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Mozambique Conservation Agriculture Inventory Report

by

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Mozambique Conservation Agriculture Inventory Report

EXECUTIVE SUMMARY

This report describes the conservation agriculture (CA) technologies being promoted and researched in Mozambique and summarizes the experiences of a variety of conservation agriculture projects across Mozambique's diverse agro-ecological zones. A wide range of development agencies, research organizations, private sector companies and educational institutions are involved in conservation agriculture. They operate in at least 84 of Mozambique's 128 districts and promote CA for higher agricultural productivity and improved utilization of natural resources including soil and water.

Manual CA systems of reduced tillage predominate, including basins and direct seeding. Animal based CA systems are promoted in areas where cattle populations are large such as Manica and Chicualacuala. Some of these CA systems rely on herbicides and synthetic fertilizers while others emphasize compost production and leguminous cover crops for soil fertility improvement and weed control. A few educational institutions have started training agricultural students on CA and a variety of CA manuals are available in Portuguese. CA equipment such as rippers, jab planters and direct seeders are generally not available.

The experiences of researchers and development agencies involved in CA are described for each agro-ecological zone. The emphasis is on how the agro-ecological context has interacted with the CA principles to affect levels of adoption and the performance of the technology. This inventory aims to facilitate networking among organizations involved in CA so that they can learn from each others' successes and challenges. It also aims to be a resource for those wishing to research the performance of CA in each agro-ecological zone of Mozambique by documenting the experiences on the ground.

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LIST OF ACRONYMS

ADRA	Adventist Development and Relief Agency
AENA	Associaçao Nacional de Extensão Rural (National Association for Rural Extension)
AJOAGO	Associação de Jovens e Amigos de Govuro (Association of Youth and Friends of Govuro)
AKF	Aga Khan Foundation
CAWG	Conservation Agriculture Working Group
CEDES	Comité Ecuménico para o Desenvolvimento Social (Ecumenical Committee for Social Development)
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CLUSA	Cooperative League of the USA
CRWRC	Christian Reformed World Relief Committee
DNEA	Direcção Nacional de Extensão Agrária (National Directorate for Agricultural Extension)
ECA	Empresa de Comercialização Agrícola (Agricultural Development Corporation)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
FAO	United Nations Food and Agriculture Organization
FH	Food for the Hungry
IABil	Instituto Agrícola de Bilibiza (Agricultural Institute of Bilibiza)
IAM	Instituto Algodoeira de Moçambique (Mozambique Cotton Institute)
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IFDC	International Fertilizer Development Center
IIAM	Instituto de Investigação Agrária de Moçambique (Agricultural Research Institute of Mozambique)
IIAM - CZC	Centro Zonal Centro (Central Zone Center)
IIAM - CZS	Centro Zonal Sul (Southern Zone Center)
IITA	International Institute of Tropical Agriculture
INGC	Instituto Nacional de Gestão de Calamidades (National Disaster Management Institute)
IRD	International Relief and Development
ISPM	Instituto Superior Politecnico Tecnológico de Manica (Manica Technological Politechnic Institute)
MCC	Mennonite Central Committee
MSU	Michigan State University
PIAIT	Plataforma para Investigação Agrária e Inovação Tecnológica em Moçambique (Platform for Agricultural Research and Technology Innovation)
PROMEC	Projecto de Promoção Económico de Camponeses (Project for Peasant Economic Promotion)
SANAM	Sociedade Algodoeira de Nampula (Cotton Society of Nampula)
TLC	Total Land Care
UEM	Universidade de Eduardo Mondlane (University of Eduardo Mondlane)
UNAC	União Nacional de Camponeses (National Peasants Union)
UNDP	United Nations Development Program
UTenn	University of Tennessee
WV	World Vision

Mozambique Conservation Agriculture Inventory Report

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Philip Grabowski and Bordalo Mouzinho

1. INTRODUCTION

The purpose of this report is to summarize the different conservation agriculture technologies being promoted and researched in Mozambique by a variety of organizations in order to set priorities for future interventions, avoid repetitions and facilitate networking among CA project managers. This inventory used interviews with CA project managers (some scientist researchers and some NGO professionals with CA experience) and review of CA project documents to build on the information gathered from the January 2012 survey of organizations which was presented at the February 2012 workshop "The Future of Conservation Agriculture in Mozambique". One of the main questions driving this inventory was to identify the specific combinations of conservation agriculture components currently being promoted and researched in Mozambique.

A. What is conservation agriculture?

Conservation agriculture generally refers to a combination or package of agricultural practices that minimize soil disturbance, incorporate legumes through intercropping or rotations and leave crop residues on the surface of the soil. The Mozambican Conservation Agriculture Working Group (CAWG) has adopted the following operational definition of conservation agriculture:

> "A farming practice that conserves, improves and makes more efficient use of natural resources through integrated management of the available resources combined with external inputs with a special emphasis on minimum tillage; in-situ crop harvest residue retention or use of mulch or cover crops, and crop rotations and mixtures." (FAO, 2002)

In practice many organizations striving for conservation agriculture face serious challenges in effectively implementing all three principles. Some organizations emphasize minimum soil disturbance while others emphasize covering the soil surface with mulch. During the interviews CA project managers provided the following contradictory working definitions of conservation agriculture (in order from open definitions to restrictive definitions):

- Every manual form of land preparation is CA because it is not the full tillage of plowing
- CA is primarily reduced tillage. If possible it can include some mulching. Fertilizer can replace the need for legumes.
- CA must include reduced tillage, mulching, rotation or intercropping with legumes
- In order to really be CA there must be zero tillage (basins and rippers disturb the soil too much) and must have intercropping (rotations are not beneficial enough).

B. Organizations involved in CA in Mozambique

There are a variety of organizations implementing some form of CA in Mozambique (Table 1). Many national and international research organizations are studying different facets of conservation agriculture across the country with some concentration of research efforts around the Agricultural Research Institute of Mozambique (IIAM) Sussendenga Research Station, Manica Province. A few private sector organizations are also using conservation agriculture including Verde Azul and some cotton companies. The largest number of organizations are development agencies (governmental, UN and non-governmental). Finally a number of international organizations and bilateral donors have invested in research on CA, especially USAID and AGRA. These categories are imperfect because some development agencies carry out research and act as donors but they serve to highlight the primary functions of most organizations.

Table 1: Types of organizations actively involved in conservation agriculture in Mozambique

Types of organizations	**List of organizations**
Research organizations	
Mozambican	IIAM, IAM, UEM
International	CIMMYT, IITA, CIAT, ICRISAT, MSU, Univ. of Tennessee, EMBRAPA
Private sector organizations	Verde Azul, SANAM, Plexus, CleanStar, ECA
Educational organizations	ISPM, IABil, AGRODEC/CeFAT
Development organizations	
Mozambican	DNEA, INGC, UNAC, Abiodes, AENA, Kulima, CEDES, AJOAGO
International	FAO, UNDP, CARE/WWF, Save the Children, ADRA, World Vision, CLUSA, CRWRC, ActionAid, Caritas, FH, IRD, TLC, MCC, IFDC, Helvetas
Donor organizations	USAID, AGRA

The January 2012 survey asked CA project managers to explain why they are involved in conservation agriculture. These responses were categorized into the responses listed in Table 2. Some of the variability in reasons for being involved with CA relate to the agroecological zone of operation of the agencies.

Table 2: Reasons why organizations are involved in CA in Mozambique

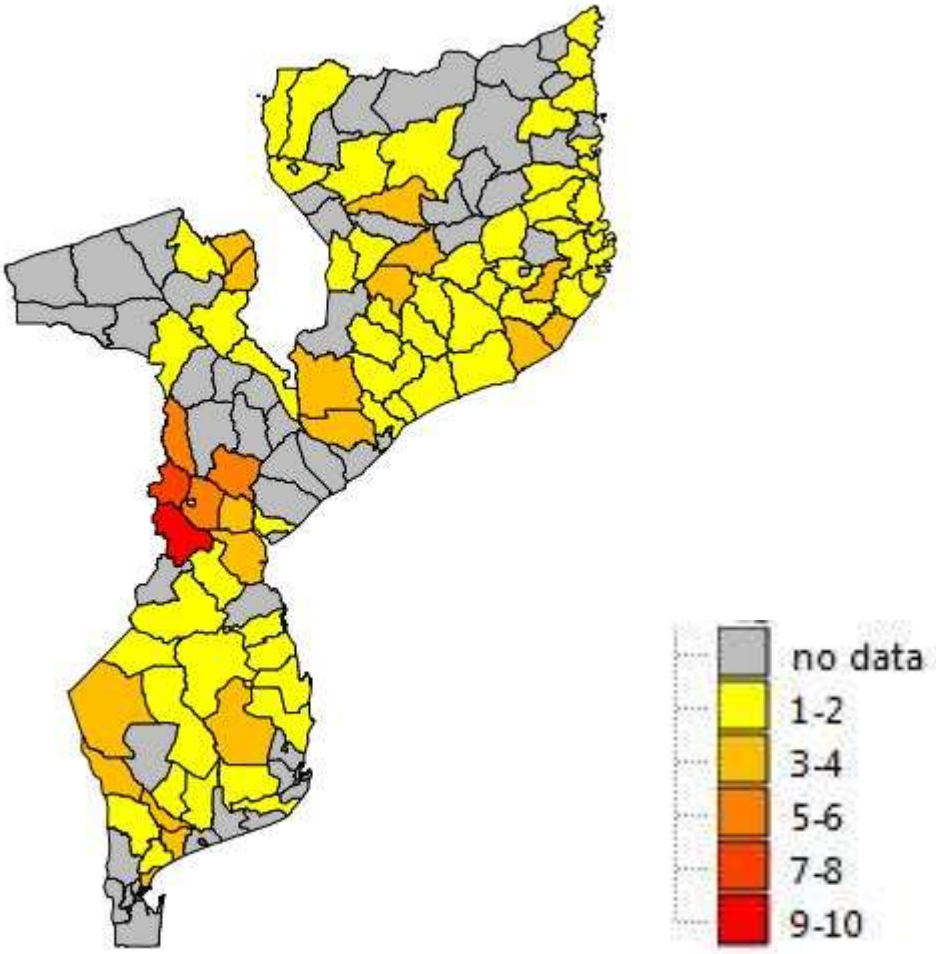
Emphasis	**Organizations**[1]
Reductions in time, effort and costs	IIAM - CZC; ActionAid; Food For Hungry; DNEA, IAM, ABIODES
Soil conservation and/or increasing soil use efficiency	IIAM, CIAT, CLUSA, Food For Hungry , IFDC, Save the Children, DNEA, University of Tennessee, UNAC e IAM, CRWRC
Soil restoration	IFDC, ADRA, CLUSA, Save The Children, World Vision e IIAM
Conservation of water and/or climate change mitigation	IIAM, CIAT, ADRA, IIAM-CZS, DNEA, IFDC, INGC, IRD, CRWRC
Reduced environmental problems and/or conservation of biodiversity	UNAC, ActionAid, CARE/WWF, Clean Star, Abiodes
Improved production and productivity	ActionAid, IITA, Food For Hungry, CARE/WWF, INGC, IRD, Save The Children, DNEA, Clean Star, IAM, AKF, CIMMYT, CRWRC
Improving farmers' practices	IITA, AKF, CIMMYT, IRD, World Vision

Data source: MSU/IIAM Survey of 30 CA project managers - 2012
[1] A list of acronyms is provided above

C. Where conservation agriculture activity is taking place

CA activities are operating in at least 84 of 128 districts of Mozambique (Figure 1). This map does not include FAO and DNEA operations which were not provided by district but reported that they operate at a national level and interact with many of the NGOs. There are many organizations operating in some districts especially Sussendenga and Manica districts. A complete list of organizations is available in Appendix 1 with the districts in which they operate, the number of farmers they interact with, and the number of years using CA. In terms of agro-ecological zones (Figure 3) there are no CA projects identified as working in R1 (south of Maputo) or R9 (border with Tanzania). No reports were available from zone R6 (mid and upper Zambezi valley) but two NGOs work there and it is probable that some work is occurring.

Figure 1: Number of organizations working on CA by district (not including FAO and DNEA who work throughout the country)



Data source: MSU/IIAM Survey of Experts.

2. TECHNOLOGIES BEING PROMOTED AND RESEARCHED

One of the distinguishing aspects of conservation agriculture is the reduction in soil disturbance through minimum or zero tillage land preparation methods. The variety of technologies used in Mozambique to achieve this are explored in the first part of this section. The next part of this section looks at how inputs are used by different organizations in Mozambique. The performance of conservation agriculture compared to conventional agriculture systems is greatly affected by the types of inputs (compost, fertilizer, herbicide and seed) used in each system. Finally there are many ways to incorporate legumes into the CA system and the last section highlights the organizations using rotations, intercrops and a variety of types of leguminous green manure cover crops.

A. Land preparation methods

Land preparation methods can be categorized first by the source of power that they use - manual, animal or tractor. Within each of these power sources there are a variety of technologies available for reducing soil disturbance. Manual systems are the most common by far in Mozambique. Within manual systems there is a large range of possibilities for minimizing soil disturbance. One of the most well known conservation agriculture systems using manual power is the basin system where farmers establish a permanent grid of planting holes with a hoe thereby allowing the incorporation of manure or compost near the plant without disturbing all the soil of the field. This system has been widely promoted by groups associated with the Farming God's Way movement, which has come out of Zimbabwe and was then adapted by the Conservation Farming Unit in Zambia.

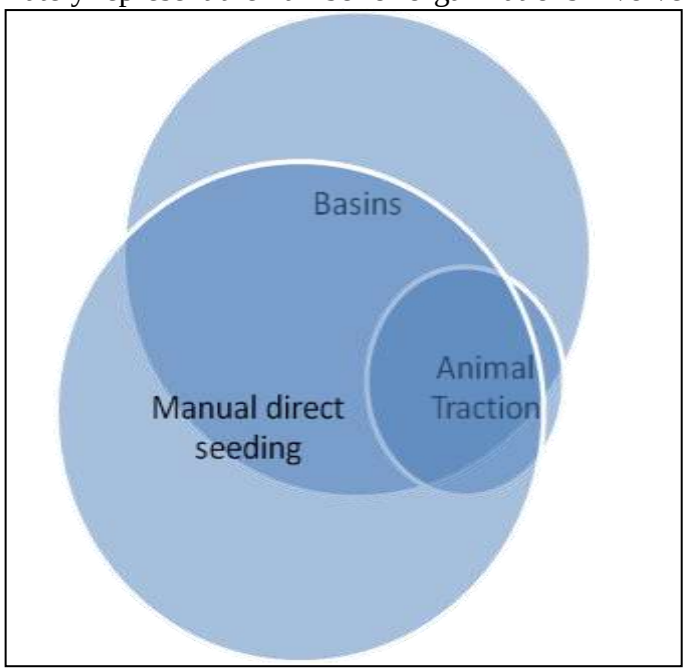
Alternatively manual power can be used for zero tillage through jab planters, dibble sticks or the single cut of a hoe. The current Brazilian style jab-planters are said to have difficulties in heavy soils. CIMMYT has started exploring a faster Chinese seeder that is swung like a hoe. Improvements in manual direct seeding equipment would help reduce the labor time currently associated with manual CA systems but further research is necessary to develop such equipment.

Tractor and animal power can be used to pull a ripper tine (or chisel plow) that opens up lines for planting but leaves most of the soil undisturbed. Alternatively tractor or animal power can be used to pull a direct seeder that jabs seed (and often fertilizer) into the soil without disturbing it (zero tillage). Only CIMMYT, FAO, IIAM, DNEA, and CIAT have small animal traction components within their larger CA efforts. Most of the animal traction efforts are in Manica and Gaza provinces where cattle are relatively more common. In other areas animal traction is generally believed to be not viable because of low livestock numbers, possibly related to tsetse fly and trypanosomiasis.

No organizations actively have farmers involved with tractor powered conservation agriculture.[1] INGC has one demonstration with tractor based conservation agriculture and FAO introduced two wheel tractors for CA in 2006. Figure 2 illustrates the relative effort for each land preparation method and Table 3 provides details on land preparation methods for most organizations.

[1] The initial analysis of the survey data (Donovan and Mouzinho, 2012) indicates many organizations using tractors for CA but it was realized later that respondents marked tractor power on the survey because they compare manual and animal CA with tractor plowing but do not do tractor ripping or use a tractor drawn direct seeder.

Figure 2: Land preparation methods promoted or researched by organizations - the areas approximately represent the number of organizations involved in each technology.[1]



Note: [1] Overlapping areas signify that one organization promotes or researches one or more technology.

Many organizations promote both basins and zero tillage as alternative manual forms of conservation agriculture. Several organizations mentioned that basins are not feasible in sandy soils because they collapse too easily. Others have stated that basins which integrate the use of manure or compost are the only way to use CA if inorganic fertilizers are not used. The quality of compost produced is important for unfertilized CA to have high yields. Zero till disturbs less soil than basins, which may result in higher soil organic matter levels in the long term. Basins are also seen by many as too labor intensive. Research in other countries (such as Zambia) has shown that animal traction conservation agriculture may have greater labor productivity. In practice the method of land preparation most likely to be adopted by farmers depends on the availability of animals, fertilizer, labor and a host of other conditions, especially soil type and farmer knowledge base. These observations highlight the importance of combining agronomic analysis with socio-economic and agro-ecological analysis for determining the most promising conservation agriculture technology under different conditions.

As was mentioned earlier, many organizations do not emphasize minimum soil disturbance in Mozambique despite the fact minimum soil disturbance is considered as fundamental in the CAWG definition of CA. Some organizations talk about reducing tillage but in practice it not evident based on the authors' field visits (CARE Nampula, ActionAid Marracuene) and some field reports (FAO - Inhambane - Nhaca, 2010). While this could be because of gradual implementation of the three principles, some project managers openly admit that reducing soil disturbance is not a key priority (SANAM, IITA). For further details on the technologies used by agro-ecological zone see section D below.

B. Purchased input use with CA

Many organizations are promoting conservation agriculture as a means of sustainable intensification of smallholder farming. They see the principles of conservation agriculture as providing the means for encouraging more widespread adoption of fertilizers and hybrid seeds so that yields and productivity can be increased. Herbicides are seen by many as essential during the early years of adoption because of the increased weed pressure with reduced soil disturbance.

On the other hand there are many organizations working on conservation agriculture which do not use chemical fertilizers and herbicides because of the high prices of these products and the difficulties farmers have finding them in the market. The smallholder farmers targeted by many organizations are considered to have too limited resources to be able to obtain these products, so the organizations focus on technologies that do not require them. Herbicides are not only expensive and unavailable but are also anecdotally reported to be diluted by sellers. During interviews some project managers also highlighted the risks associated with promoting these purchased inputs by pointing out the lack of training for using fertilizer and herbicides as well as the irregularity of rainfall which may lead to a failure to recover the costs of these investments.

Table 3: Organizations using different combinations of land preparation methods, fertilizer and herbicide use[1]

Organizations	Land prep types	Fertilizer	Herbicide
UNAC, IITA, CLUSA	Manual zero till only	No	No
TLC, IAM		Yes	Yes
AKF, INGC, ActionAid, CARE/WWF, Clean Star	Manual zero till and basins	No	No
IIAM-CZS, UEM, IFDC, DNEA,		Yes	Yes
Save the Children, ADRA, IRD, CRWRC	Basins only	No	No
World Vision		Yes	No
CIMMYT, DNEA, IIAM, CIAT	Manual and animal traction	Yes	Yes
FAO		Yes	No

Data source: MSU/IIAM Survey of Experts.

[1] Note that just because an organization promotes fertilizer or herbicide use does not mean that all farmers that participate with them must use these inputs.

For those farmers with low purchasing power there are various weed control alternatives. For example FAO encourages intercropping to outcompete weeds including pumpkin, pigeon pea and sesame. Aga Khan Foundation encourages farmers to accumulate grass from fallow land to apply as mulch so that the conservation agriculture plots are well mulched, preventing weed growth without herbicides. This labor intensive practice may be necessary for immediate weed control but may not be sustainable from a labor perspective as well as because of its ability to mine nutrients from fallow land for cultivated land.

C. Fitting legumes into CA systems

Every organization that participated in the survey incorporates legumes into conservation agriculture through intercropping or rotations or both (Table 4). There is a great diversity of intercropping and rotation systems including complex multi-species intercrops and relay crops to extend the growing season.

Table 4: Strategies for incorporating legumes by type of organization.

	Legume rotations	Legume intercrop	*Mucuna* cover crop	Other cover crop
Research organizations	8 out of 8 organizations	6 out of 8 organizations	CIMMYT, UEM, IFDC	CIMMYT, UEM, FAO, FHI, CLUSA
Development organizations	11 out of 14 organizations	12 out of 14 organizations	AKF, CARE/WWF, INGC, DNEA, IRD	AKF, CARE/WWF, INGC, CIAT, UTenn, IITA
Private sector organizations	1 out of 3 organizations	2 out of 3 organizations	Verde Azul	Verde Azul, SANAM

Data source: MSU/IIAM Survey of Experts.

During the interviews, respondents highlighted a number of benefits and challenges from rotations and intercrops. One project manager explained that competition between species can be reduced during intercropping by planting them in rows that run east-west so that the shade primarily comes from crops of the same species. He also pointed out that diverse crops improve soil health through micronutrient concentrations. Other benefits include pigeon pea's ability to de-compact the soil with its deep tap root, pump phosphorous from deep down in the soil profile and fix nitrogen. CIMMYT reports 100% productivity gains from rotating maize with sunhemp but farmers do not accept it readily because it is not a food crop, though it is good for fodder. Much work remains to document and analyze the diversity of options organizations are using to incorporate legumes into conservation agriculture in Mozambique.

D. Details of CA use by agro-ecological zone

This section reviews the experiences of researchers and development agencies in Mozambique. The CA technologies used in each agro-ecological zone are described based on what is known from the review of available evidence. This detailed description emphasizes how the agro-ecological context has interacted with the CA principles to affect levels of adoption and the performance of the technology. For details about each agro-ecological zone see the table in Appendix 2 from Amane and Mlay (2002)

Figure 3: Agro-ecological zones of Mozambique

Source: Amane and Mlay, 2002)

Southern Mozambique

The southern part of Mozambique north of Maputo is divided into two agro-ecological zones - R2 which has higher rainfall and lies along the coast and R3 which is lower rainfall and further inland. Most of the CA work in agroecological zone R2 is in Inhambane province by the following organizations: CARE, IRD, FAO, DNEA, UNAC, IIAM-CZS, and INGC. ActionAid works with UNAC in Marracuene and Abiodes is promoting organic vegetable production in the same district. Some of the CA work in this region emphasizes mulching irrigated vegetables along flood plains with little understanding of reduced tillage such as FAO and DNEA's work in Massinga district as detailed by Nhaca (2010) and ActionAid's work in Marracuene district (field visit 2012). The main benefit noted in Massinga was reduced labor in watering because of the mulch (Nhaca, 2010). No differences in opinions by gender about this form were detected by Nhaca (2010).

In addition CARE and IRD have promoted permanent planting basins in Inhambane for rainy season crop production. After 4 years CARE was able to train over 15,000 farmers on CA and documented high adoption levels of mulching (66%), cover crop use (77%) and legume intercropping (88%). However only 30% of farmers tried the basins because they were too labor intensive and collapsed too easily in the sandy soils (Sampath, 2011). IRD has been using Farmer Field Schools to promote basins with leguminous cover crops like *Mucuna* in order to achieve the weed control and moisture retention benefits from permanent soil cover. Both CARE and IRD had women comprising 68% of participants. A report on UNAC's work in Inhambane noted high participation by women but still unequal control of project resources (Mattick, no date). Both CARE and IRD emphasize drought tolerant crop varieties in order to complement CA efforts. One challenge documented by CARE was that intercropping and cover cropping led to soil N increases but soil P decreases, presumably because it was picked up by legumes (Sampath, 2011). Little detail is provided about these soil tests (season, pH, methodology) in order to verify their importance for production. No documents were found to obtain details on the work of IIAM-CZS in Funhalouro and Mabote or INGC in Funhalouro and Mabote districts.

The CA work in the more arid interior (R3) includes a FAO project in Chicualacuala and research focused on Chókwè district and the Limpopo basin projects by CG centers and UEM students. IIAM-CZS and INGC also work in the area but no documents were found for details. From the survey information though, it is known that IIAM-CZS researches both manual and animal CA with some use of herbicides while INGC focuses on manual forms of CA without herbicides. An FAO report (Midgely, Dejene and Mattick, 2012) describing the project in Chicualacuala district states that CA was resisted in part because of farmers investment in plowing and the associated rental income and because the trial year was too dry for good results. The authors suggest that ox-drawn rippers may be needed for reducing tillage in this context. The farmers in the project were receptive to mulching and intercropping and the report recommends promoting these components first before emphasizing reduced tillage. Cover crops are recommended but there is a challenge of free range cattle.

Siambi (2010) describes the ICRISAT trials carried out in Gaza province for 4 years starting in 2006. The main emphasis was on yield differences and many of the results showed no significant

differences. In one year mulch and fertilizer together improved maize yields from 700kg/ha to 1200kg/ha. In the next year little yield difference was found in maize yields between zero till, basins and conventional tillage with mulch. Pigeon pea maize intercrops caused no reduction in maize yields in one year as well. Complementary information about labor inputs and erosion levels would provide a more thorough basis for comparison of the systems instead of the exclusive emphasis on yields.

Ncube et al (2008) summarize the CGIAR research in Limpopo river basin. Experiments in Chókwè showed basins providing 8 fold maize yield increases from 14kg/ha to 111 kg/ha, both extremely low due to low rainfall. Cowpea yields went up from 92 kg/ha conventional to 131 kg/ha in basins but this was not statistically significant. The report also highlights that the benefits of basins are greater when combined with mulching and improved agronomic practices. The authors also suggest that water availability from basins is more significant in heavier soils because of low water holding capacity in sandy soils.

The work of several UEM students supported this work in the Limpopo river basin. Camba (2007) used modeling to estimate how mulch would have affected maize yields using 40 years of rainfall data from Chókwè and one year's worth of evapotranspiration data with mulch. The results reported are that in 90% of the years, mulch would have reduced evapotranspiration by 10%. This result seems hardly meaningful for crop production but the author suggests that it would add a maximum of 45kg/ha to the base maize yields of 200-300kg/ha (Camba, 2007). In a survey of 29 farmers in Chókwè about water harvesting techniques (Mamade 2006) 21% were using basins for water harvesting (10-15cm deep and 50-70cm in diameter) but there is no description of the sampling for these farmers and it seems unlikely that it was a representative sample of the district. Niquice (2006) modeled yield benefits from water harvesting but concluded that in field harvesting would not be able to significantly reduce water stress during maize flowering on the years with poor rainfall distribution even if the total precipitation was average. Ncube et al (2008) cite Niquice's modeling work stating that yield is expected to increase at lower plant densities in Chókwè if the rainwater can be channeled to the root zone through basins. This type of conclusion should be specific in terms of plant densities and it should be noted that its validity depends to a great extent on the assumptions of the model and its level of calibration to the local soil and climate which are not evident in the report.

Central Mozambique

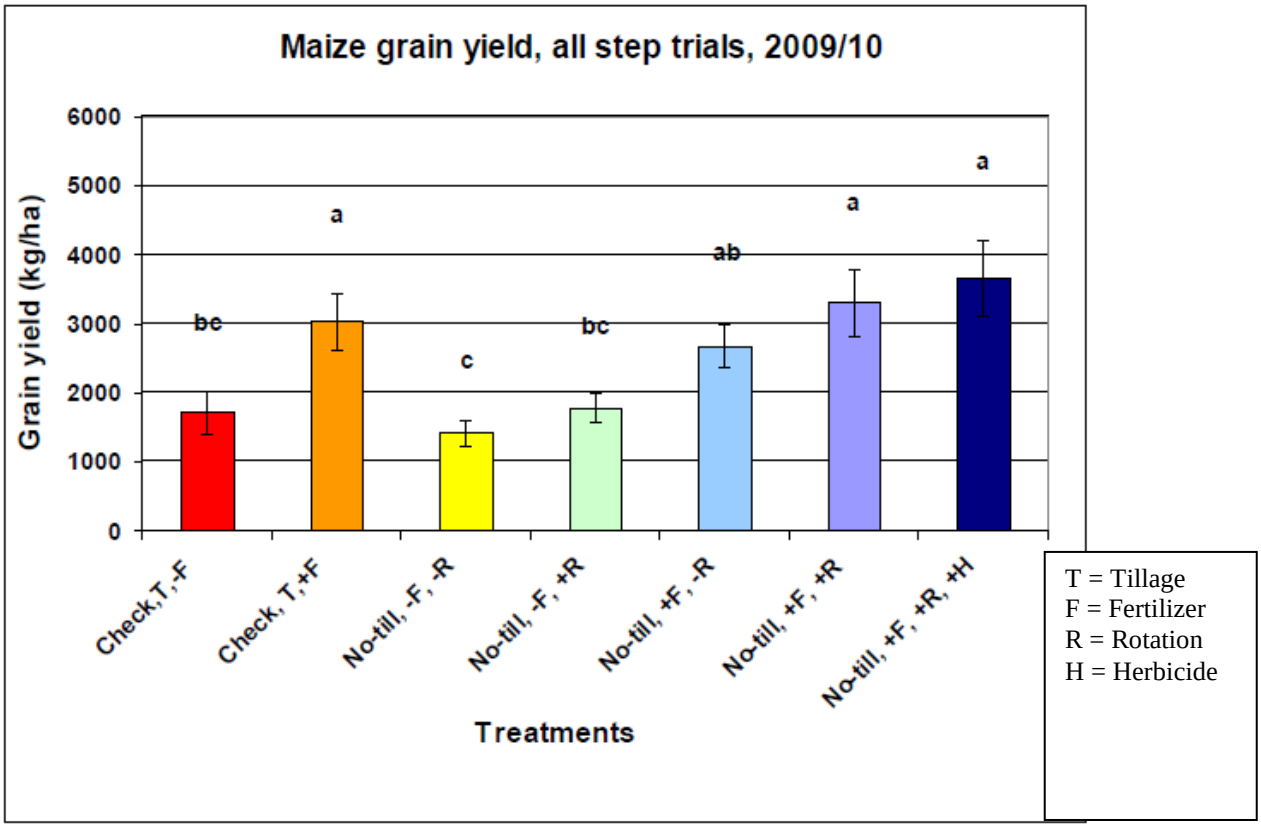
Manica province

The majority of the research on CA and many of the largest projects have been in Manica and Sofala provinces especially in agro-ecological zone R4. Most of Manica and part of Sofala is in agro-ecological zone R4 with an average of 1000mm rainfall and an elevation of 200-1000m (Amane and Mlay, 2002). The border with Zimbabwe is in zone R10 with higher elevation and rainfall. Sussendenga research station in Manica has been the hub of the many research studies in the zone by UEM, IIAM-CZC, CIAT, IITA, CIMMYT, IFDC and others. One notable challenge is high termite activity levels on the research station especially for CA plots (Famba, 2011; Putz, 2008). CIMMYT has recently shown impressive termite control through the use of *Tephrosia.*

CIMMYT has carried out CA maize trials on farmers' fields for a number of years throughout R4 zone including Barue, Nhamatanda and Sussendenga districts. The SIMLESA research project has located 44 of its 66 trials in this agro-ecological zone in many of the same areas. These trials generally use improved maize varieties, fertilizer and herbicides for CA. Rotation with legumes and types of land preparation (jab-planter, basin, ox-ripping and full tillage) are compared in some of the trials. During the 2012 reporting and planning meeting held by CIMMTY, it was observed how the high variability in rainfall between years cause the results to be difficult to interpret. In general CA as used on these trials seems to show some long term yield benefits though it is unable to sustain high yields during poor rainfall years. Thierfelder and Nyagumbo (2011) document the year to year variability of CA yields at Sussendenga and highlight the importance of rotations for increasing infiltration and reducing erosion. One insightful result from CIMMYT (Thierfelder 2010) is the incremental benefits of including more CA components together (such as herbicides, residues, fertilizer and zero tillage) as shown in Figure 4. The statistically significant differences are between fertilized and unfertilized plots but there appears to be a trend of increasing yields as rotations and herbicides are added.

Many other studies have been carried out in this agro-ecological zone. Famba's research at Sussendenga (2011) showed that CA decreased runoff and erosion though yield differences were not significant. Famba also developed a crop model for CA using APSIM that was calibrated to match Sussendenga results. The model suggests that if termites were not removing mulch there may be significant N immobilization which could negatively affect yields. This hypothesis obviously should be tested empirically where termites are not as active. Rusinamhodzi et al (2011) studied maize-legume intercrops under no-till and found positive land equivalent ratios and reduced risk of crop failure when alternate rows of pigeon pea and cowpea were planted with maize. They emphasize the importance of the market linkage for selling legumes, the problem of livestock for late maturing pigeon pea and the increased weeding time with intercropping. Nhancale's research in Manica (2000) showed that zero till maize production could increase yields from 2 tons/ha to 3.3 tons/ha with no increase in costs.

Figure 4: Maize grain yield for step trials in three countries of southern Africa (Malawi, Mozambique, and Zimbabwe) from 2009/2010 (Thierfelder, 2010).



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The SIMLESA baseline study (Cachomba and Menale, 2012) indicates that only 25% of the 510 households in the sample use fertilizer and that legumes are grown on only 0.42 ha of the 3ha cultivated per household. The same study indicates that 21% of farmers in Sussendenga (n=131) and 32% in Manica district (n=127) were already using zero or reduced tillage and over 80% retain their crop residues. This surprisingly high result is likely due to it focusing on communities targeted already with CA. The report says it used proportionate sampling with random selection of villages but this does not imply that the results are representative of the districts.

Nkala (2012) explored the link between CA and livelihoods in three villages in this agro-ecological zone documenting the vulnerability of many households and some productivity gains from CA. The data is not very informative because it directly asked farmers binary questions about improvements in their food security and livelihoods. Stronger evidence could be derived from panel data on consumption or food stocks over time during the course of adopting CA. Nevertheless Nkala makes many useful insights about CA and livelihoods. For example Nkala emphasizes how farmers are actively redesigning CA packages to fit their needs and asserts that a participatory approach to adapting the technology is more appropriate than a technology transfer approach. Mango and Joachim (no date) describe how CIAT is setting up innovation platforms in 6 centers of R4 in order to foster this type of farmer centered innovation.

Sofala province (and part of Zambezia)

The coastal part of Sofala and Zambezia province are in agro-ecological zone R5 which receives between 1000 and 1400mm of precipitation and predominantly sandy soils (Amane and Mlay, 2002). This area is challenged by high risk of both flooding and drought and low fertility soils. Cleanstar Mozambique is a private sector organization working in Dondo and Savane and encouraging CA cassava production by smallholders so that it can produce ethanol for cooking stoves. Cleanstar is working with the University of Tennessee to explore fertilizer responses of cassava and cover crop possibilities for weed control and soil fertility enhancement.

The Austrian and German governments funded PROMEC to promote CA in Sofala from 2003 to 2006 and in this period the CA technologies were tested and adapted and 1200 farmers were trained (Taimo et al 2005). PROMEC promoted all three components of CA and found that immediate benefits were possible especially for horticultural crops. For example onion production benefited from reduced labor in land preparation (from 45 days to 7 days) complete reduction in weeding (14 weedings to none) and reduced irrigation (3 times/wk to 1 time/wk) when CA was used (Taimo et al. 2005). The project promoted *Mucuna* as a cover crop and this was seen to be very effective at eliminating Cyperus spp. weeds over two seasons (Calegari 2005). CA was used for zero till cassava production as well as maize and even included intercropping legumes with pineapples (Calegari 2005). The results of this work are also summarized in Zandamela et al (2006) which indicate that 50 ha of vegetables were under CA at that time and that maize yields were increased from 800 kg/ha to 1000 kg/ha. The project partnered with Food for the Hungry and Caritas who continue to promote CA.

In the Zambezia portion of this agro-ecological zone ADRA, World Vision, IIAM-CZC and CIAT are promoting and researching CA systems but few documents are available about this work. One report by Muchiguel and Mendoza (no date) about ADRA's work in Mocuba emphasizes teaching farmers to stop burning and to intercrop legumes with their crops. Both World Vision and ADRA are promoting the basin form of CA without fertilizer or herbicides.

Tete province

Tete province ranges from high elevation and high rainfall R10 in the Angonia highlands (1200-2400mm) to the hot and semi-arid conditions of R6 along the Zambezi river valley (400-600mm).

Total Land Care has been working with CIMMYT and CIAT in Angonia, Macanga and Tsangano districts promoting zero till maize production with residues, fertilizer and herbicide use. SIMLESA has established some trials in Angonia and carried out a socio-economic survey about CA but the results are not yet available. Grabowski's thesis (2011) points out the low profitability of this high input system when yields are average and compares it with the low input basin system promoted by CRWRC in the same area. The low input system had lower yields but was more accessible to low income households. Achieving large scale adoption of the low-input system is difficult because of labor constraints in making basins and controlling weeds. Initial results from an economic survey of over 500 households in the same region found that farmers using CA (6.8% of villages where CA had been promoted) sell a larger portion of their maize, which may suggest higher production levels than conventional maize producers (McNair et al. 2012). There is little information about how CA is being promoted in the more arid parts of Tete province, though both CRWRC and UNAC are operating in Moatize, Mutarara and Changara districts.

Northern Mozambique

Many development agencies are promoting CA in different parts of northern Mozambique. Agro-ecological zone R8 runs along the coast and receives 800-1200mm of precipitation with a broad range of soil types. Along the coast of Nampula CARE is working with AENA to encourage mulching and intercropping of cassava by using the Farmer Field School Approach. Farmers interviewed in this location were nearly unanimous in describing CA as economically and ecologically beneficial (Pomeroy and Aljofre, no date) In Cabo Delgado the Aga Khan Foundation is promoting manual basins with mulching and legume intercrops, rotations and relay cropping lablab. They document maize yields increasing gradually from 0.8 tons/ha baseline to 1.2 tons/ha in 2010 and then jumping to 3.2 in 2011 (Dambiro *et al.* 2011). Cowpea yields also increased steadily from 0.6 tons/ha to 1.7 tons/ha in 2011. Unfortunately no control plots were reported for each year so it could be possible that the increases are simply due to weather patterns better for maize production in 2011. Dambiro *et al.* note that there is a need for coordination in the area so that Quirimbas National Park, WWF, Helvetas, the local NGO Kulima, the Bilibiza Agricultural Institute, and provincial and central governments can all be working together for CA. The Helvetas project is described in Zandamela et al (2006) as focusing on reducing soil degradation by stopping burning and maintaining residues on the soil surface to decrease erosion and increase infiltration. The case of CA projects in Quirimbas National Park by WWF and Kulima suggest a broader definition of "conservation" that is not only concerned with soil as a resource for agriculture but also how agriculture affects the conservation of wildlife.

The interior areas of Zambezia, Nampula and Cabo Delgado as well most of Niassa province are in agro-ecological zone R7 with 1000-1200mm rainfall and an elevation between 200 and 1000m (Amane and Mlay, 2002). Several organizations are promoting and researching CA in this zone including CARE, Save the Children, CLUSA, FAO, IITA, IFDC. In addition this is the zone where cotton is primarily grown and IAM is doing some cotton CA research and Plexus and SANAM will be training farmers on CA in the near future. CARE's Olima Wo Suka project emphasized mulching, intercropping and incorporating residues to achieve higher yields (Zandamela et al 2006). Maize yields were higher for both maize (up from 1600 kg/ha to 2500

kg/ha in 03/04) and groundnuts (up from 700kg/ha to 1050 kg/ha in 03/04). Pienaar and Sanchez (2012) claim that adoption of CA is low and partial in Nampula, partly because of inconsistent implementation of recommended practices and also the lack of access to the technologies. There are also a number of high elevations zones (R10) in northern Mozambique but no documentation of CA projects in these areas though CRWRC and UNAC promote CA in Lichinga which is in R10.

3. ADDITIONAL INVENTORY INFORMATION

A. Educational efforts

A few agricultural training facilities are actively engaged in conservation agriculture including Instituto Superior Politécnico de Manica (ISPM) in Chimoio and the Agricultural Institute of Bilibiza (IABil) in Cabo Delgado Province. More work needs to be done to develop a complete inventory of agriculture training institutions promoting CA and document what they teach.
A number of manuals on conservation agriculture have been developed in Portuguese for Mozambique:

- Guião prático de AC by Calegari e Taímo - developed for PROMEC
- Manual de AC para técnicos e agricultores by Calegari and Taimo (2007) - developed for PROMEC
- Manual de Agricultura Sustentável by Nhancale e Chilaule (2010) - developed for UNAC
- O guião de facilitador, abordagem de Escola Machamba: AC regenerativa by Kamp (2011) which is also available in English from CARE
- SANA consortium documents for cassava, maize and groundnut production with sections on CA.

B. Private sector organizations involved in conservation agriculture

There are only a few private sector organizations currently involved in conservation agriculture in Mozambique. Because of the potential for the private sector to significantly transform agricultural practices, this category of organizations is described here. Clean Star is operating in Dondo and Savane districts of Sofala and contracting with farmers to produce cassava for ethanol production. Clean Star is exploring how cover crops, minimum tillage and crop residues can help farmers on the nutrient poor sands typical of that area.

The Empresa de Comercialização Agrícola (ECA) is contracting with farmers in Barue district to purchase their surplus grain and linking them with credit for inputs. In 2012, ECA worked with over 937 small-holders around Catandica and hopes to expand to 2,000 in 2013. ECA aims to introduce sustainable farming practices such CA to farmers and provide them access to markets. They have established 22 small-holder “clubs” at 5km intervals along the N7 road 50 km north and south of Catandica. They have supplied the materials for each club to construct simple thatch-roofed warehouses that act as focal points for farmer training, demonstrations and the collection of maize. Each club has a loan provided by the Banco Oportunidade to enable them to buy inputs.

The loans are guaranteed by ECA and ECA purchases the maize from the club to repay the loans. Though it has only functioned for one year this model where the private sector contracts with smallholders for grain and legume production seems to have potential for providing credit for inputs and guaranteeing sales of surplus which could drive sustainable intensification with CA.

Several cotton companies in Mozambique have joined the Cotton Made In Africa initiative which includes conservation agriculture training as a component for being certified for this label. Because of this Plexus and SANAM and perhaps other cotton companies are starting up CA training programs but the efforts are extremely new. This is in stark contrast to neighboring Zambia where cotton companies have been promoting CA for over a decade.

The relative lack of involvement of cotton companies in CA (compared to Zambia) according to Mike Burgess (who has consulted companies on CA in both countries) stems from the differences in agro-ecological conditions between northern Mozambique (where most cotton is grown) and the cotton belt of Zambia. Tsetse fly limits cattle production in this part of Mozambique and the lack of plowing dramatically changes the relative benefit of using conservation agriculture. Burgess explains that in Montepuez "the traditional system is a form of conservation farming, as nobody ploughs their lands, so you don't get the problem that occurs in Zambia, of waiting for the rain then ploughing the land, which results in delayed planting. So planting generally starts at the right time in Mozambique". Burgess also states that "most of the cotton is intercropped with beans, which are harvested before the cotton." It will be interesting to see how the cotton companies adapt conservation agriculture to cotton production systems over the next few years in Mozambique.

C. Agro-dealers and equipment

There is little or no local manufacturing of conservation agriculture equipment in Mozambique. GrowNet is a Zimbabwean firm manufacturing animal drawn direct seeders that can be imported to Mozambique. Other equipment is available from China, Brazil, India and South Africa. AGRODEC/CeFAT – Training and Technical Assistance Centre is reported to have carried out some CA equipment demonstrations. Further details can be found in Nhancale (no date).

4. CONCLUSIONS AND IMPLICATIONS

Various types of conservation agriculture are being promoted and researched in Mozambique by a wide range of development agencies, research organizations, private sector companies and educational institutions. Manual CA systems predominate, though pockets of animal based CA promotion exist in areas where cattle populations are large. Some of these CA systems rely on herbicides and synthetic fertilizers while others emphasize compost production and leguminous cover crops for soil fertility improvement and weed control. For some projects reduced tillage is essential while in other areas this core feature of CA has received less attention because of challenges with basins in sandy soils.

In agro-ecological zone R2 along the southern coast CA is promoted for irrigated horticulture

crops where mulching helps control weeds and reduce the frequency of irrigation needed. It is also promoted for rainfed crops but adoption of permanent basins is low because of labor requirements and because they collapse in the sandy soil. Research on CA in the more arid interior of the south (zone R3) has focused on how mulch and basins could improve rainfed crop yields by increasing water availability but the evidence is not conclusive.

The majority of the research on CA and many of the largest projects have been in Manica and Sofala provinces especially in agro-ecological zone R4 where maize is the most important staple food. Much of the research combines CA with fertilizer and herbicides while many of the NGOs promote CA without these commercial inputs, both emphasizing higher maize yields. In R5 with sandy soils and a climate more prone to droughts and floods there has been more emphasis on the benefits of cover crops and mulch with some organizations focusing on cassava. Little information is available about any CA work in the Zambezi valley of Tete province though some research and promotion has been documented in the Angonia highlands with many similarities to the work in Manica.

In northern Mozambique CA is being promoted by a variety of NGOs but less research has been carried out there. Along the coast (R8) of Nampula CA is being promoted primarily with cassava emphasizing mulching and intercropping with legumes. In Cabo Delgado minimum tillage is emphasized and combined with mulching with grasses and leguminous cover crops. In the interior (R7) there are reports of yield increases with CA despite a lack of commercial inputs. Cotton companies in this zone are becoming more interested in CA as a means of increasing farmers' cotton yields.

Overall, there is a great deal of practical experience within Mozambique on how to research the impact of CA, how to train farmers on CA, and how to adapt the technologies to each context. Many mistakes can be avoided by learning from the experience of others. Unfortunately much of this experience is not easy to tap into. This inventory aims to facilitate networking among organizations involved in CA. It also aims to be a resource for those wishing to research the performance of CA in each agro-ecological zone of Mozambique by documenting the experiences on the ground. By finding out what is working on the ground and learning from mistakes and challenges development agencies can better serve smallholder farmers.

Appendix 1 - Registry of organizations involved in conservation agriculture in Mozambique

Name of organization	Type of org.	Name of contact	Website	Districts where they work (by province)	# of farmers	Years
Abiodes	NGO	Emidio Matlombe	http://www.abiodes.org.mz/	**Maputo:** Marracuene - Bobole	<99	10
ActionAid	NGO	Mauricio Matsinhe	http://www.actionaid.org.uk/665/mozambique.html	**Maputo:** Manhica and Marracuene	-	5
Adventist Development and Relief Agency	NGO	Florencio Maquina	http://www.adramozambique.org/	**Zambezia:** Ile, Mocuba, Maganja da Costa, Lugela, Pebane	100-500	5
Aga Khan Development Network	NGO	Jose Dambiro	http://www.akdn.org/mozambique	**Cabo Delgado**: Ibo, Macomia, Meluco, Metuge e Quissanga	100-4999	4
AGRODEC/CeFAT – Training and Technical Assistance Centre	Educational					
Associação de Jovens e Amigos de Govuro, AJOAGO	NGO			Inhambane		
Associação Nacional de Extensão Rural	NGO		http://apf-mozambique.ning.com/group/aena-associacao-nacional-de-extensao-rural	Nampula		
CARE	NGO	Nicholas Dexter	http://www.care.org/careswork/countryprofiles/79.asp	**Nampula**: Meconta, Angoche and Moma; **Zambezia**: Pebane; **Inhambane**: Inhassoro, Vilanculos and Govuro	5000-9999	11
CARE/WWF	NGO	Dan Mullins	http://wwf.panda.org/what_we_do/how_we_work/policy/development_poverty/macro_economics/what_we_do/programs/wwf_care_alliance_/	Cabo Delgado		

Name of organization	Type of org.	Name of contact	Website	Districts where they work (by province)	# of farmers	Years
CARITAS	NGO	Lino Agostinho Miguel	http://www.caritas.org/worldmap/africa/mozambique.html	Sofala	-	-
Christian Reformed World Relief Committee	NGO	Istifanus Gimba	http://www.crcna.org/pages/crwrc_samt_mozambique.cfm	**Tete:** Angonia, Tsangano, Mutarara; **Niassa:** Lichinga, Mecanhelas, Massumba, Nasnehenge	1000-4999	8
CIAT	Research	Nelson Mango	http://www.ciat.cgiar.org	**Zambezia:** Mopeia; **Manica:** Manica, Sussundenga, Barue, Gondola; **Sofala:** Gorongosa, Buzi, Nhamatanda	1000-4999	7
CIMMYT	Research	Christian Thierfelder	http://blog.cimmyt.org/?tag=mozambique	**Tete:** Angonia and Tsangano; **Manica:** Gondola, Manica, Sussundenga and Barue; **Sofala:** Buzi, Nhamatanda and Gorongosa	1000-4999	8
Cleanstar Mozambique	Private	Bill Rustrick	http://www.cleanstarmozambique.com/	**Sofala**: Dondo, Savane	100-500	3
CLUSA	NGO	Carlos Sanchez	http://www.ncba.coop/ncba-clusa/home	**Nampula:** Memba, Meconta, Monapo, Murrupula, Moma, Mogovolas, Mogincual, Musurril, Angoche, Nacala porto, I. Mocambique, Erati, Nacala velha e Nacaroa.	>10,000	4
Comité Ecuménico para o Desenvolvimento Social, CEDES	NGO		http://www.actallianceorg/about/actmembers/comite-ecumenico-para-o-desenvolvimento-social	Inhambane		
Direcção. Nacional de Extensão Agrária	Gov't	Inacio Nhancale	http://www.portaldogoverno.gov.mz	**Todas provincias**	1000-4999	12
Empresa de Comercialização Agrícola	Private	Grant Taylor Moses Muchayaya	http://www.agdevco.com/portfolio.php?projectId=5	**Manica:** Barue, Catandica	~1000	1
FAO	UN	Felicidade Panguene	http://www.fao.org/isfp/country-information/mozambique/en/	**Sofala, Manica, Tete, Nampula, Zambezia, Gaza and Niassa.**	>10,000	10

Name of organization	Type of org.	Name of contact	Website	Districts where they work (by province)	# of farmers	Years
Food for the Hungry	NGO	Alloys Omolo	http://fh.org/work/countries/mozambique	**Cabo Delgado**: Palma, Nangade and Mocimboa da praia	5000-9999	3
Helvetas	NGO		http://www.helvetas.org.mz/	**Cabo Delgado:** Chiure and Ancuabe (2006)		
ICRISAT	Research	Moses Siambi, Justice Nyamangara	http://test1.icrisat.org/aboutus/global_Presence.htm	Gaza		
IFDC	NGO	Alexander Fernando	http://www.ifdc.org/Nations/Mozambique	**Nampula**: Ribaue and Malema; **Manica:** Manica, Sussundenga, Barue and Gondola; **Sofala:** Gorongosa, Nhamatanda, Dondo e Buzi	5000-9999	3
IIAM	Research	Laurinda Nobela	www.iiam.gov.mz	**Manica:** Sussundenga, Manica and Barue; **Inhambane:** Inharime; **Maputo:** Marracuene	1000-4999	15
IIAM	Research	Domingos Dias	www.iiam.gov.mz	**Tete**: Angonia; **Manica**: Sussundenga e Manica; **Sofala**: Gorongosa	100-500	2
IIAM/CZCENTRO	Research	Elina Ernesto Langa	www.iiam.gov.mz	**Tete:** Angonia, Moatize, Tsangano, Macanga; **Zambezia:** Mopeia and Murrumbala; **Manica:** Manica, Barue, Vanduzi, Gondola and Sussundenga; **Sofala:** Gorongosa, Buzi, Nhamatanda, Chibabava	>10,000	7
IIAM-Centro Zonal Centro	Research	Ricardo Maria	www.iiam.gov.mz	**Gaza**: Chibuto; **Manica**: Barue	<99	1
IIAM-Centro Zonal Sul	Research	Manuel Sitoe	www.iiam.gov.mz	**Inhambane**: Funhalouro and Mabote; **Gaza**: chicualacuala, Guija, Mabalane, Bilene e Chockwe, Massingir, Massangena; **Maputo**: Magude	100-500	7
IITA	Research	Steve Boahen	http://www.iita.org/iita-mozambique	**Nampula:** Malema, Rapale, Meconta and Nampula; **Tete:** Angonia, Macanga, Tsangano; **Zambezia:** Gurue; **Manica:** Sussundenga, Gondola, Vanduzi	>10,000	5
Instituto Agricola Bilibiza	Educational			Cabo Delgado		

Name of organization	Type of org.	Name of contact	Website	Districts where they work (by province)	# of farmers	Years
Instituto do Algodão de Moçambique	Research	Judite Massengele	http://www.iam.gov.mz/	**Nampula** : Meconta, Monapo e Mecuburi	<99	1
Instituto Nacional de Gestão das Calamidades	Gov't	Marcelino Sisenando	http://www.portaldogoverno.gov.mz	**Tete**: Changara; **Manica:** Matchazi; **Inhambane:** Mabote and Funhalouro; **Gaza:** Chigubo and Massangena	500-999	5
Instituto Superior Politecnico de Manica	Educational	Rafael Massinga	http://www.ispm.ac.mz/	Manica		
International Relief and Development	NGO	Steve McSween	http://www.ird.org/en/our-work/programs/scip-program-in-southern-mozambique	**Inhambane**: Massinga, Funhalouro and Panda	1000-4999	3
Kulima	NGO		http://www.kulima.org	Cabo Delgado		
Mennonite Central Committee	NGO		http://www.mcc.org/category/taxonomycountriesxml/mozambique			
Plexus	Private	Brian Archibald	http://www.plexus-cotton.com/Operations/Mozambique	Cabo Delgado and Nampula	-	0
SANAM	Private	Pedro Viriato	http://www.exportersindia.com/company/413422/	Nampula		
Save the Children	NGO	Wales Magumbi	http://www.savethechildren.org/site/c.8rKLIXMGIpI4E/b.6150457/k.2A7C/Mozambique.htm	**Nampula:** Nacala Porto, Ilha de Mocambique, Mossuril, Meconta, Mogincual, Angoche, Moma, Mogovolas and Murrupula	>10,000	4
Total Land Care	NGO	Jose Luis Antonio Munguambe		**Tete:** Angonia, Tsangano, Macanga	-	5
UNDP	UN		http://www.undp.org.mz/			

Name of organization	Type of org.	Name of contact	Website	Districts where they work (by province)	# of farmers	Years
União Nacional de Camponeses de Moçambique	NGO	Inacio Maria Manuel	http://www.unac.org.mz/	**Niassa** : Cuamba, Mecanhelas, Marupa, Lichinga, Sanga, Lago e Madjune; **Cabo Delgado** : Pemba-Metuge, Mecufi; **Tete**: Mutarara, Changara; **Zambézia**: Morrumbala e Namacurra; **Manica**: Manica, Sussundenga; **Sofala**: Gorongosa	100-500	6
Universidade de Eduardo Mondlane	Educational and Research	Sebastiao Inacio Famba	http://www.uem.mz/	**Manica:** Sussundenga	<99	5
University of Tennessee/SANREM-CRSP	Research	Neal Eash and Forbes Walker	http://www.oired.vt.edu/sanremcrsp/	Sofala; Manica and Tete (with CIMMYT)	100-500	10
Verde Azul	Private	Abdala Mussa	http://www.verdeazul.co.mz/	**Cabo Delgado**: Chiure	-	2
World Vision	NGO	Richard Kondowe	http://www.worldvision.org/our-work/international-work/mozambique	**Zambezia**: Morrumbala, Mopeia, Nicoadala, Namacurra, Gile, Namarroi, Alto Molocue, Gurue and Namarroi	1000-4999	2

Appendix 2: Details on the agro-ecological zones (Amane and Mlay, 2002)

Summary of the Principal Characteristics of the Agro-Ecological Zones of Mozambique

Zone	Area (km^2)	Population	Density (Pop/km^2)	Altitude (m)	Precipitation (mm)	Humidity Index	Predominant Soils
1	19 855	209 489	10	100-500	400-800	Semi-arid dry, with patches of semi-arid humid, in the Libombos highlands.	Arenosols e Nitosols
2	69 301	1 714 557	24	0-200	800-1000	Semi-arid humid, with some patches of sub-humid, on the coast.	Arenosols, Fluvisols and Manangas
3	75 460	377 892	5	100-200	400-800	Semi-arid and arid	Manangas and Arenosols
4	64 049	876 151	13	200-1000	1000-1200	Sub-humid, with semi-arid humid areas	Ferralsols an d Luvisols
5	73 517	1 640 937	22	0-200	1000-1400	Semi-arid humid, with humid areas	Fluvisols and Arenosols
6	69 495	649 985	9	200-600	400-600	Semi-arid dry	Lixisols and Fluvisols
7	234 236	2 746 120	11	200-1000	1000-1200	Semi-arid humid, with sub-humid areas	Ferralsols, Luvisols and Acrisols
8	87 556	2 637 004	30	0-200	800-1200	Semi-arid humid, with sub-humid patches and one reasonably large patch of semi-arid dry.	Lixisols, Leptosols and Arenosols
9	14 150	98 654	7	800-1000	1000-1200	Semi-arid humid	Nitosols
10	65 414	1 218 235	18	1000-1700	1200-2400	Sub-humid e humid	Ferralsols e Leptosols

Arid: < 500 mm de precipitation
Semi-arid dry: 500 - 800 mm de precipitation
Semi-arid humid: 800 - 1 000 mm de precipitation
Sub-humid: 1 000 - 1 400 mm de precipitation
Humid: > 1 400 mm de precipitation

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