Ecological approaches to ensuring food security: A learning platform for understanding and advancing Conservation Agriculture in Africa and Asia

IDRC Project Number: 107467-00020999-021

Name of Research Institution: University of Manitoba**:** Department of Plant Science, 222 Agriculture Building, University of Manitoba, Winnipeg, MB R3T 2N2

Prepared by: Martin Entz

Coauthors: Anne Kirk and Alden Braul

Report Type: Final Report

Date: Sept 13, 2016

Location of Study: Zimbabwe, Malawi, Bangladesh, Canada

Members of Research Team and Involvement:
Dr. Martin Entz, University of Manitoba: Project Leader and involved in all aspects of project
Saidi Mkomwa, African Conservation Tillage Network: Participate in learning platform
Mike Salomons, Canadian Foodgrains Bank: Graduate student involved in field trials and surveys
Ralph Martin, University of Guelph: Participate in learning platform and advocacy for Agroecology
Laura Sims, Université de Saint-Boniface: Involved in survey analysis and design of learning platform
Isaiah Nyagumbo, CIMMYT: Advisor in field research
Rashid Islam, Bangladesh Agricultural University: Lead field trials in Bangladesh

Contact Information of Project Lead
Phone: 204-474-6077
Email: M.Entz@umanitoba.ca

Executive Summary

Conservation agriculture, often known as "CA", is a farming system that seeks to reduce soil disturbance with tillage; provide permanent soil cover; and emphasizes crop diversity. Conservation agriculture has been promoted by many NGO's and governments in Southern Africa, including the Canadian Foodgrains Bank. Criticisms of CA as it has been promoted include the emphasis on maize monoculture and reliance on expensive external inputs. The feasibility of using plant material for soil cover (mulch) has also been questioned. The CA interventions offered by the Canadian Foodgrains Bank and their partners were aimed at resource-poor, small-holder farmers who have been relying on food aid. Their programming recognized that farmers cannot afford external inputs and so the approach was to maximize efficiency of local inputs. A pilot project from 2006 to 2011 showed an 80% adoption rate of CA in areas where it had been promoted, with a 24 to 72% increase in maize yields (Woodring and Braul, 2011).

Despite this success, technical staff from the Canadian Foodgrains Bank approached various research institutions, including the University of Manitoba, with questions about how CA could be improved. In particular, Foodgrains Bank technical staff were concerned with the lack of plant diversity in CA programs. Second, if CA was to be scaled up, sources of soil cover other than local plant residues and brush would be needed. Martin Entz, the principle investigator here, conducted a study tour in 2012 to better understand the limitations of CA and possibilities for introducing other agroecological methods into the CA system. Thereafter, Entz proceeded to lead this 24 month IDRC grant.

The first of 5 major objectives of this IDRC-funded project was to better understand limitations for scaling up CA among small-holder farmers in Zimbabwe. Face-to-face discussions and focus groups provided ample evidence of the success of CA implemented on small areas of farms. However, the problem of mulch (ie, soil cover) limitation was identified. A larger survey of 60 farmers showed that when farmers expand their CA fields to include larger portions of their farms, the level of herbicide and fertilizer inputs increases. This left us with the question of how to scale up CA with less reliance on expensive crop inputs.

One option was to include legumes as soil covering crops and grow these legumes together with maize crops. In this way, farmers would simply plant seeds for soil cover instead of moving large volumes of plant material from elsewhere. A source of farmer knowledge about legumes came from a Farmer-to-Farmer agroecology project in northern Malawi, where farmers had been testing a wide range of legume species as well as legume cropping systems in their maize-dominated systems. An assessment of the Malawi project was conducted not only by University of Manitoba staff, but also by Zimbabwe farmers who visited the Malawi project. Malawi farmers then visited CA sites in Zimbabwe. The information gathering exchanges provided the opportunity to synthesize a new CA approach.

Field experiments were then conducted to evaluate the performance of several legume species in the small-holder CA systems in Zimbabwe. A total of 12 replicated field studies were conducted over 2 growing seasons with the legume species cowpea, pigeon pea and lablab grown with maize. Detailed measurements on legume and maize growth, development, seed yield, etc were collected by locally hired technicians and with support from the local government extension service. Results showed that adding legumes to the CA systems increased total food production and never reduced maize yield. On the question of whether the presence of the legume could substitute for the plant-based mulch, we observed similar performance in 50% of cases, while in the other 50% of cases, maize with mulch alone

yielded more seed than maize intercropped with legume in the absence of mulch. Further work is proposed on our dataset to better understand how the growth dynamics of legumes may be changed to provide more consistent soil cover.

One goal of this project was to develop learning platforms to allow more agroecological thinking and practice to be used by CA farmers, and indeed, extension workers. This objective was achieved in three ways. The first was an agroecology curriculum aimed at semi-literate farmers. This comprehensive curriculum document was developed in collaboration with local farmers and colleagues at Cornell University and Michigan State University. The second learning platform was the field experiment. During the 2nd season of the field experiments, we decided to involve farmers directly in conducting the research under the supervision of a facilitator. This approach created a deeper understanding of how to conduct innovation. The final step in the learning platform involves 1) revising the farmer agroecology curriculum for university level students – where the principles behind agroecological practices are emphasized – and 2) preparing an on-line "Executive Agroecology course" aimed at policy makers, business leaders and political leaders.

The learning platform approach to farmer innovation has also been presented to NGO's. One suggestion is that "Monitoring and Evaluation" be conducted as part of the farmer and facilitator data gathering process, thereby increasing the financial efficiency and transparency of projects.

The success of this 24 month project was due to the excellent collaboration of the research team, the enthusiasm and excellent management skills of farmers and technicians involved, and linkages to other institutions involved in curriculum development. The work is not over. This IDRC funded project has greatly improved our knowledge of what is possible, and has provided us with ideas for develop and further farmer and university-led innovation in agroecology for food security.

The Research Problem

This project seeks to better understand the various components of the CA system as it is practiced on small holder farms in southern Africa and Bangladesh with five key objectives.

Objective 1: Survey farmers to better understand the socio- economic spin off from CA.

Objective 2: Better understand the social and biophysical dynamics of soil-covering plant mulch in CA systems, and farmer practices to "scale up" CA.

Objective 3: Learn how legume intercrops can be incorporated into a maize-based CA system.

Objective 4: Construct learning platforms focused on agroecological approaches to food security, climate resilience, and environmental sustainability. This will include a curriculum for farmers, college and university students, and policy makers and business leaders.

Objective 5: Offer ideas to policy makers, NGO's and government extension services for encouraging and embracing agroecological approaches to food security.

Background to Research Problem

The benefits of conservation agriculture are well-documented in Canada. Increased soil carbon, improved water infiltration and storage have also been documented for a range of CA systems in Zimbabwe (Thierfelder et al., 2015) and Malawi (Thierfelder et al., 2013). A survey of small-holder farmers in Zimbabwe found that small-scale hoe-based CA increased maize yields by 100 to 400% (Woodring and Braul 2011). Social-economic benefits of CA are thought to be particularly important for women (Woodring and Braul, 2011; Blank 2013).

Eliminating tillage improves soil in CA systems, but it is the soil covering plant mulch that plays the critical role of reducing soil water evaporation and adding carbon to increase soil organic matter. The value of soil covering mulch is increasingly recognized by farmers. Some farmers store mulch away from animal predation, and sell or barter for mulch (Bunch 2013, pers. comm.). Others fence their CA fields in order to keep grazing animals away. Blank (2013, pers. comm.) recently observed that village elders in Zimbabwe allocated mulch preferentially to widows to ensure their food security. The role of plant mulch in ecological CA systems is also recognized in Canada for water conservation (Vaisman et al., 2011).

Mulch supply also presents challenges. After maize harvest in communal areas in Zimbabwe livestock roam free to search for food. Unless fields are well fenced residue from the previous crop will be consumed by livestock. Collecting fencing supplies and removing crop residue from the field after harvest present challenges. If the amount of plant material from the previous crop is not enough to conserve water in the following crop, collecting additional biomass may be a challenge and could be socially unacceptable due to the demands of livestock during the dry season. In addition to livestock feeding mulch is also used as building material and fuel; therefore, the farmer must optimize allocation of plant material between water conservation, livestock, and household uses. For these reasons, researchers and farmers are testing "in situ" mulch production using novel intercrop strategies. Intercrops of interest are drought tolerant seed-bearing legumes that provide both soil cover throughout the growing season and after main crop harvest, as well as seed for food. New ideas and approaches to mulch production are key to expanding areas under CA on individual farms (Blank 2013, pers. comm.).

A second challenge to CA regards nutrients. Working on 450 farms in Zimbabwe, Nyamangara et al. (2013) concluded that without fertilizer, CA is not worth promoting. This conclusion is deeply disturbing and indeed vexing, given that fertilizer is used on less than 10% of farms in southern Africa. Do we give up on the idea of CA for smallholder farmers unless they have fertilizer? The main alternative to fertilizer is animal manure, which is highly effective in small holder African CA systems (Blank 2013) and has been promoted by NGO's and extension workers (e.g., African Conservation Tillage Network). Another hopeful and perhaps more available option for N supplementation are N assimilating plants (legumes). Legume intercropping also addresses one of CA's most important weaknesses, insufficient plant diversity. Using legume plants in CA builds on African and Asian intercropping practices, thereby embracing traditional knowledge. In northern temperate regions, legume cover crops are grown exclusively for N and weed suppression; however, in Asia and Africa, legumes must also provide seeds for humans or animals.

Researchers and farmers are addressing the dual problems of lack of mulch and lack of N fertilizer by introducing legumes plants into CA, though this work is in its infancy. Thierfelder et al. (2013) tested pigeon pea as an intercrop in CA maize production and concluded that this resulted in extra high protein food. Bunch (2013, pers. comm.) is actively working with farmers who are trying various legume intercrops including pigeon pea, lablab, and tephrosia. Besner-Kerr (2013) is using a community-based approach to understanding the role of intercrops for food security in Malawi. This project links the Malawi intercropping with promising CA work in Zimbabwe (Woodring and Braul, 2011).

Agroecological methods for food security often do not receive the attention they deserve by teachers and extension workers; emphasis remains mostly on green revolution technologies despite rapid developments in ecological farming through initiatives like CA (Woodring and Braul, 2011) and others (Pretty 2008). Communicating ecological approaches to food security is therefore critical for properly informing policy makers, extension workers, students, and the general public about the full range of options for food security and rural community development. Information technology such as radio, cell phones, and the internet allows this to be a truly global conversation among farmers. Policy makers also need to understand the role that agroecological methods can play in increasing food security and contributing to greater environmental sustainability. In this way, we need to articulate alternative paradigms for policy makers.

Encouraging and teaching farmers sustainable agricultural systems is a process that Canadian (and other) governments and myriad NGOs have been engaged in for decades. The way farmers are engaged in new practices varied greatly. "There are many examples of poor CA roll outs" (Bridgit Bwalya, Zambian PhD student speaking at the Contested Agronomy Conference, University of Sussex, March 2016). Extension and development work that provides useful solutions *and* increases capacity of rural households, and indeed local extension agencies, are needed. Dominic Glover, Sussex Development Institute, argues that "Innovation should take place on the farmers' fields. While the green revolution has deskilled farmers, agricultural innovation can take place only if development programs are "skill intensive". Increased skills on the farm will empower farmers." (pers. comm.). From a development agency perspective, the process of monitoring and evaluation can often consume a large portion of the development budget. Can development be done better? Can the innovation happening in the community also serve as the evaluation criteria, saving money?

I became involved in research to improve small-holder production systems several years ago with conservation projects in Central America and eastern Africa. Conservation agriculture (CA) has been promoted as a response to declining crop productivity, soil quality loss and water shortages brought on by a shorter rainy season. I have witnessed the adoption and effectiveness of CA in many different contexts. In small-holder agricultural systems, CA is practiced at scales ranging from "garden plots" (less than ¼ ha) to areas of several hectares. The garden plot scale of CA has been particularly important in short-term food security and has been promoted by NGO's and government extension services.

I also understand the criticisms of CA that have been articulated by social and natural scientists and even NGOs. While I embrace the idea that "CA is not a completely new way of agriculture as it only tries to replace the unsustainable parts of current systems" (Wall, 2007), CA has often been promoted badly. The first concern regards extension efforts that have emphasized CA as monoculture while traditional systems for many small-holders involved polyculture with two or more crops grown together. Conservation agriculture is in danger of failing if it does not embrace the basics of traditional farmer practice. A second concern regarding the long-term sustainability of small-holder CA is availability of soil-covering mulch. Plant biomass for mulch is sometimes in short supply in semi-arid ecozones and there is the ever-present competition from livestock: to mulch or to munch (Daniel Rodriguez, pers. comm.)?

The overarching theme in this project is to embrace and promote agroecological systems in small-holder agricultural production with CA as a starting point. In other words, we have decided to work in communities where small-scale CA has worked, and has made a positive difference in people's lives. The present project seeks to understand the dynamics of these adopted systems with a view to describing constraints and opportunities. Second, this project is testing legume-maize intercrops under CA. The need to evaluate multi-crop approaches in CA was made apparent on a study trip in 2013 – where women were happy to have groundnut and cowpea volunteer plants growing in their maize CA systems. These are the encounters and experiences which motivated the present project.

My 25 years of ecological agriculture work in Canada has increasingly used a farmer participatory approach. I have recognized that integrated approaches to production (eg., greater reliance on natural nutrient cycles, integrated pest management, livestock integration) requires greater knowledge among farmers, and indeed extension workers. My team presently operates 1) a Farmer participatory plant breeding program, the first in Canada; 2) a cropping system co-design program, where farmers become the innovators in partnership with our institute; and 3) and learning platforms where farmers are pulled together to share ecological knowledge, experiences and failures. This approach has increased the skill set of Canadian farmers and has increased on-farm innovation. Can the lessons of on-farm innovation in "marginalized" communities work for small-holder farmers as well?

Since starting the IDRC funded project, my understanding of agroecological approaches in small-holder production has grown and I have been fortunate to make many new contacts and indeed new collaborations that benefit the IDRC-funded work. For example, we are now collaborating with a project in northern Malawi where legume introduction (or re-introduction after a generation of neglect) has been conducted for over 15 years.

Progress towards milestones

A schematic diagram outlining major components of the project is shown in Figure 1. Each box represents an important piece of the project. The progress towards achieving success in each component is described below.

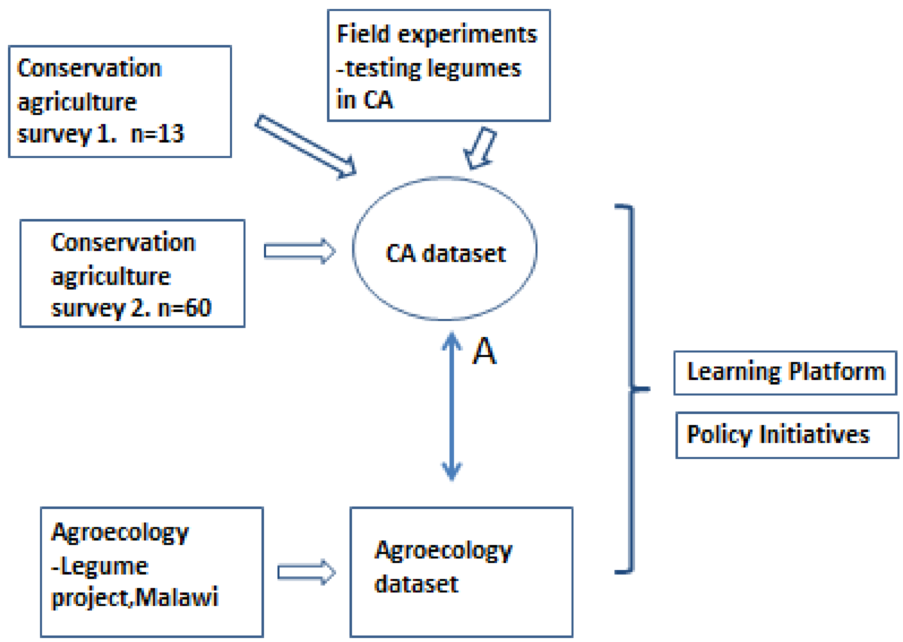


Figure 1. Project schematic showing major components and connections. “A” refers to the comparative analysis of CA vs Agroecology development programs.

Milestone 1. Surveys

Two surveys were included in the project; both aimed at understanding the social and biophysical benefits of conservation agriculture and identifying constraints to conservation agriculture adoption as it has been taught to farmers in Zimbabwe. The first survey was conducted exclusively by our team (Anne Kirk – 13 households) while the second was conducted in collaboration with the Canadian Foodgrains Bank (60 households). The second survey also included input from several other African countries where CA programs had been active.

Milestone 2. Comparison of Agroecology with Conservation Agriculture

We studied two different development interventions; the Malawian Farmer-to-farmer agroecology program based in Ekwendeni, near Mzuzu, Malawi, and the Conservation Agriculture program in Zimbabwe that had been supported by the Canadian Foodgrains Bank and its partners. The two approaches were compared on the basis of productivity, sustainability, resilience, and gender equality outcomes. We also sought to combine the best of both programs into our field research projects in Zimbabwe.

Milestone 3. Field experiments

Field experiments were conducted in Zimbabwe and Bangladesh during two growing seasons. Zimbabwe field studies were managed and executed under the direct supervision of the University of Manitoba team, with assistance of Zimbabwe-based technicians hired through the project. The field studies in Bangladesh were conceptualized and carried out by Rashid Islam, Bangladesh Agricultural University.

Milestone 4. Conservation agriculture dataset

We collected detailed measurements of maize and legume growth, mulch, soil parameters and yields from the field sites included in the Zimbabwe studies. This dataset will be available for future research. The dataset from Bangladesh field experiments is housed in a MSc thesis available from Bangladesh Agricultural University.

Milestone 5. Developing the Learning Platform

There are 3 main aspects of this work. The first is a farmer-friendly learning platform for agroecology. This involved developing a curriculum for use by semi-literate farmers. The curriculum, entitled "Farming for Change" is complete and was field tested in 2016 (See appendix 2). The second initiative involved using on-farm innovation in Zimbabwe. This goal was perhaps one of the most exciting in the project, resulting in true farmer empowerment. We engaged farmers directly in the research and education program with sites located on their farms. We called these "field learning platforms". The third goal related to learning platforms involves a university level version of the agroecology curriculum described above, and an Executive version of the "Agroecology for Food Security" course for policy makers, business leaders and political leaders.

Milestone 6. Policy Initiatives

This was accomplished by influencing policy initiatives and participating in writing policy briefs by our partners and others interested in considering Agroecological approaches to food security. Examples include working with one of our partners, the Canadian Foodgrains Bank, to write a policy brief entitled "Agriculture for Clean and Inclusive Economic Growth"; presentation at Food Secure Canada conference in 2016; and interaction with the Canadian Food Secure Policy group. We will also offer on on-line Executive course entitled "Agroecology for Food Security".

Synthesis of research results and development outcomes

Objective 1. Farm surveys

Survey 1. Detailed interviews of Zimbabwe farmers who adopted mulch-based conservation agriculture

Interviews and focus group discussions with farmers were used to measure the impact of CA adoption on improving livelihoods and to gather information on the use of mulch and legumes in CA systems. In the first year of the project 13 interviews and three focus groups were conducted.

Of the 13 farmers interviewed, 5 farmers had been practicing CA for 1-4 years, 6 for 5-10 years, and two for more than 10 years. Most of the farmers learned CA from an organization promoting CA, and one farmer learned CA from neighbours. Twelve of the 13 farmers were farming land both conventionally and using CA methods. Land area averaged 0.6 and 3.76 hectares under CA and conventional farming practices, respectively. This trend where only a small area on each farm is managed with CA, while the remainder of the farm is farmed conventionally, is a common occurrence on many small holder farms (Chris Woodring, pers. comm.). When asked why they only practice CA on a small portion of their farms, the response was that this was the maximum amount of mulch that they could manage. Therefore, CA expansion on these farms appeared to be limited by mulch – either availability of enough mulch, or labour constraints in moving the mulch. The concept of shallow planting stations used in CA is shown in Figure 2.

Figure 2. Plant station approach used in Conservation Agriculture. Plots on upper left have had mulch applied.

Crops grown in CA plots, in order of most to least common, include maize, cowpea, groundnut, sorghum, millet, sugar bean, and sweet potato. In general, a greater diversity of crops was found in conventional plots. This important observation confirms that CA adoption tended to be with maize monoculture. Some farmers interviewed didn't know that crops other than maize could be planted using CA methods, and others said that they focus on maize in their CA crops because it is a staple and they can expect higher yields in CA compared to conventional. When farmers learned that crops other than maize can be grown using CA methods, these farmers expressed interest in growing a wider diversity of crops in their CA plots. This observation supported our work to test different legumes within CA.

The main benefit of practicing CA was identified as higher yields. Increased yields were attributed to improved soil fertility due to concentrating manure in the planting station and by mulching to conserve water by 46 and 62% of respondents, respectively. A secondary benefit of CA was identified as less labour. Due to higher yields in their CA plots farmers are able to farm less land and are therefore required to maintain a smaller area.

When asked about the disadvantages of CA, 38% of the farmers said that there are none. Digging basins and collecting mulch were most commonly identified as disadvantages, while one farmer said that there are more weeds in CA, and another identified finding fencing supplies to keep animals away from the CA plots as a problem. Only 38% of farmers said that they have problems finding enough mulch, while 31% of farmers identify the time required to collect mulch as the main barrier to mulching.

Improved soil fertility due to concentrated manure in the planting station was identified as a benefit of CA. Forty-six percent of farmers apply manure only, while 54% apply both manure and chemical fertilizer. The majority of farmers said that they apply manure and chemical fertilizer to the CA plots first, and to the conventional plots only if they have enough. This indicates that farmers know that yield potential, and return on fertilizer and manure investment, is greater in CA fields compared with adjoining conventionally-managed fields.

The majority of the farmers interviewed do not intercrop on their farms. But it was interesting that 31% of farmers intercrop in their CA plots compared with only 15% in their conventional plots. Unfortunately we did not ask about intercropping trends over time. However, in casual conversation in the focus group discussions, it appeared that interest in intercropping in CA fields had been growing over time.

CA adoption has improved livelihoods of all farmers interviewed. Most of the farmers interviewed (62%) were not able to produce food for the entire year before the adoption of CA. The money earned from selling extra food was most often used to build a house, buy livestock, pay school fees, and buy household items. The adoption of CA also resulted in improved variety in the diets of 23% of the farmers interviewed. Improved status in the community and more harmony in the home were listed as consequences of CA adoption by 15% of farmers interviewed. CA adoption has the potential to benefit entire villages, as 15% of the farmers said that they now have extra food that they can share with relatives and neighbours.

Survey 2. CA adopters: 60 farmers in 6 different countries

A second survey was conducted in May/June of 2015. This survey was led by Canadian Foodgrains Bank staff though we participated in some of the interviews and we are able to use the data. A total of 60 farmer interviews were conducted in 6 countries (Kenya, Tanzania, Uganda, Malawi, Zambia and Zimbabwe). Of particular interest is to compare practices used in small-scale (less than 1 ha) and larger scale CA farming. Questions included "What practices are farmers using when CA is practiced on a larger scale – when it is scaled up?" "How will larger scale CA affect the need for external inputs (eg., animal traction, machines, herbicides and fertilizers) and will gender play a role?" A summary of some of the information is provided in Table 1.

Results from the survey showed that maize yields per unit area of land are similar with and without herbicides (Table 1). However, herbicide use coincided with farmers practicing CA on a much larger landbase (15.2 ha vs 4.5 ha). Therefore, scaling up monoculture CA coincided with herbicide use for weed control. Total food production was greatest on the larger farms, where herbicides, fertilizers and animal traction were used. It was interesting to note that these larger farms produced more than the 1 tonne of maize (the minimum amount to sustain one family for one year, Braul, pers. comm.). Therefore, once CA is practiced on a larger landbase, maize crops could be sold to bring cash into the household.

It was interesting to note that input use was greater among men than women (Table 1). Based on survey results, it appeared that male farmers would end up with more disposable income from farming than women farmers.

Table 1. Summary statistics of survey 2: 60 conservation agriculture farmers from 6 countries.

Summary Statistics (averages)	Average Farm Size	Plot Size	Maize Production (MT per ha)	Maize Production (total MT)
CA farmers using herbicide (37 farmers)	15.2 ha	2.4 ha	4.2	6.5
CA farmers not using herbicide (22 farmers)	4.5 ha	0.5 ha	4.7	1.3
CA farmers using fertilizer (44 farmers)	6.9 ha	1.6 ha	4.6	3.8
CA farmers not using fertilizer (15 farmers)	23.8 ha	2.1 ha	3.8	6.7
Female Farmers (25 farmers)	11.9 ha	1.1 ha	4.5 tons	2.0 tons
Male Farmers (33 farmers)	10.7 ha	2.1 ha	4.3 tons	6.4 tons
Female farmers using herbicide:	36%			
Male farmers using herbicide:	82%			
CA farmers using tractor or animal drawn machinery (n=21)	14.3 ha	2.8 ha	3.8 tons	7.0 tons
CA farmers using hand tools (n=38)	9.5 ha	1.0 ha	4.7 tons	3.2 tons
Tractor or animal machinery also using herbicide	76%			
Hand tools using herbicide	55%			

Objective 2. Agroecology vs Conservation Agriculture

The Farmer-to-Farmer Agroecology program based in northern Malawi was compared and contrasted with the Conservation Agriculture development program in Zimbabwe. The motivation for this comparison was to develop a new synthesis, where positive elements from each program could be combined into a new approach. The second objective was to better understand the learning approaches used in the two projects (Table 2).

One important highlight of the Malawi program was the emphasis on legume integration into maize-based cropping. This was a significant strength of the program and was linked to improvements in soil health and positive nutritional outcomes (Besner-Kerr et al. 2007).

One important highlight of the Zimbabwe program was the rapid adoption of CA in the communities where it was introduced. For example, participation levels of 80% within a community were common. That is, 80% of farmers shifted a small area of their landbase to CA (Woodring and Braul, 2011).

Table 2. A summary of the practices, approaches, assessment regimes and outcomes in two food security programs.

Practices in Malawi	**Practices in Zimbabwe**
Legume integration into farming systems	Planting stations
Learn tillage management to optimize legume N	Mulch soil covering
Increase cereal diversity (millet, sorghum, etc)	More efficient use of compost in plant station
Compost making	
Food preparation with drought tolerant crops	
The approach in Malawi	**The approach in Zimbabwe**
Farmer research teams	Training in CA practice
Increase knowledge of broad range of practices	Focus on one practice, CA
Community based	Individuals from same community participating
Gender emphasis deliberate	Gender dynamics “unintended”
Markets for legumes	
Assessment in Malawi (Besner Kerr et al. 2007)	**Assessment in Zimbabwe** (Woodring and Braul, 2011)
Broad range of human health outcomes	Adoption of practice on farms
Nutritional diversity in diet	Yield increases
Gender equality	Household food security
Outcomes in Malawi (Besner Kerr et al. 2007)	**Outcomes in Zimbabwe** (Woodring and Braul, 2011)
Food security increased from 42 to 54% ($P<0.05$)	Maize production increased by 20 to 72%
Severe food insecurity decreased from 42 to 23%	CA adoption rate was 80%
Intervention group grew more tobacco as a cash crop. HH income rose 6%	

The overall approach in Malawi was to increase knowledge of a broader range of issues, which changed the attitude of participating farmers and resulted in improvements in their farming practices. So, to a certain extent, the emphasis in the Malawi project was:

Knowledge →attitude→practice

There were also examples of where the interventions in Malawi started with an improved practice, for example, adoption of pigeon pea or “double-up legumes” (Sieg Snapp, Michigan State University, pers. comm.).

The approach in Zimbabwe was very much focused on the one particular farming practice – that of hoe-based CA. The Canadian Foodgrains Bank sponsored CA projects grew out of the need for immediate increases in food supply and the target households were those that received a significant portion of food through aid. However, while the emphasis was on one particular practice, this did shift farmers’ attitudes. Attitude changes sometimes started with women, who were often the first to adopt CA on small plots around the house. Their skeptical husbands were convinced of CA’s merits once they saw the higher maize yields. Therefore, attitudes towards how to make maize crops more drought tolerant with CA changed with the project. Empowerment of women during the CA program was often observed.

Knowledge of nutrient cycling was increased as farmers experimented with different manures and manure/fertilizer combinations in CA planting stations. By concentrating these resources into a smaller volume of soil, the effects were much greater. A second learning included a better understanding of the role of soil covering mulch to increase resilience of crops during dry periods. Therefore, the Zimbabwe project did also achieve shifts in attitudes and also growth in agroecological knowledge. Except in this case, the process started with a distinct and new practice:

Improved practice→attitude→knowledge

New Synthesis

A new synthesis was achieved through this comparative analysis. The shallow planting station approach to maize production in CA was combined with legume plants grown together with maize (Figure 3). Specific questions asked included: 1) how well do legumes grow in CA systems; 2) what should be the planting arrangement when legumes and maize are grown together in CA?; 3) How well do legumes grow under a mulch system?; and 4) can shading from legumes substitute for mulch as it is presently used in CA systems? These questions were then tested in field experiments over two growing seasons in Zimbabwe.

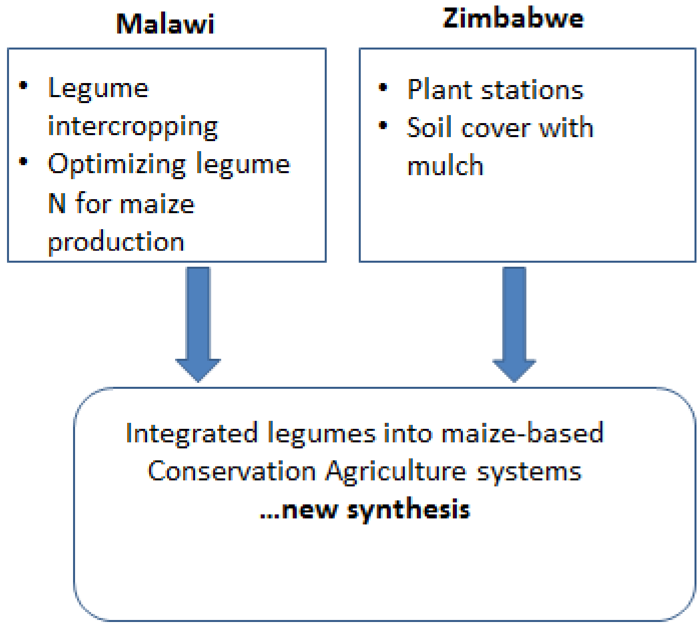


Figure 3. Synthesis of unique features of the CA program in Zimbabwe and the Agroecology program in Malawi.

Objective 3. Field experiments.

<u>Study 1. Legume intercropping in conservation agriculture</u>

Field experiments to test the effect of legume intercropping within a maize-based CA system were conducted over two growing season; 2014/15 and 2015/16. Field experiments were conducted on 4 farms in the Gwanda district in 2014/15, and on 8 farms in the Gwanda, Neshuro and Lupane districts in 2015/16. The replicated field experiments addressed the following questions:

Question 1. How do legumes and maize compare in terms of drought tolerance?

One important observation was that legumes often survived drought conditions when maize did not. For example, during the 2014/15 field studies, 2 of the 4 field sites experienced complete maize failure in both conventional and CA plots (Table 4). On the other hand, legumes continued to grow through the severe drought conditions (Figure 4).

Table 4. Grain yields of maize and legumes from the trials carried out on four farms in 2014/15.

	Farm 1		Farm 2		Farm 3		Farm 4		Mean	
	Maize	Legume	Maize	Legume	Maize	Legume	Maize	Legume	Maize	Legume
					yield (kg ha^{-1})					
Sole maize	2306	NA	1380	NA	-	NA	-	NA	1843	NA
Maize/CP	2130	2882	1435	1563	-	813	-	451	1782	1427
Maize/LL	2389	410	1352	306	-	250	-	90	1870	264
Maize/PP	2667	549	1148	208	-	194	-	278	1907	307

CP – cowpea; LL – lablab; PP – pigeon pea

Figure 4. Pigeon pea (left), lablab (middle), and cowpea (right) intercrops growing between rows of drought-stressed maize in mid-February 2015, approximately 3 months after planting.

In the 2015/16 field experiments, maize failures were also encountered but farmers reseeded maize when seedling died due to drought. Maize was reseeded on 3 of 8 farms; in one case maize was reseeded 3 times. Grain legumes were never reseeded in 2015/16 experiments; once again demonstrating the superior drought tolerance of the legumes.

Including legumes with maize in the same fields did not reduce maize yield for any of the 12 site-years of the experiment. Therefore, not only did legumes add to food production per hectare (Tables 4 and 5), legumes provided this benefit without compromising maize yield. These results clearly demonstrate the positive role of legume intercropping for increased food production under a range of conditions, including severe drought. We hope to continue these field sites in order to investigate the benefit of legumes to the following year's maize crop.

Table 5. Grain yields (kg/ha) of maize and legumes averaged across field experiments on 8 farms in 2015/16.

		Maize	Legume	Total
Mulched	Sole maize	3952	0	3952
	Maize/CP	4030	1694	5724
	Maize/LL	3896	911	4807
	Maize/PP	4183	364	4547
No Mulch	Sole maize	2464	0	2464
	Maize/CP	2931	1419	4350
	Maize/LL	2719	1427	4146
	Maize/PP	2529	307	2836

Question 2. Does legume intercropping benefit maize as much as mulch?

The survey of small-holder farmers practicing hoe-based CA in Zimbabwe showed that labour requirements to procure mulch were sometimes a challenge. Therefore, an important question in the research was "can legumes provide similar levels of soil covering and maize yield enhancement as mulch?" In other words, "will the living plant growth of the legume intercrop have the same positive effect on maize yield as the plant residue mulch sources?"

This question was evaluated by comparing maize yields when grown alone (no intercrop) under a mulch regime with maize grown without a mulch but in the presence of legume intercrops. In 2015/16, maize yield in the no mulch/plus legume plots was similar to or greater than maize yield in the CA monoculture plots 50% of the time, ie., in 4 of 8 sites. In the remaining 4 sites, maize monoculture with mulch yielded more than maize in the no mulch/plus legume plots. Therefore, our hypothesis was proven correct 50% of the time, but rejected 50% of the time. We are presently analyzing the legume and maize growth and development data to better understand the mechanisms behind these observations.

Question 3. What are the growth characteristics of novel legumes when intercropped with maize?

Because little is known about growth and development patterns of legume intercrops in CA systems, detailed information on growth and soil cover characteristics of all 3 legumes was collected in all studies. Particularly important will be to learn about the growth of lablab, a semi-perennial legume that has received relatively little research attention as an intercrop legume (Figure 5). This work is presently ongoing.

Figure 5. Zimbabwe farmers learning how to manage lablab when intercropped with maize.

Question 4. *How do legume plants respond to mulch relative to maize?*

At many of the sites, the relative yield response to mulch varied with legume species, though any differences were quite small. Cowpea and pigeon pea grain yield was greater when grown under the mulch, while lablab yield was lower in the mulch (Table 5). Analysis of legume growth pattern from these field experiments will be used to help explain and understand these differences. It is important to recognize that the legume data is from legumes that are intercropped with maize, and not legumes growing alone.

Question 5. *How quickly does mulch decompose?*

The effort to bring mulch to the CA plot will be most beneficial if the mulch lasts for the entire growing season – and perhaps beyond. Mulch decomposition rates have been calculated for the 2014/15 study sites (Figure 6). A significant amount of mulch decomposition occurred between the January and February field visits at all three farms, with farm 1 losing 64% of the mulch biomass during this time period, and farms 2 and 4 losing 55 and 37%, respectively. Mulch decomposition was also high between the April and May field visits with farm 1 losing 22% of the mulch biomass during this time period, and farms 2 and 4 losing 42 and 47%, respectively. Throughout the growing season 79-85% of the mulch applied to the plots decomposed (Figure 6). Results for the 2015/16 season were similar (data still being analyzed).

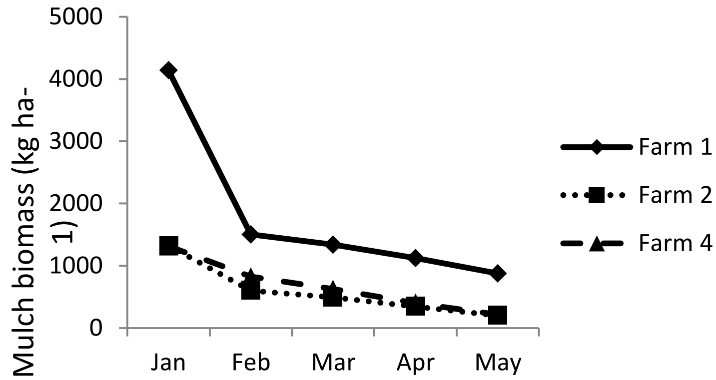


Figure 6. Mulch biomass at farm 1, 2, and 4 monthly throughout the sampling period in 2014/15.

When mulch is "lost", it actually enters the soil as organic matter. Over time, these mulch carbon additions will increase overall soil production capacity. However, a goal of 3000 kg/ha of mulch on the soil surface through to the end of harvest, ie., March, would be best. Future analysis will compare mulch biomass levels with legume cover crop biomass. It may be that modest amounts of mulch in combination with legumes, which produce soil covering during the time that mulch is decomposing, may provide season long soil cover.

Study 2. Evaluation of mulch cover in vegetable production in Bangladesh

Field experiments were conducted by Dr. Rashid Islam of Bangladesh Agricultural University. Experiments were conducted in the farmer's fields (Sutiakhali, Mymensingh Sadar, Bangladesh) to evaluate the efficacy of different mulches viz. water hyacinth, straw, plastic and saw dust on soil physiochemical and biological properties in relation to the natural incidence and severity of major potato, eggplant and tomato diseases (Figure 7). The inclusion of plastic mulch was of particular interest since plastic mulches are becoming increasingly popular in dryland areas (eg. NW China), yet the use of plastic soil covering brings with it new problems such as soil solarization (killing of soil organisms) due to temperature spikes and pollution of the environment.

Figure 7. Application mulches in the experimental plots of tomato in Bangladesh.

The crops were exposed to natural infection under field condition. Late blight caused by *Phytophthora infestans* infection was identified in the experimental plots of potato. The results revealed a minimum late blight incidence and severity in the plots received mulch with water hyacinth followed by saw dust, straw and plastic while the maximum late blight incidence and severity were recorded in the control plots (no mulch) (Figure 8). However, in tomato the lowest late blight incidence was recorded in plots received saw dust mulches followed by straw, water hyacinth and plastic.

Mulch type also affected the incidence of leaf curl and wilt. In case of leaf curl, saw dust performed best as compared to all other mulches including control while water hyancinth, straw and plastic mulches performed better compared to control plots in reducing the leaf curl incidence. In case of eggplant, fruit rot caused by *Phomopsis vexans* and wilt caused by *Ralstonia solanacearum* infections were identified. The results showed that the lowest fruit rot infection was noticed in the plots received mulch with water hyacinth followed by mulches with plastic, straw and sawdust as compared to the control plots (no mulch). On the other hand, the lowest wilt incidence was recorded in plots received mulch with sawdust followed by water hyacinth, plastic and straw as compared to control plots (no mulch). The different mulches have also positive effect on yield of eggplant, potato and tomato. The results showed that mulches with water hyacinth and saw dust performed best as compared to control and other mulches in case of eggplant. However, in case of potato water hyacinth and saw dust performed better as compared to other two mulches and control (no mulch). In tomato, plastic mulches showed best results in terms of yield followed by water hyancinth and saw dust over control. In conclusion, mulches with water hyancinth, saw dust, straw and plastic may increase the yield of potato, tomato and eggplant by reducing the disease incidence and severity. However, the effect of these mulches on the soil properties in under investigation.

Overall, the results of the Bangladesh vegetable studies showed that all mulches improved yield and disease outcomes compared to the unmulched controls. Therefore, CA in vegetable production was advantages. Among the mulches, plastic usually did not perform as well as biological mulches, though plastic usually performed better than the unmulched control plots.

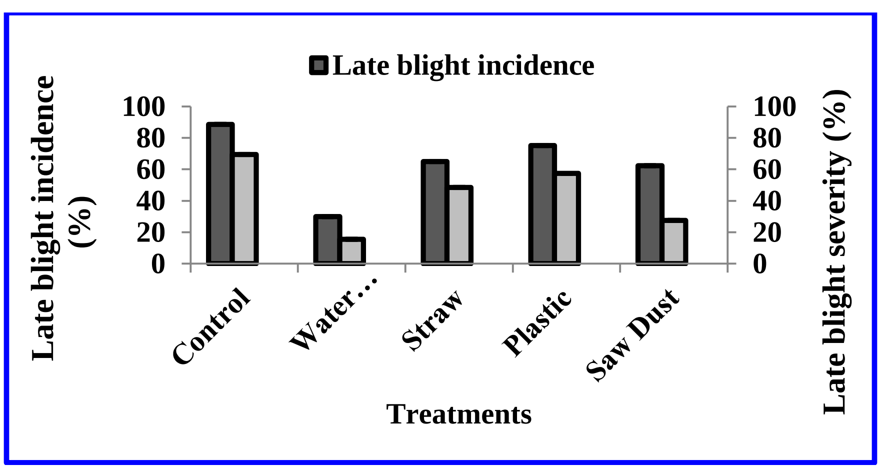


Figure 8. Effect of different mulches on the incidence and severity of late blight disease of potato.

Objective 4. Field experiment dataset.

Data from all field experiments is housed in excel spreadsheets and stored on the University of Manitoba computer back up system. Data from Bangladesh is also published in a thesis. Part of the dataset from Zimbabwe sites (maize and legume yields) is forming the basis of an MSc thesis (Mike Salomons). The legume growth and development data is being prepared for scientific publication at the present time by Entz, Braul and Kirk. However, all the data will remain available for other researchers to use in future.

Objective 5. The learning platforms

Curriculum for farmers

A comprehensive curriculum for semi-literate farmers was prepared in collaboration with colleagues from Malawi, Zimbabwe and Cornell University. The Table of Contents of Contents for this 2 week course entitled "Farming for Change" is in Appendix 2. The Agroecology sections of the course were written by my team and will be available for future development and education initiatives.

Farmer participatory research as learning platform

Before this project, the approach used by the Canadian Foodgrains Bank CA development program was to get farmers to accept a set of instructions about how to establish a CA plot. Support was provided for farmers to learn how to execute the prescribed CA method including spacing of planting stations, compost/fertilizer management, maize planting arrangement and mulch spreading.

Our project built on farmers' knowledge about the basics of CA, but focused on including farmers as researchers investigating the role of legume cover crops in the CA system. In this model, their fields became the learning centre – or the learning platform. The goal was to include the farmers more closely in the innovation process. A summary of the outcomes are:

- Broader learning opportunities: In a sense, there were three trials going on simultaneously. One was the impact of mulch, the second the impact of different legumes and all this was compared to the maize alone trials and the farmers' conventional fields. Learning often comes out of trying to make sense of different stories. In this case the stories were different treatments. It seemed like there was an awakened interest or curiosity in how things grew in the different treatments and farms.
- Learning from each other's learning platforms: Farmers were encouraged to visit other plots, both when the enumerator came or when they were visiting their neighbour.
- Field plot locations: The sites were in remote farming areas; those not typically served by extension workers or NGOs. Where possible, sites were positioned close to roads so other people in the community would walk by and observe what was changing in the crop.
- Learning platforms serving others beyond the community: The field plots became centres of learning for other people as other organizations (government and NGOs) brought their farmers to look at the plots. The reach was therefore much broader than just the community. In Neshuro alone, over 150 people from different organizations came and visited the plots.
- Field day celebration: The final field day to celebrate the success of the project in Neshuro attracted around 200 people to present the findings of the trial. The farmer and the AGRITEX officer (Zimbabwe extension service) explained the different treatments and drew conclusions.

- Data collected by the enumerator served as the “Monitoring and evaluation” dataset from the project. No further follow-up survey was necessary.

Figure 9. Farmers visiting one farmer’s learning platform.

Curriculum for University students and Policy Makers
The agroecolocy portions of the “Farming for Change” course is being modified as a university course. Therefore, the principles behind the steps highlighted in the curriculum for farmers are more thoroughly articulated. This material will be made available on-line and will be rolled out for the first time during the University of Manitoba’s “Application in Agroecology” course (AGEC 4510) which will be offered for the first time in January, 2017. The module within AGEC 4510 that will focus on development agronomy will be entitled “Agroecolocy for Food Security”. This portion of the course will be offered on-line to interested Universities.

An Executive version of the “Agroecology for Food Security” course will be offered to policy makers and business leaders in an on-line format.

Objective 6. Policy influence.

Influencing Policy discussions
One of our goals was to convince policy makers that ecological approaches to food security require greater emphasis in future development business initiatives. This is being achieved by:
- Offering policy makers, business leaders and political leaders an “Executive agroecology course”.
- Contributing to a policy paper entitled “Agriculture for Clean and Inclusive Economic Growth”, led by the Canadian Foodgrains Bank.
- Speaker at the Food Secure Canada conference in Toronto in October, 2016.
- Presentation to a National Policy group, “Food Secure Policy Group”.

Influencing food security development initiatives

Based on the success of the participatory learning platform approach, we have developed a model about how future agricultural interventions could be conducted using a participatory "Learning platform" model. What is different about this model compared with many current development programs is that it includes the farmers directly in the research (Figure 10). This means farmers must become observant in a very deliberate way. Second, the role of the facilitator is not only to help the farmers learn, but to assimilate the information from the on-farm experiences. Such an approach has the potential to serve a participatory "Monitoring and Evaluation" component. This has the potential to save money; many projects have large "M + E" budgets; why not tie these funds more closely to gathering of practical information.

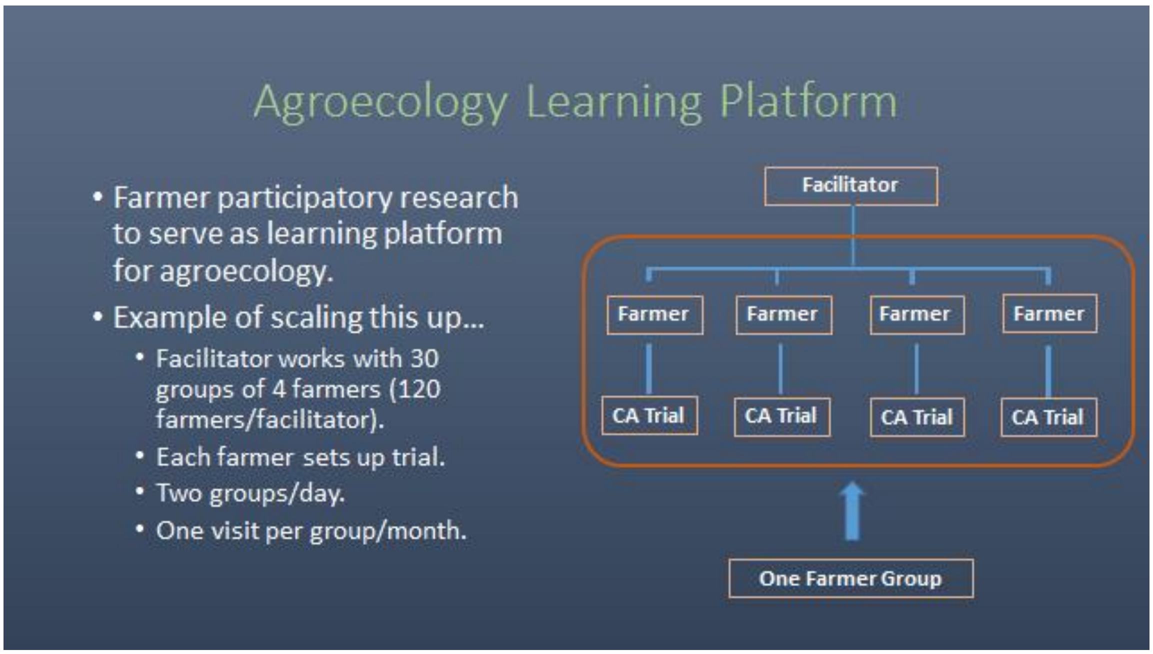
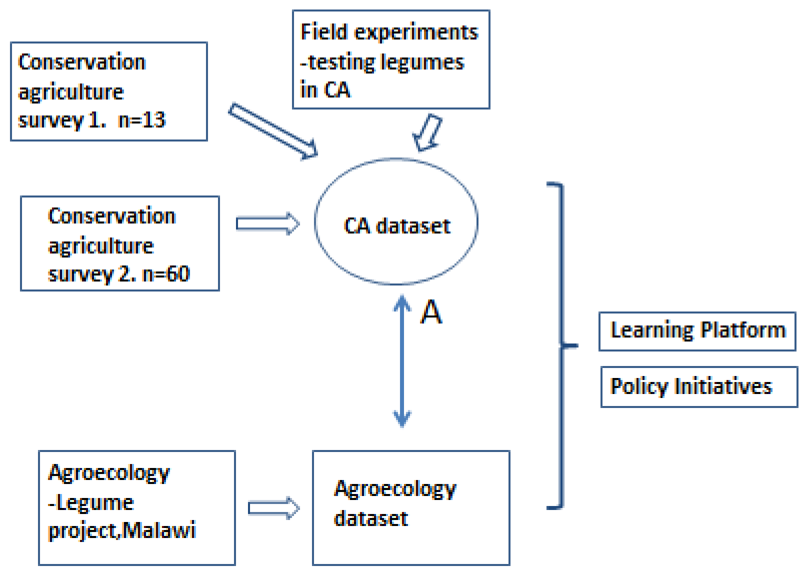


Figure 10. Model of Learning platform presented to development agencies and policy makers.

Methodology



Objective 1. Surveys
Surveys were led by the University of Manitoba group in one case, and in collaboration with the Canadian Foodgrains Bank in others. For the survey initiated by the University of Manitoba, ethics approval was the first step. Once ethics approval was granted, Anne Kirk visited households in several areas in the Gwanda district. Farmer interviews and focus group discussions were conducted by Anne Kirk, with assistance from the Mennonite Central Committee (MCC)/Canadian Food Grains Bank (CFGB) conservation agriculture technical officer for Southern Africa and a CFGB contractor. Transportation was provided by MCC and MCC/CFGB partner organizations.

Objective 2. Comparison of AE and CA
Gathering information about the Malawi Farmer-to-farmer agroecology and the Zimbabwe CA programs was conducted by Martin Entz over a 2 year period. This included reviewing reports from the two projects as well as face-to-face visits. The first visits to both sites was conducted by Entz before the start of this IDRC project, while the second visit took place during the life of the project. Additional information about these projects was gleaned from the scientific and gray literature and from project reports.

Objectives 3 and 4. Field experiments and Learning Platform for farmers
The objectives of our on-farm experiments were to evaluate the performance of legumes intercropped with maize, examine the impact of intercropped legumes on maize, and evaluate the benefit of mulch to maize and legume intercrops. Two replicate split plot experiments with eight treatments were conducted on four farms in the Gwanda District of Zimbabwe in 2014/15 and on eight farms in the

Gwanda, Neshuru and Lupane districts of Zimbabwe in 2015/16. Farms in these districts are in agro-ecological zone IV, which is characterized by a mean annual rainfall of 450-600 mm, a mean annual temperature of 18-24 °C (Mugandani et al., 2012). The rainy season starts in November and typically ends in March. The soil types found on the participating farms range from sand to loamy sand. Main plot treatments are mulch or no mulch and the sub-plot treatments are type of legume cover crop (Table 6). Details of how the sites were managed are as follow:

- Project introduction to local Zimbabwe NGOs: University of Manitoba contacted two organizations who were interested in partnering with U of M in the establishment of farmer learning platforms using farmer-managed field trials. The NGOs were interested in the project because it was designed to not only improve farmer knowledge on agroecological practices, but also address the mulch scarcity issue which limits the scale-up of CA.
- Field visit and farmer selection: The U of M research technician (Anne Kirk or Alden Braul) travelled to Zimbabwe to assist the enumerators in selecting farmers, explaining the trial to farmers and establishing the trial. These were very remote villages and Alden (who has extensive experience working in Zimbabwe) traveled by local bus and stayed with villagers. Alden met with and gained the trust of the village leadership.
- Knowledge of CA varied significantly between farmers with some having had years of experience while others (primarily in Neshuro) having no knowledge of CA. In some cases the NGO had already selected the farmers and sites, where in other cases the U of M technician was involved in farmer selection. In one area farmers actually competed with each other to have the plot established on their land given the prestige of participating in an international research project.
- Trial establishment: U of M provided the seed for the trials. As the conditions were not optimum for planting given the lack of rain, farmers were trained on the seed planting depth and density. Farmers received a copy of the trial design with explanations in their local language on how to establish the trial. No conventional check treatment was included, since according to Ramash (University of Ottawa, pers. comm.), farmers are well aware of the performance of their traditional systems.
- Soil was not tilled in any of the trials. Planting stations were measured and dug using two grids, depending on the region - 75 cm x 75 cm and 90 cm x 60 cm.
- Farmers added an equal amount of composted manure to all the planting stations. This was generally two handfuls.
- Seeding dates varied between all plots depending on rainfall and irrigation opportunities. For many farmers, their first planting of maize in 2015/16 died which needed to be reseeded 2-3 times usually in some but not all planting stations. The cowpea and lablab did not require replanting. However, poor germination of pigeonpea resulted in several replanting with still poor germination.
- Open pollinated maize and legume seed were the inputs provided to all the farmers.
- Mulch was added to the plots using locally available sources. The type and amount of mulch added to the mulched plots varied between farmers and within the plot on a trial.
- None of the farmers applied fertilizer. No herbicides or insecticides were used, although we did not state that the farmers could not use them. Farmers were allowed to manage the plot as they normally would on their conventional land which primarily included weeding.
- The farmers harvested the cowpea as it ripened, and kept the harvest in bags to weigh at a later date.
- Biomass of mulch and crops were taken.

- Weeding the crop was the most important task which farmers did faithfully. They noticed the crops with cowpea and lablab required less weeding.
- Some pruning of the lablab was required where the maize had been replanted.
- Field visits by enumerators: Farmers managed the trial as they would any other field. The "learning piece" was formally done when the enumerator would come to the farm and discuss the performance of the different treatments with the farmers. Informal learning by the farmer themselves or with neighbours curious to know what they were doing, likely happened frequently based on comments from the farmers. It was simply quite fascinating to see the stark difference between the mulched and unmulched, as well as they unique growth patterns between the legume intercrops. Without prompting, farmers commented how their trial was where they learned. It was their classroom, ie., their learning platform.
- Data collection: The enumerators also collected data on biomass of mulch and intercrop at different intervals, plant height, decomposition of mulch, etc.. All this was a very new experience for farmers which helped them take note of what was happening in their field, and there was something technical around crop production. The simple act of measuring a crop growth was interesting to farmers. At least one of the enumerators was very good at creating a dialogue around what was happening in the learning platform to stimulate questions and curiosity, but more than anything to encourage observation. The fact that the interest moved from one legume to the next based on their growth patterns highlighted the new thinking that was stimulated by the trial. For example, cowpea completed its growth cycle first, then lablab, then pigeonpea. Farmers were all very keen on the cowpea at the outset, then turned their interest to lablab when the cowpea was done, and lastly to pigeonpea.

Table 6. Treatments included in the study.

Main plot	Sub plot	Treatment name
Mulch	No cover crop	Mulched maize monocrop
	Cowpea	Mulched maize intercropped with cowpea
	Lablab	Mulched maize intercropped with lablab
	Pigeon pea	Mulched maize intercropped with pigeon pea
No mulch	No cover crop	Maize monocrop
	Cowpea	Maize intercropped with cowpea
	Lablab	Maize intercropped with lablab
	Pigeon pea	Maize intercropped with pigeonpea

Planting stations were used in both the mulched and unmulched treatments. This allowed the effect of mulch to be isolated as an experimental treatment (Figure 11).

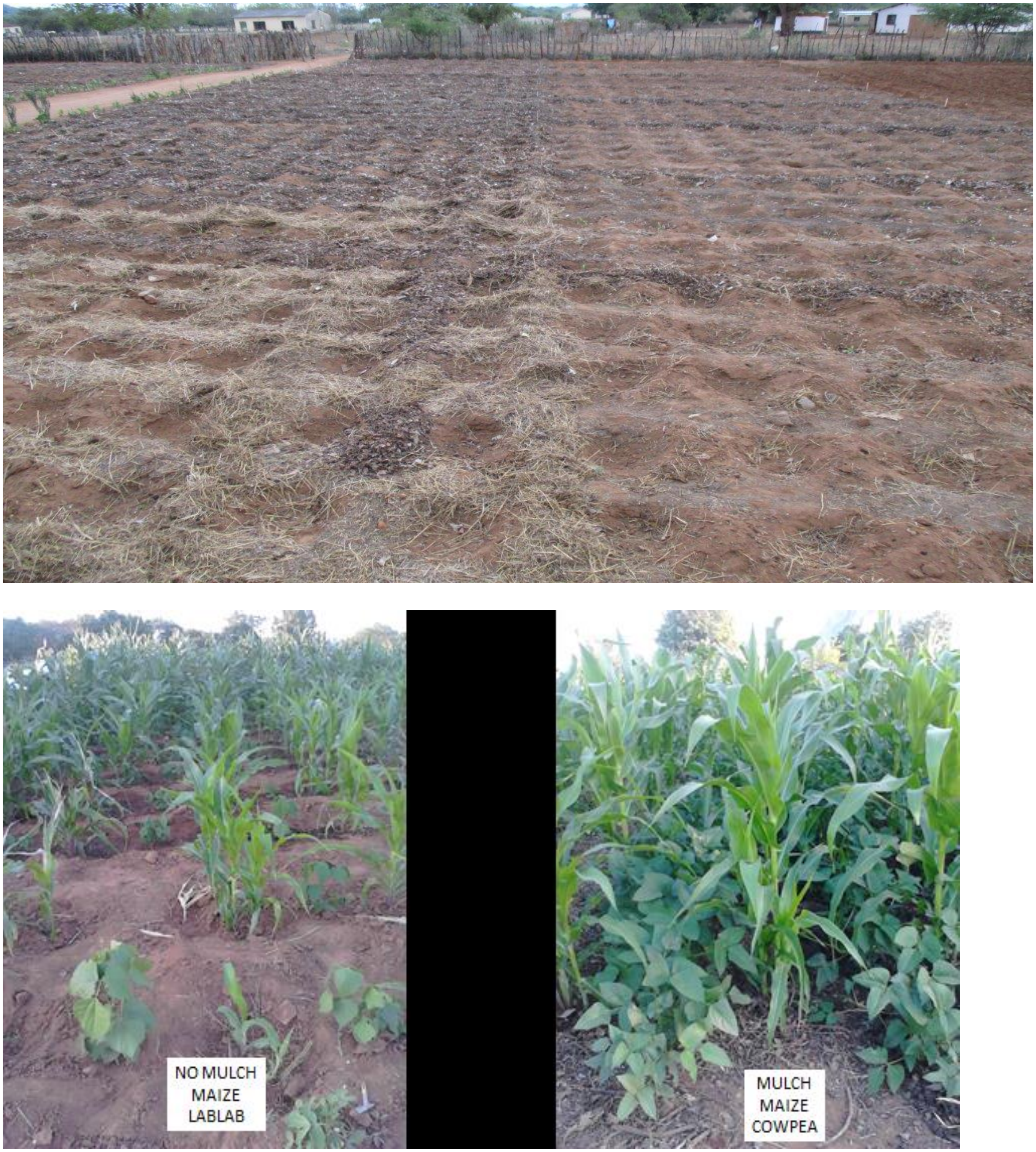


Figure 11. Images from field studies conducted in 2015/16.

Objective 4. The Learning Platforms

Learning platforms were developed for farmers, university students and policy makers, business leaders and political leaders. The farmer learning platform was the field plot (discussed above). Our project also contributed to the "Farming for Change" curriculum, which will be available for use as a teaching tool for semi-literate farmers. Sections on agroecology and conservation agriculture that were contributed by the University of Manitoba team are highlighted in yellow (Appendix 2).

The learning platform for University students will be the "Agroecology for Food Security" course. This course presents the theoretical basis for the agroecological processes described in the "Farming for Change" farmer curriculum. This course will be available as an in-class course at the University of Manitoba and as an on-line course to University and college students around the world.

The learning platform for policy makers, business leaders and political leaders will be a combination of contributions to policy papers (as described above) and access to a "Executive Agroecology for Food Security" course available on-line from the University of Manitoba. This is a departure from the original plan of offering 2 one-day workshops in Canada (see original proposal). Our team decided it would be better to offer an on-line course that leaders could tap into at their own time and at their own pace. We feel this approach will allow us to reach many more leaders.

Objective 5. Policy Influence

The methods to achieve this goal include offering leaders and policy makers an on-line course in "Agroecology for Food Security" (described above); participating in preparing policy documents on food security; and participating in food security conferences and other advocacy.

Project outputs

Output	Status	Format/Availability
Survey of 13 households in Zimbabwe	Completed	Summary tables – Information will be included in technical paper submitted to open access journal. Survey results will be part of the field study paper (see below).
Survey of 60 CA adopting farms	Completed	Report available from Canadian Foodgrains Bank
Results from Farmer participatory field studies	Data analysis underway. Data part of Mike Salomons MSc thesis	Will be published in open access journal (eg., Field crops research).
Field experiment dataset	Being finalized into spreadsheets	Will be available on University of Manitoba website (under our Natural Systems Agriculture page).
Learning platform approach to learning	Document for publication	Will be published in open access journal
“Farming for Change” curriculum for semi-literate farmers	Final stages of preparation; just been field tested.	The chapters that University of Manitoba was responsible (all the agroecology chapters) will be available on-line, readily accessible.
Agroecology curriculum for University students “Agroecology for Food Security”	In progress	Available on-line – open access. First offering January 2017
Executive “Agroecology for Food Security” course for policy makers, business leaders and politicians	In progress	Will be available first time in March, 2017
Policy documents	In partnership with Food Secure Canada policy group and others	Various formats. Will link to U of M website for all available documents

Problems and Challenges

Mid-term review

I have included the mid-term review in this section of the report. The mid-term review was conducted by Alden Braul before he joined the project as a manager. By pure coincidence, Alden indicated his interest and availability of a position at the University of Manitoba after completing this mid-term review. Alden's report from reflection in June, 2015 are summarized below:

Strengths

1. The link with a local NGO (BIC-CDS) was key to the success of the project in the first year. Through connections with CFGB, UofM was able to identify a partner and begin working very quickly with farmers who were participating in an ag development project. Clearly, partnering with an existing organization was key to the project success.
2. Integrating legume cover crops into CA systems was a novel way to address the mulch-scarcity issue. This approach immediately helped to gain farmer interest and involvement.
3. Through the surveys, important observations were made about the agronomy and social dynamics that are part of promoting and implementing a CA systems.
4. Given the complexity of agriculture development, the project did a good job in addressing a number of key research questions.
5. The project selected a mix of farmers to run the four trials. Two were very food insecure that had a lot to gain from the learnings that would come out of the trial. Interestingly, the two farmers who were better off, had the knowledge and farm management skills to apply the learnings and take the results to another level.

Challenges

1. Trials were limited to one geographical area (Gwanda) that is typically very dry and prone to crop failure. In the case of crop failure (as there was), the learnings were limited. The trials should have been conducted in a couple regions to reduce risk.
2. The project did not address how the farmer-managed trials could be used as a scaled-up learning platform for farmers, not just the people within the information chain above them. I guess we stumbled onto this the second year.
3. Comparative analysis between Malawi and Zimbabwe. The project should have been more clear in how data collection around livelihood impacts between the Zimbabwe/CA approach and the Malawian agroecology project. I did not see any data collected from Malawi, only Zimbabwe.
4. Although the development partner was an excellent conduit to link up to farmers, the partner did not own the project which limited dissemination of learnings. There are likely many reasons for the limited ownership. If more time had been available at the outset, an MOU should have been developed that articulated how the partner would be involved beyond providing logistical support.
5. Farmers were interviewed at the outset of the project, but were not involved in the data interpretation component. Links connecting the first survey with the field data from the farmer-managed trials should have been made using focus group discussions with the participating farmers at the end of the first year. This would have helped to validate or challenge some of the information collected in the first round of data collection.
6. Links to local research stations (i.e.: ICRISAT) were not made during the first year.
7. Plot sizes were small during the first year which limited data collection, especially biomass sampling.

8. This project deserved to be much larger to more effectively address the complexity of the many issues it was addressing. As such, the conclusions the project could draw were limited and likely required more focus. (this not just applies to year one, but to the whole project in general)
9. The summary that Anne wrote could have had a bigger impact if it included observations made by farmers about the treatments and their preferences for the different mulch/intercrop combinations.
10. A major challenge is introducing new legume species as people do not have experience preparing and consuming lablab and pigeon pea. If funding had been provided to the NGO to do this, there may have been more impacts related to the trials the first year.

Administration reflections and recommendations

Our main challenge was getting funds to the Zimbabwe technicians at certain times during the life of the project. There were several occasions in 2015/16 when the Canadian government placed Zimbabwe on a watch list for financial transactions. During these times the University of Manitoba would not allow us to transfer funds through the usual channels. However the University of Manitoba did grant us permission to send funds via Western Union. This was awkward, since we needed to pay the Western Union with our own funds and then claim it back through the University system. Also, the University of Manitoba's policy is not to allow researchers to send funds by Western Union.

Interaction with the Canadian Foodgrains Bank made an enormous contribution to the success of this project. The network of African organization supported by the Foodgrains Bank made access to the farming community quite simple. Also, it allowed us to place our field studies into areas that were very remote and not often serviced by development projects.

Collaboration with colleagues from Cornell University, who invited us to participate in the "Farming for Change" Curriculum and colleagues from Michigan State University, who participated in the legume work, strengthened our work.

After the mid-term review, we initiated more contact with ICRISAT based in Bulawayo, Zimbabwe. A graduate student working on legume integration in CA (supervised by Ken Giller, Wageningen University) assisted in concepts for our field learning platforms. Also, Neil Miller, MCC CA technical specialist in Tanzania is working on lablab plant adaption, testing different accessions and varieties of lablab as well as inoculant strains for N-fixation. He is also supported by Ken Giller of Wageningen University in the Netherlands.

Citations

Bezner Kerr, R., S. Snapp, M. Chirwa, L. Shumba and R. Msachi. 2007. Participatory research on legume diversification with Malawian smallholder farmers for improved human nutrition and soil fertility. Expl. Agric. 43:437-453.

Bezner Kerr, R. 2013. Seed struggles and food sovereignty in northern Malawi. Journal of Peasant Studies. 40:867-897.

Blank, D. 2013. Soil Fertility Changes in a Foundations for Farming System. MSc Thesis; conducted in Western Central Zimbabwe as part of a MSc. program in 'Sustainable Agriculture and Integrated Watershed Management' Hohenheim University (Germany) & Chiang Mai University (Thailand).

Lal, R. 1974. Soil temperature, soil moisture and maize yield from mulched and unmulched tropical soils. Plant Soil 40:129-143.

Mugandani, R., Wuta, M., Makarau, A., and Chipindu, B. 2012. Re-classification of agro-ecological regions of Zimbabwe in conformity with climate variability and change. Afr Crop Sci J 20:361-369.

Nyamangara, J., E. Nyaradzo Masvaya, R. Tirivavi, and K. Nyengerai. 2013. Effect of hand-hoe based conservation agriculture on soil fertility and maize yield in selected smallholder areas in Zimbabwe. Soil & Tillage Research 126:19–25.

Pretty J. 2008. Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society of London B: Biological Sciences. 2008 363:447-465.

Thierfelder, C., Mutenje, M., Mujeyi, A., and Mupangwa, W. 2015, Where is the limit? Lessons learned from long-term conservation agriculture research in Zimuto Communal Area, Zimbabwe. Food Sec 7:15-31.

Thierfelder, C. and Wall, P.C. 2009. Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe. Soil Till Res 105:217-227.

Thierfelder C, Chisui JL, Gama M, Cheesman S, Jere ZD, Bunderson WT, Eash NS, Rusinamhodzi L. 2013. Maize-based conservation agriculture systems in Malawi: Long-term trends in productivity. Field Crops Research 142:47-57.

Vaisman I, Entz MH, Flaten DN, Gulden RH. 2011. Blade roller–green manure interactions on nitrogen dynamics, weeds, and organic wheat. Agron J. 103:879-89.

Wall PC. 2007. Tailoring conservation agriculture to the needs of small farmers in developing countries: an analysis of issues. Journal of crop improvement. 15:137-55.

Woodring, C. and A. Braul. 2011. http://www.foodgrainsbank.ca/uploads/Abundance%20through%20Mulch%20and%20Hoe%20-%20Conservation%20Farming%20in%20Zimbabwe%20-%20Case%20Study%20-%20March%202011.pdf

Appendix 1. Farmer focus group survey results (Gwanda district, Zimbabwe)
Prepared by Anne Kirk
February, 2015

Location: Margret Farm (Farm 4 in intercropping trial)

Farmers present: 9 women and 3 men, a mix of ages

1) Are you following the three principles of CF?

Who is practicing CF – all farmers in attendance
Crops grown under CF – groundnut, cowpea, sorghum, roundnuts, maize (all farmers were growing more than just maize under CF)
Crop rotation – all
Mulch – everyone is mulching to some extent, but most farmers admit that they are not mulching much

2) Are you having challenges finding enough mulch?

- It is not easy to get enough grass to cover the ground
- Some plots are not well fenced in and animals come in and eat the mulch
- Mulch is available, but it is more available during the growing season when the grass is growing
- The termites eat the mulch if it is kept in the field

3) Do you have enough time to collect mulch?

- By the time the program starts there's lots of time, but mulch is not so available
- There isn't enough time to collect mulch during the rainly season. I work on my plots and there are other jobs to do

4) Does anyone have 100% ground cover in their plots?

- No, but all farmers have mulched part of their plots

5) Do you mulch crops other than maize?

- Maize only, but I intercrop my other crops with maize (1 person)
- Maize, sorghum and cowpea
- Everything but sorghum

6) Do you intercrop?

- One person intercrops:
  - I plant pumpkins, melons, beans, cowpeas, and groundnuts with maize
  - This is the second year that I am trying intercropping, but I like it because you can make better use of space
  - With pumpkins, in some instances the vines completely cover the ground
  - I think that the intercrops work well as a living mulch (we visited these plots later, and the farmer showed us the actually the intercropped maize was shorter and tasseled earlier than the mulched and unmulched mono-cropped maize. She thought that the intercrop was competing for moisture)
- I don't intercrop because I think that it may affect the crop rotation. For disease control we should rotate crops, but if we are always intercropping we may have more disease problems

7) What crops are you growing conventionally?

- Pumpkin, watermelon, melon

8) Why don't you grow pumpkin, watermelon and melon in the CA plots?

- Because they will climb up the maize plants
- In basins we expect two maize plants, we can't add other plants because then it would be too much competition
- Don't want plants in the maize CA, it is better to plant on it's own
- Since this is a new technology I think maize should be there on its own. I think it would affect the evaluation of how the maize performs in CA if we were growing other crops

9) How did you learn CA?

- First learned from World Vision, then from another organization, and now from BICC (most people started with World Vision in 2006, there was one person who learned from a neighbor)
- I liked the spacing that World Vision told us to do better. The spacing was 25 x 60 cm and the maize covered the ground quickly. The spacing that we use now is too wide (A few people agreed and a few disagreed)
- When we learned from World Vision we started off with a 50 x 50 m plot of CA and a 50 x 50 m plot of conventional so that we could compare. One farmer said that after the program she turned the 50 x 50 m conventional plot into CA as well
- Learned from a neighbor (two farmers)

10) Who can learn CA?

- Everyone (with the CDS program)
- The people that first introduced CA had restrictions. You couldn't join CA if you were under 18 or old. It ended up segregating people.

11) Since most people that are currently in the BIC program learned CA methods from another organization first, why did you join the BIC CDS program?

- Seed
- World Vision was not making any follow up visits and I am getting more training now. Many organizations just tell you to do CA and then never come back (Vusa clarified this later. Before working for the BICC program he was involved in another CA program. They had a regular program with farmers and they would do training with these farmers and visit their fields. But they would also receive funding from certain organizations (ex. The EU) to conduct mass trainings with as many farmers as possible. These training sessions would last for 30 minutes and they would have to try to explain how to do CA in this very short period of time, with no follow up or practical demonstrations.)
- I joined because I wanted to receive more training (All of the farmers seemed to agree with this)

12) In the CA training, what activities were most useful?

- All of the training was useful
- I like the workshops because we learn the theory and then this is followed up with practical information and demonstrations
- I appreciate the extension worker visits. These are better than just the workshops because they can show you how to do things on your own farm
- Field days

13) Why is CA being adopted by certain people and not others?

- Digging basins isn't easy. Some young people are afraid to dig basins, but for those that have don't it we can't abandon it. Even though I am old I still prefer to dig basins rather than ploughing
- When people see the harvest that we can get they want to start
- Some people don't want visits from extension workers. They think that they are going to take some of your harvests from you. I have been telling my neighbours that the extension workers don't want anything from you.

14) What are the benefits of CA?

- I am no longer seeing CA as a difficult task. By the time the rains come I'm done with my basins and ready for the rain
- CF helps to have an early crop. If the rains were good our maize would have matured by now
- When we dig basins we get some food, even in a bad year. One year the people that had basins were able to harvest a little and conventional farmers didn't harvest anything. When it came tie for food relief the conventional farmers made sure that the CA farmers weren't signed up because they knew we harvested

15) What are the disadvantages of CA?

- Sometimes if we have a shortage of manure it seems like CA doesn't work

16) Why did you decide to adopt CA?

- Some of us tried CA because we didn't have draft power
- Before CA we would have to borrow livestock from others to plough our fields and we would only be able to till very late in the season. Sometimes we couldn't even plant all of our land
- I had very little manure and I wanted to stretch it

17) What do you use for fertilizer?

- Fertilizer, humus, manure, ashes
- Use the same in both CA and conventional (the group seemed to agree on this)

22) Where is mulch collected?

- Collect tree leaves
- Grass is collected around the farm

23) How much mulch is necessary for water retention?

- 4 cm
- I don't think that you need a lot of mulch, as long as it covers the soil
- Other people say that the mulch dries up, so you need more. (The farmers debated about how much mulch was necessary)
- The most mulch you have the more water retention you have

24) How much mulch is necessary for weed control?

- Mulch is very helpful for controlling weeds, the thicker the better

25) Have you tried ripping

- 4/10 farmers tried

26) How did the ripper work?

- Didn't do well in my field, especially maize
- The ripper worked well with groundnut and cowpea
- Crops planted in ripped lines had poor germination, so I dug holes in the ripped lines to replant
- Poor germination, but if we had adequate moisture it would have been okay

27) Why did you decide to try the ripper?

- The ripper can help with CA, but digging basins isn't a problem
- I like the ripper because I can prepare my land anytime after harvest. It takes a long time to dig basins, but ripping is quicker. I can rip and plant in the same day
- If you have a big plot you can prepare it early enough and on time
- I joined the CDS program because I wanted to compare the ripper and planting basins
- I like ripping because I can do it anytime. If you don't have livestock you can hire someone to rip before the rains come when they aren't that busy

28) How do you do ripping if you don't have livestock

- One of the farmers present has livestock, the rest were assisted with ripping by their lead farmer
- Hire someone to rip
- Cost of ripping:
    - Varies, one person said it's free, others paid $50 to have their plots ripped (50 x 50 m or 100 x 100 m)
    - Some people charge the same to rip and plough a field even though ripping is much faster

29) Do you mulch in the ripped plots?

- Most people don't, one person mulched some of the ripped plots
- Mulch on the ripped plots is important, in ripped plots that have some mulch the maize is dong much better in the mulched areas

30) Ripping didn't work very well for you this year, will you try it again?

- Yes (none of the farmers said that their ripped plots looked good)

31) A seed bank program was started by CDS, how is it working?

- I like having a seed bank. Seed is often not available from local shops so we have to go to the city to buy seed
- You don't know the quality of the seed at the shops, so it's better to store your own
- Seed is too expensive, so having a seed bank is good
    - 5 kg of maize seed = $17
    - 10 kg of maize seed = $28
- When people can't find seed or it's too expensive then they use use general seed from their graineries, not seed that they have selected for planting
- Some people store 5 of 10 kg for planting (discussion about seed and it was agreed that 5 kg of seed for a 50 x 50 m plot is too much)
- It seemed as though all of the farmers would choose to store their own seed

32) How are the seed banks organized?

- Lead farmers will inspect your fields to see which plot qualifies to contribute to the seed bank
    - Check to make sure no cross pollination
    - Seed quality
- The field that qualifies will be harvested for seed for the group
- The farmer that contributes the seed crop will be compensated with grain from the farmers that will be using that seed but didn't contribute
- Last year my sorghum field had poor quality seed, so I swapped with another farmers that had good seed, so everyone would have good seed to plant
- We started inspecting fields as a group and deciding together which seed we should store for planting because we were having problems with farmers contributing poor quality seed to the seed bank. We didn't want their poor quality seed to pollute the seed bank
    - Some farmers were contributing seed from the whole cob instead of removing the tip. When I got seed back from the seed bank it was suspicious, but I had no choice but to plant it anyways
- As a group we discuss where to store the seed. All of our seed is placed in the same place and we lock the grainery. The ward lead farmer keeps the key for the grainery

33) Were you growing sorghum before the CDS program?

- 6/10 farmers started growing sorghum after it was introduced by CDS

34) How do you like growing sorghum?

- We were given seed from CDS, and it was impure seed, there was even some millet in there
    - I selected properly within that seed so it is betterthis year
- Learnt that sorghum can withstand the heat better than maize
- There is a good market for sorghum, people that make beer will give you 2 buckets of maize for 1 bucket of sorghum
- Everyone agreed that they will continue to grow sorghum even after the CDS program ends

35) What are the advantages of CA?

- We get a better plant population when we use the basins compared to conventional farming
- Once you start using the basins and are used to the work you don't want to go back to ploughing

36) How will more people be encouraged to join CA?

- Some of us have adopted CA but not really embraced it (I think they mean they could do a better job mulching). If we get into CA full force then we can really encourage others

37) Advice for other farmers that would like to try?

- I would encourage people to start with a small plot to see what happens
- We in the program should be exemplary, we should practice what we learned today and it would encourage others

Comments from the focus group and the field visit:

- The farmers have really embraced CA and we had a good discussion. The farmers recognize things that the could be doing better, such as mulching
- There were a mix of age groups at the focus group, although the middle aged people seemed to do the most talking
- The focus group consisted of farmers from two different villages (Mtshabezi and Margret's village). We did field tours at two farms in Mtshabezi first, then brought three women from that village to the focus group. After the focus group we toured Margret's farm and went to the farmer that is doing intercropping to see her fields.
- At Margret's farm the ripped plots look good, and there is a good plant stand despite not having any mulch
    - I think these ripped plots were planted after the basins, so they were likely planted in better moisture
- There was a lot of interest from the farmers in the intercropping plots, especially the lablab
    - Some concern that the lablab will vine and that if it was planted too early it would suffocate the maize

Focus group visit to a farmers field that is practicing intercropping

Litha Ngwenya farms in Gwekwe village and is 34 years old. This is Litha's second year doing CA and she learned from her neighbor. She wanted to try CA to see how CA compares to conventional farming. She farms a relatively small area (about 1 ha), but about 1/3 of her land is conventional, 1/3 is ripped CA, and 1/3 is basins.

- Ripped maize intercropped with ground nuts, cowpea, sugar beans (they spread more than cowpea), bambara nuts, squash, watermelon
    - The benefit of the sugarbeans is that they take longer to mature than cowpea, so you can eat the leaves as a vegetable with maize for longer
    - The benefit of cowpeas is that they mature faster so you can get beans earlier. Some varieties are indeterminate and you can harvest beans three times during the growing season
- The intercrop is planted 3 days after maize
- She intercrops because she farms a small area. Prefers intercropping to rotating crops, because with intercropping you can plant maize in the entire field and when you rotate crops you plant maize on a smaller area
- Some areas of the field are mulched, but not very much. The mulch used is maize stover and tree leaves

- When asked if she sees a difference between the ripped maize and maize planted in basins, she said that the ripped maize showed signs of moisture stress earlier, and that the basins were better for conserving moisture.
- When asked how the intercropped maize compares to mono-cropped maize she said that the maize planted on its own looked better. The maize that was intercropped is shorter and was tasseling earlier. Last year when they had more moisture the intercropped maize showed no signs of moisture stress.

Appendix 2. Farming for Change Curriculum

Sections highlighted in Yellow were developed my University of Manitoba team.

Day 1

Introduction The overall goal of this curriculum

Learning and Teaching Approaches (2 hours, includes 4 activities)

Goal: Introduce the curriculum's learning and teaching approaches.
Introduction to this curriculum (30 minutes)
Learning and Teaching Approaches 1 Exploring how we teach (30 minutes)
Learning and Teaching Approaches 2 Ways people learn (30 minutes)
Learning and Teaching Approaches 3 How to begin teaching in a community (30 minutes)
Learning and Teaching Approaches 4 Sharing stories (30 minutes)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Nutrition 1 Nutrition Basics (2 hours)

Goal: Introduce the importance of good nutrition.
Nutrition 1.1 What nutrition means (30 minutes)
Nutrition 1.2 Nutrition is the responsibility of everyone (30 minutes)
Nutrition 1.3 Types and consequences of poor nutrition (30 minutes)
Nutrition 1.4 Identify important steps to keeping clean (30 minutes)

Drama (30 minutes)
Lunch (1 hour)

Inequality 1 Learning about Inequalities (2.5 hours)

Goal: Create a space of trust to discuss and recognize inequality in our communities.
Inequality 1.1 Inequality and bias (45 minutes)
Inequality 1.2 Inequalities and human rights (30 minutes)
Inequality 1.3 Local politics and politics at a broader scale (45 minutes)

Drama (30 minutes)

Day 2

Farming with Nature 1 Key Features of Farming with Nature or Mixed Farming (4.5 hours, includes field visit)

Goal: Learn about how to farm with nature and how these practices can help farmers meet goals for their farms and households.
Farming with Nature 1.1 Introduction to mixed farming (30 minutes)
Farming with Nature 1.2 Learning from nature (1 hour)
Farming with Nature 1.3 Seeing mixed farming practices in action (2 hours)

Farming with Nature 1.4 Matching farming practices with goals for the household (1 hour)
Drama (30 minutes)
Lunch (1 hour)

Nutrition 2 Dietary Diversity (1.5 hours)

Goal: Identify important steps in maintaining dietary diversity in the household throughout the year.
Nutrition 2.1 Review dietary diversity and food groups (1 hour)
Nutrition 2.2 Challenges and solutions to dietary diversity (30 minutes)
Weather and Climate Change 1 Local Weather and Climate Change (1.75 hours)
Goal: Share observations of local weather and learn about weather and climate.
Weather and Climate Change 1.1 Past seasonal weather patterns for the region (1 hour)
Weather and Climate Change 1.2 Understanding weather and climate (15 minutes)
Weather and Climate Change 1.3 How weather patterns are changing (30 minutes)
Drama (30 minutes)

Day 3

Inequality 2 Gender Inequality in Homes and Communities (1 hour)
Goal: Explore values and attitudes about men and women, the differences between gender and sex, and consequences of gender inequality.
Inequality 2.1 Gender versus sex (30 minutes)
Inequality 2.2 Opinions about gender and sex (30 minutes)
Farming with Nature 2 Crop Diversity (6 hours, includes field visit)
Goal: Learn about cropping systems, plants, and animals used in mixed farming in the region.
Farming with Nature 2.1 Crops and animals that can be grown locally (30 minutes)
Farming with Nature 2.2 Diversity in farm systems (2 hours)
Lunch (1 hour)

Farming with Nature 2.3 How to use trees and other perennials (1.5 hours)
Farming with Nature 2.4 Helping crops and animals work together (2 hours)
Drama (30 minutes)

Day 4

Weather and Climate Change 2 Extreme Weather and Climate Change (2.5 hours)

Goal: Develop strategies for coping with extreme weather and adapting to climate change.
Weather and Climate Change 2.1 Major weather challenges (1 hour)
Weather and Climate Change 2.2 Ways to handle high-priority weather challenges (1 hour)
Drama (30 minutes)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Nutrition 3 Healthy Cooking (2.5 hours)

Goal: Identify the necessary steps for healthy cooking.

Nutrition 3.1 Cooking methods to keep nutrients in food (30 minutes)

Nutrition 3.2 Clean food handling practices (30 minutes)

Nutrition 3.3 Learn 2–3 new recipes (1.5 hours)

Drama (30 minutes)

Lunch—sharing delicious recipes! (1 hour)

Inequality 3 Gender Roles (2 hours)

Goal: Think about how gender roles are created and different roles and responsibilities that men and women might have.

Inequality 3.1 How gender is socially constructed (1 hour)

Inequality 3.2 Different types of gender roles (1 hour)

Day 5

Farming with Nature 3 Soil Health (4 hours, includes field visit)

Goal: Learn how soil in each field is different, what those differences mean, and ways to improve soil.

Farming with Nature 3.1 Understanding soil (1.5 hours)

Lunch (1 hour)

Nutrition 4 Special Nutritional Needs and Family Planning (2 hours)

Goal: Learn about adolescent, pre-pregnancy, and adult women's needs.

Nutrition 4.1 Special nutritional needs of adolescents and adult women (30 minutes)

Nutrition 4.2 Understanding the importance of family planning (1 hour)

Nutrition 4.3 Difficulties and solutions for special nutritional needs and family planning (30 minutes)

Drama (30 minutes)

Day 6

Nutrition 5 Nutrition during Pregnancy (2 hours)

Goal: Learn about special nutritional needs in pregnancy.

Nutrition 5.1 Important behaviors for a healthy pregnancy (30 minutes)

Nutrition 5.2 Steps to ensure good health (1 hour)

Nutrition 5.3 Support networks during pregnancy (30 minutes)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Farming with Nature 3.2 Adding organic matter to soil (2.5 hours)

Lunch (1 hour)

Inequality 4 Work at the Home and Other Places (3 hours)

Goal: Discuss and plan solutions for addressing inequality in different types of work.

Inequality 4.1 Who does the care work? (1.5 hours)

Inequality 4.2 Inequality and agriculture (1.5 hours)

Day 7

Weather and Climate Change 3 Climate Change's Causes and Our Future Climate (3 hours)

Goal: Discuss causes of climate change, climate predictions, and our uncertain future.
Weather and Climate Change 3.1 How gases in the atmosphere change the climate (1.5 hours)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Weather and Climate 3.2 Heat-trapping gases are like a blanket (1 hour)
Weather and Climate 3.3 What we know and don't know about our future climate (30 minutes)

Drama (30 minutes)

Lunch (1 hour)

Learning by Observing and Testing (1.75 hours)

Goal: Explore different ways to find out which farming practices work best for your farm.
Learning by Observing and Testing 1 Making observations (45 minutes)
Learning by Observing and Testing 2 Creating tests about what we notice (1 hour)

Inequality 5 Relationships (2.5 hours)

Goal: Identify and reflect on what is healthy and unhealthy in romantic relationships.
Inequality 5.1 Healthy and unhealthy relationships (1 hour)
Inequality 5.2 Communication in relationships (1.5 hours)

Drama (30 minutes)

Day 8

Inequality 6 Family Budgets and Food (2 hours)

Goal: Plan more equitable family decision-making about income and food.
Inequality 6.1 Making a family budget (1 hour)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Inequality 6.2 Inequality and nutrition (1 hour)

Drama (30 minutes)

Lunch (1 hour)

Nutrition 6 Breastfeeding (3 hours)

Goal: Learn about the benefits of breastfeeding and best practices.
Nutrition 6.1 Benefits of breastfeeding (45 minutes)
Nutrition 6.2 Good breastfeeding practices (45 minutes)
Nutrition 6.3 Nutritional needs during breastfeeding (30 minutes)

Nutrition 6.4 Challenges and solutions when breastfeeding (1 hour)

Drama (30 minutes)

Day 9

Farming with Nature 3 Tillage and Water Conservation (3.5 hours)

Farming with Nature 3.3 Tillage practices (1.5 hours)

Farming with Nature 3.4 Water conservation practices (2 hours)

Drama (30 minutes)

Lunch (1 hour)

Farming with Nature 3 Soil Health continued (1–3 hours)

Goal: Learn how soil in each field is different, what those differences mean, and ways to improve soil.

Farming with Nature 3.5 Erosion and soil conservation (1 hour)

Farming with Nature 3.6 Trying a soil conservation method (2 hours, optional)

Drama (30 minutes)

Day 10

Nutrition 7 Complementary Feeding (1.5 hours)

Goal: Learn about feeding and nutrition for children under two years of age.

Nutrition 7.1 When to start complementary feeding (30 minutes)

Nutrition 7.2 Complementary feeding practices (30 minutes)

Nutrition 7.3 How everyone can help with complementary feeding (30 minutes)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Inequality 7 Gender Inequality and Violence (2.5 hours)

Goal: Discuss the types of violence that happen in families and romantic relationships.

Inequality 7.1 Ensuring a safe space (15 minutes)

Inequality 7.2 What is violence? (45 minutes)

Inequality 7.3 The cycle of violence (1 hour)

Inequality 7.4 Sexual violence (30 minutes)

Drama (30 minutes)

Lunch (1 hour)

Farming with Nature 4 Weed and Insect Management (2.5 hours)

Goal: Learn to design more effective weed and insect management systems.

Farming with Nature 4.1 Weed management (2.5 hours)

Day 11

Nutrition 8 Nutrition and Children's Health (1.5 hours)

Goal: Discuss what school-aged children need to eat to stay healthy.
Nutrition 8.1 Good nutrition for children (45 minutes)
Nutrition 8.2 Children's illnesses and special diets (45 minutes)
Tea/Coffee/Healthy Snacks Break (30 minutes)

Nutrition 9 Recipes for Children's Food (2 hours)

Goal: Learn delicious recipes for young children and older children.
Nutrition 9.1 Learn 2–3 new recipes (1 hour)
Nutrition 9.2 Reviewing nutrition (1 hour)
Lunch (1 hour)

Farming with Nature 4 Weed and Insect Management continued (2 hours)

Farming with Nature 4.2 Insect and disease management (2 hours)

Drama (30 minutes)

Weather and Climate Change 4 Farming to Reduce the Threat of Climate Change (3 hours)

Goal: Discuss what farmers can do to slow down climate change and plan ways to cope as a community with climate change.
Weather and Climate Change 4.1 Farming to reduce climate change (1 hour)
Weather and Climate Change 4.2 Challenges for community planning (30 minutes)
Weather and Climate Change 4.3 Developing a community plan for climate change (1 hour)
Drama (30 minutes)

Day 12

Inequality 8 What We Can Do about Gender-based Violence (3.5 hours)

Goal: Discuss people's responsibilities in the community and support for victims of violence.
Inequality 8.1 Speaking out (1.5 hours)
Inequality 8.2 Resolving conflict (1 hour)
Inequality 8.3 Support networks (1 hour)
Tea/Coffee/Healthy Snacks Break (30 minutes)

Inequality 9 Alcohol and Drug Abuse (1.5 hours)

Goal: Talk about the effects of alcohol and drug abuse and how people can help each other.
Inequality 9.1 Understanding alcohol and drug abuse (1 hour)
Inequality 9.2 A man gets drunk (30 minutes)
Lunch (1 hour)
Farming with Nature 5 Planning Your Farm (2.5 hours)

Goal: Learn to understand connections in mixed farming systems and plan for the future.

Farming with Nature 5.1 How to make important decisions about your farm (2 hours)
Farming with Nature 5.2 Planning ahead (30 minutes)

Day 13

Inequality 10 Gender Inequality and HIV (1 hour)

Goal: Learn about HIV and AIDS and how HIV is linked with inequalities.
Inequality 10.1 Defining HIV/AIDS (30 minutes)
Inequality 10.2 A woman gets HIV (30 minutes)

Tea/Coffee/Healthy Snacks Break (30 minutes)

Inequality 11 Raising Children (2.5 hours)

Goal: Discuss how positive parenting can help children grow into the people we want them to be.

Inequality 11.1 The needs of children (1 hour)
Inequality 11.2 Positive parenting skills (1.5 hours)

Lunch (1 hour)

Final Reflections (1 hour)

Goal: Make a commitment to be a more involved community member, parent, spouse, and farmer.

Final Reflections 1 Promoting gender and social equality (30 minutes)
Final Reflections 2 Staying involved (30 minutes)

-