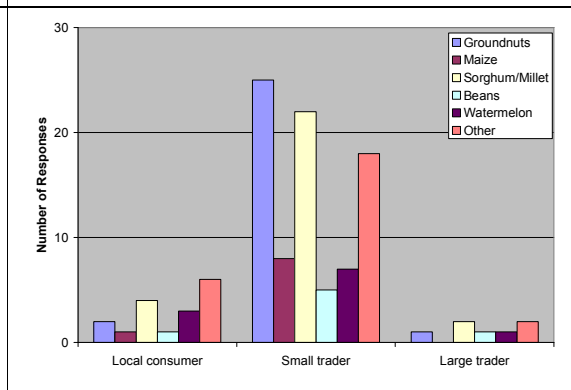


Fig. 12b: Buyers of farm produce in Dodoma.

With regard the buyers, small traders are the leaders in buying farm produce in both regions (Figure 12). Large traders are not common in the villages because most farmers are subsistence and they harvest only enough for their household consumption leaving little for selling.

With regard to communication infrastructure, the study villages in Arusha do not have year round passable roads with exception of Oldonyo Sambu. Telecommunications in all villages in Arusha are well connected. In Dodoma, roads are well maintained and all villages are served by mobile telephone companies. Also, there is a rail service in Kikombo and Msamalo Wards.



Figures 13a & b are showing the telephone mast and railway station, respectively, in study sites in Dodoma.

3.2.5 Policies and bylaws at local scale

Policies and bylaws were mentioned as playing an important role in the adoption and spread of CA technologies. Government policies from the national level to district, to ward and village level bylaws that hinder or accelerate the adoption of CA were noted by farmers and change agents. Change agents interviewed indicated that the government is keen and supportive on conservation agriculture. The National Agricultural Input Voucher Scheme (NAVIS) was mentioned as one way by which the government has managed to equip farmers with inputs to support their efforts of alleviating poverty and reducing hunger as indicated in the agricultural policy of Tanzania.

The government supports local laws prohibiting grazing on farms after harvest which was limiting conservation agriculture adoption. At village level, bylaws for prohibiting grazing on farms with crops or after harvest have stipulated fines for particular offences. In Ilkuishen and Ekenywa villages in Oltrumet Ward for example, a fine of TZS. 50,000/= was set for a cattle grazing on a field.

District Agricultural Development Offices in Arusha are also working closely with farmers supporting the availability of implements and inputs. Interviewed farmers noted the provision of implements to some of the CA groups as one of the efforts to promote CA. It was also mentioned that government efforts to increase the number of extension staff from village level are clear as nearly every village has at least one extension officer. Provision of loans in terms of implements to groups and individuals who practice CA was mentioned to be a major boost by the government. A key informant interviewed in Ekenywa acknowledged to have received a loan for a direct seeder and had been able to re-pay the loan according to schedule.

During the key informant interviews it was also noted that apart from the government efforts to increase the number of extension officers, there is a lack of motivation among staff due to lack of transport to meet the demands and needs of people in the villages. Extension officers themselves talked about the difficult conditions they have to endure to travel from one point to another and the housing conditions in villages and the lack of training packages in CA. Despite having bylaws that prohibit grazing of animals on farms, the enforcement of such laws at the village level has been hindered by tradition to the detriment of CA adoption efforts.

3.2.6 Policies at national scale

Policies at the national level play an important role in the adoption and up-scaling of conservation agriculture technologies. Key informants identified and suggested policies that could facilitate adoption of conservation agriculture technologies at national level.

Increase investments in SLM by devoting significant national budget resources in accordance with the Maputo Declaration, the Abuja Declaration on Africa Green Revolution, the Abuja Resolution on Food Security and in line with commitments for the achievements of MDGs 1 and 7. This should also include mobilization of international funding to boost investments in SLM for more income diversification and increasing livelihood support to targeted communities whose actions on land resources pose negative feedback. This would also address capacity issues.

Formulate and implement policy interventions; enforcement of the existing rules and regulations in the areas of land use planning, land tenure, developing smart markets and fertilizer subsidies at local, national and sub-regional levels.

Strengthen partnerships by building a common action-based SLM framework with governments, DPs, higher learning and research institutions, NGOs and UN agencies under a Country Partnership Program (CPP) for SLM.

3.3 Successful CA interventions

3.3.1 Successful projects in the study areas

Several successful projects in the study areas were able to continue after completion of the projects and even spread outside the project area. In Arusha, SCAPA was mentioned as a project that was started in the Arusha district in the late 1980s. This project mainly trained farmers on agroforestry, terraces and crop and livestock management in collaboration with RELMA. There was a tremendous response from people and degradation was largely controlled. The elements of success were mainly the provision of training, formation of groups, demonstration plots, farmer field schools, and provision of implements such as rippers, jab planters and inputs such as lablab seeds and improved pigeon pea seeds.

Conservation Agriculture and Sustainable Agriculture and Rural Development (CA-SARD), a regional project in East Africa, is another project adopted by farmers. The project is supported by FAO to facilitate and accelerate profitable CA by training farmers and supplying implements. The project worked in Arumeru, Bukoba and Karatu Districts in Tanzania, and uses mainly farmer field schools, which emphasize farmer-created techniques. While 11 groups were facilitated in Arumeru in 2005, the district has now 28 CA groups with five of the groups being facilitated by DADPs in Arumeru District. The district extension officer in Arumeru said they provide implements and inputs to CA groups and many people are asking to form new groups.

INADES have successfully promoted *chololo* pits in Dodoma. For example, in Mnase Ward in Dodoma, sixty farmers trained on *chololo* pits. The NGO also mobilized and facilitated people in communities to implement project activities through demonstration plots, farmer exchange visits and formation of farmers groups. There was a little concern by farmers that there was minimum support from the government.

Lay Volunteer International Association (LVIA) in Dodoma promoted minimum tillage through the use of ox-drawn equipment including use of rippers. The organization provided farmers with starter pack soft loans, which included oxen and equipment. They also provided 21-days training on the use of ox-drawn equipment. The soft loans were supposed to be paid in three installments over a three-year period.

Also, LVIA promoted the use of minimum tillage equipment outside the project area. The organization supported farmer exchange visits from neighboring areas. This motivated farmers from outside the project area to adopt minimum tillage practices. For example, in Nyaherezi and Igandu villages in Chamwino District, farmers borrowed ox-drawn equipment from project villages so they could also practice minimum tillage on their farms.

3.4 Constraints that limit CA technologies adoption and up-scaling

3.4.1 Perception of limitations for CA adoption

Analysis was carried out to investigate why some farmers were not adopting conservation technologies. Labor intensiveness, lack of training, and lack of capital to invest in the new technologies were the main constraints in Arusha (Fig. 14a). Lack of training, poverty, and land ownership were the main reasons for farmers not to adopt CA technologies in Dodoma Region (Fig 14b). Farmers are hesitant to invest in labor on new technologies such as *chololo* pits and terraces on hired farms where they are not sure of continuing to farm in the subsequent season.

Other reasons in both regions were lack of interest, lack of incentives, and time constraints. In addition, availability of farm inputs, costly implements, low returns, and lack of land for implementing the technologies were also reasons mentioned by farmers.

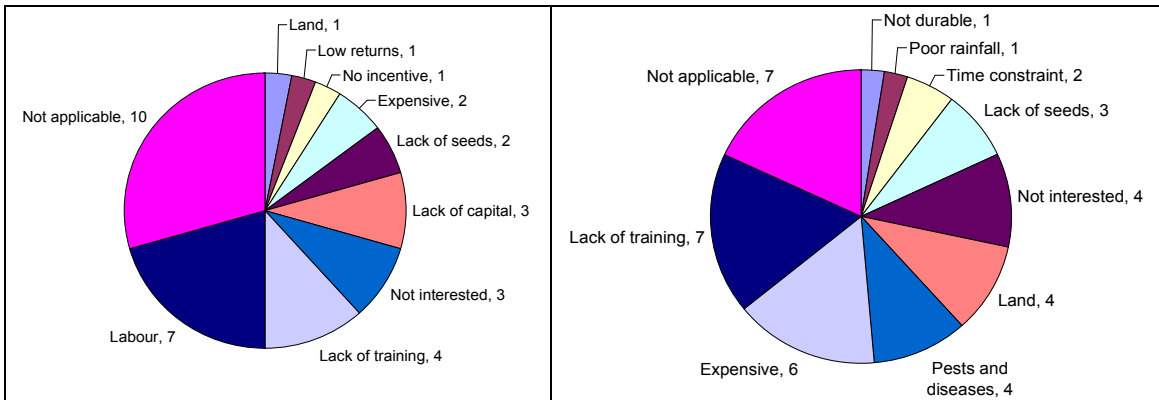


Fig. 14a: Limitations for adoption of CA technologies in Arusha.

Fig. 14b: Limitations for adoption of CA technologies in Dodoma.

3.4.2 Technical, biophysical, and economic constrains

Failure of adoption of CA technologies was also the result of some technical, biophysical, and economic constraints. Lack of immediate returns was among the reasons for not adopting as most technologies take more than two years for farmers to start realizing results. The key informants also indicated that lack of training for farmers and extension agents was a major constraint. Interviews with farmers indicated that technologies such as the *chololo* pits in Dodoma and terraces in Arusha are labor intensive and expensive compared to conventional tillage. Technologies such as *chololo* pits are area specific. They are suited to slopping areas with heavy soils. Considering the minimum tillage using ox-drawn equipment, which is a popular technology in Dodoma, most farmers (over 80%) are subsistent and they do not produce enough to have the financial power to adopt the technologies.

3.4.3 Legal and institutional framework

Newer technologies originating from farmers get little support and attention by the system. Local government continues to support standard and conventional technologies such as bench terracing and minimum tillage using ox-drawn equipment. In addition, local government leaders in villages do not command respect compared to chiefdom areas. Hence, when given the task of promoting technologies they do not get attention by the majority.

Land tenure was also a factor limiting widespread use of CA technologies. From the key informant interviews, many of the younger generation indicated that main reason for failure to invest in CA technologies was lack of ownership of the farms, as most of them were hiring from the village elders. Results from the questionnaire survey indicated that 95% of respondents who adopted CA technologies were farm owners.

CA technologies involve leaving crop residues for the next cropping season. However, these residues are sometimes eaten by livestock. In Arusha Region there is a bylaw for livestock that destroy crops in the field, which is a fine of TZS 50,000 for every cow caught grazing on a farm. But the implementation of the fine is hindered by social relationships as most people tend to seek reconciliation to end the matter without paying fines.

Finally, extension agents are not well motivated. There is a need for them to be given more training on CA, transport and housing facilities.

3.4.4 Markets and communication constraints

The marketing systems in rural areas within the study villages are not well established and stabilized. Interviews with farmers and village leaders revealed that there are no permanent markets within their villages. Despite the presence of farmer groups, there is still poor communication among farmer groups and farmers. As a result, producers lack market information and hence fail to have collective marketing strategies. Every farmer sells the same commodities with different inflated prices.

The presence of many middlemen also is a source of farmers selling their products at very low prices, resulting in low household income. Buyers inflate volume measuring instruments

during purchase of crops from farmers (e.g. 25 l bucket for a price of 20 l), and deflate the volumes during selling back (e.g. 16 l for a price of 20 l).

In Dodoma Region, the National Food Reserve Agency (NFRA) used to buy only maize. There is a need for the NFRA to buy more crops such as sorghum, mesia, millet and sunflowers, since these are the types of crop grown by the majority and are suited to the semi-arid climate of Dodoma.

3.4.5 Socio-economic constrains

Socio-economic issues were among the factors contributing to poor adoption and up-scaling of CA technologies. When different change agents promote CA technologies in the villages, most strategies focus on the fewer wealthier farmers (10%) who can afford to invest in the technologies and buy improved seeds. An example is availability of equipment and tools that are affordable to farmers. This has resulted in a majority of the poor farmers failing to afford and hence adopt CA technologies.

Subsistence farmers have their alternative means of living such as selling labor, preparing charcoal and running small businesses. They also use livestock as their own banks and sell some whenever they have financial problems. Issuance of government food aid in case of emergencies gives farmers assurance of government help in case they do not harvest. As a result, some farmers do not see the necessity of adopting CA technologies for conserving soil moisture and thereby improving their farm yields.

3.4.6 Credit, inputs, and equipment

The availability of credit and agricultural inputs and equipment at affordable cost has been a constraint to the adoption of CA technologies in both Arusha and Dodoma Regions. In Arusha Region for example, CA implements such as rippers and no-till seeders were initially imported from Brazil. They were expensive to most farmers and only a few implements were provided to a few groups at the time. Nandra Engineering (a local manufacturer in Moshi), and CARMATEC in Arusha started fabricating some of the implements and selling to farmers at prices cheaper than the Brazilian equipment. However, interviews with farmers in Arusha indicated that the local made rippers were less durable compared to the Brazilian rippers. This was reported to be a major setback especially during the farming season when every farmer needs to work on the farm, but implements are few.

Apart from those in groups, even farmers who are eager to adopt are kept at bay by the unavailability of implements. Farm inputs such as seeds especially lablab and pigeon pea were also mentioned to be major constraints limiting adoption as they are not locally available and farmers depend on change agents to provide inputs.

3.4.7 Change agents

The *chololo* pit farming technology was invented in 1997 by a farmer in Chololo village. However, agricultural extensionists ignored it since the technology was not on their agenda. While extension officers have been allocated from village, ward to district level, the extension services at all levels are not adequately reaching the farmers. With regard to publicity of the technologies, especially those invented by farmers, there are few publications or formal research to advise and popularize the technologies among the research community.

3.5 Adoption constraints at national level

3.5.1 Inadequate funding of sustainable land management activities

Sustainable land management (SLM) is not considered to be a priority in the national budget for consecutive financial years. The annual budgetary priority areas dictated by the Ministry of Finance have not adequately furnished the area of financing SLM activities. The national budget to cater for sustainable land management in the crop sub-sector has been about 0.4%, and around 0.1% for the whole agricultural sector budget. Likewise, the agricultural sector budget has been small at 5-6.5% of the total national budget.

3.5.2 Conflicting sector policies

Contradicting sector policies and regulations, especially on SLM issues, ends up in misinforming the public, thus jeopardizing their response tendencies which are often not geared towards addressing sustainability principles of natural resources management. The new land laws have adequately accommodated all issues of access to land that were previously a problem. What remains here is to see how various sector ministries would put in place their respective management plans for sustainable land management to adequately complement applications of those laws at field level.

3.5.3 Weak implementation of new land law

Decentralization in Tanzania has been improved by enacting the new land law (Land Acts No. 4 and Village Land Act No. 5 of 1999). The problem is enforcement of the Laws and incorporation of land resources management in the development action plans at lower government levels. This is exacerbated by the land tenure system whereby the customary land ownership predominates especially in rural areas.

3.5.4 Lack of recognition of indigenous land management systems

The indigenous land management systems are at risk of disappearing or are in conflict with certain modern management systems. These traditional systems should be strengthened, conserved and improved through appropriate methodologies to involve farmers, herders, agro-pastoralists and traditional foresters.

3.5.5 Inadequate capacity

There is inefficient capacity of extension services and various actors (including NGOs) in scaling up the success stories registered from local level interventions. Therefore, appropriate training curricula would be needed to strengthen their capacities. Furthermore, the level of awareness of policy and decision makers including the private sector, in the domain of SLM needs to be strengthened for better policy toward increasing investments. Database development and research activities for scaling up best agricultural production and environmental resource use and preservation practices need to be undertaken.

3.6 Steps for promoting adoption and up-scaling of CA technologies in Tanzania

Key informants identified steps that are necessary for adoption and up-scaling of CA technologies in Tanzania. The steps were identified in a group discussion with the key informants individually and as a group. Farmers are willing to adopt technologies that have proven to be beneficial in increasing yields, conserving soil moisture and reducing soil erosion. Also, most farmers are interested in a technology that has a quick and good return on investments. The first step identified by key informants was training on CA technologies.

The advantages obtained from a particular technology should be clearly stipulated to farmers during the training to encourage them to adopt. It was stressed that the training should start with change agents or NGOs to understand fully about the technology. Accordingly, apart from training farmers, there is a need for the change agents who are involved in the promotion to have complete training on the technologies.

4. SUMMARY AND CONCLUSIONS

4.1 Summary

In Arumeru District, the level of adoption of terraces, minimum tillage, and cover cropping CA technologies was very high. In Dodoma urban and Chamwino Districts, there is high adoption of large planting pits, minimum tillage, and use of ox-drawn equipment such as rippers. The adoption of these technologies has continued in other districts and regions beyond the project sites. The study also found that farmers really depend on these technologies for household food security and for income generation. They indicated that up to 50% of produce could be lost if they did not practice CA. In Arusha, the intensity of adoption is higher for the better off compared to the poor. However, in Dodoma the wealth status was not a factor as all wealth categories had higher levels of adoption.

The study found that maize and sorghum are the two crops grown extensively in two areas of Arusha and Dodoma. The yield levels of most crops grown on these technologies are very low but typical of Sub-Saharan Africa, with maize having the highest yield at around 1 ton/ha. Economic analysis of these technologies relative to crops grown showed a return on investments for maize grown on terraces or a combination of the same with cover crops or minimum tillage. The return from investments for sorghum on large planting pits (*chololo* pits) is highly questionable because of high investment costs and low yield and the price of sorghum. The low yields also due to the fact that Dodoma is semi-arid, receiving mean annual rains of 300-500 mm.

The role of change agents in promoting CA technologies was quite evident in both locations, Arusha and Dodoma. NGOs and projects were instrumental in promoting adoption of CA technologies. Also, extension agents at local levels were mentioned by respondents as being very effective in delivering CA messages.

The technical and economic characteristics of the technology were seen as the main factors for adopting or rejecting a technology. For example, for farmers to easily adopt a technology, it should not be highly labor intensive and should be able to capture and conserve water. The return on investment should also be quick and farmers should be trained on the use of technology and its economics.

The process of technology adoption should include the use of various participatory methods including farmer field schools, experimental plots, farmer exchange visits, and training of trainers among others. Use of farmer groups, incentives, and support instruments such as SACCOS or warehouse receipts systems are also important to ensure that farmers realize some acceptable profits from their efforts. Involvement of various stakeholders is also important including local governments and agricultural change agents at national, regional, district, ward and village levels. Farmers and other stakeholders were able to propose

eleven actionable recommendations that need to be implemented for successful scaling-out CA technologies in Tanzania.

4.2 Conclusions

In general, this study on adoption and up-scaling of CA technologies was not unique as many studies of this nature have been done under various names including CA, in-situ rainwater harvesting, soil and water conservation measures, and water system innovations. Therefore, the findings and facts have not really changed drastically over time. The need to continue investing in the promotion of CA technologies is still there in Tanzania and in Africa south of the Sahara. Most of the CA technologies are area specific, but they bear similar characteristics regardless of locations as described in the literature review.

Factors that facilitate or constrain adoption have also not changed with the main factors being technological and economic ones with quick returns from investments being another important factor. The scaling-out process is well established in Tanzania and it has proved to be effective in promoting adoption. Important elements in the process include the interactive participatory process such as the use of farmer field schools, experimentation plots, and farmer exchange visits.

An important contribution of this study is data on the yield and economic and socio-economic analysis on CA technologies. The study showed that sometimes the socio-economic importance of a technology can override its economic significance. For example, sorghum is socioeconomically more important to the people of rural Dodoma even though it might give negative economic returns. Therefore, the intention to promote CA technologies should not only look at the economic importance, but also its socio-economic importance to the people in the area. Their desire to adopt and out-scale a technology should be among the most important investment factors the government and development partners should consider.

Appendix 1: Successful AWM technologies and degraded land



How rewarding to see the results of AWM techniques on the sloping landscape in Songwe division, Mbeya – “it be at a stone-throw distance or at a far reaching horizon: it is spectacular, heart capturing, and convincing!” Picture by Paulo S.M. Tarimo.



Seen on the steep slopes of Pare Mountains is the apparent advance of rill erosion on smallholder farms. Some thought is required to understand how to work on the AWM/SWC techniques to achieve positive results. Picture by Paulo S.M. Tarimo.



Transformation of a bare slope into a productive landscape in Songwe, Mbeya. What is seen is an agroforestry “technology” comprised of five “techniques”: (1) Fanya juu” terrace, (2) Guatemala grass strip, (3) Coffee and banana trees planted in a row on the higher ground along the terrace, (4) Pyrethrum planted on the lower ground, (5) Gravelia trees planted to mark the border line of the farm. Picture by Paulo S.M. Tarimo.



It takes commitment to reclaim land first to have in place the intended SWC/AWM technologies working. The left photo above shows the demanding task of digging out stones to get cultivable soil. The stones are a resource for making the bench riser of the terrace. The right photo shows the final landscape formation. Picture by Paulo S.M. Tarimo.