THE IMPACT OF CONSERVATION AGRICULTURE ON FOOD SECURITY IN THREE LOW VELDT DISTRICTS OF ZIMBABWE

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Conservation agriculture (CA) is not a new technology and there is extensive literature on the agronomic, economical and environmental benefits of CA, however the impact of CA on the livelihoods and food security of smallholder farmers has largely been assumed. This paper presents results from evaluations of Concern Worldwide’s CA programme in three semi-arid districts of Zimbabwe to demonstrate the impact that CA has made on food security at household and village levels.

For substantial and equitable progress towards food security, increased attention to and investment in agricultural development is required, with a focus on poverty reduction, mitigated global warming emissions, resilience to the effects of climate change and the rights and education of women farmers. Based on both agronomic and livelihoods research, investment in CA by both national governments and donors has the potential to meet these conditions, and so contribute towards rural poverty reduction and an increase in food supply, while at the same time maintaining or improving soil fertility and providing a range of environmental goods and services.
Overview of conservation agriculture

Conservation agriculture (CA) was born out of the United States’ dust bowl of the 1930s and is widely practised in large-scale commercial agriculture in North America, Brazil, Australia, Argentina, Morocco, South Africa and Paraguay, and increasingly in Europe, China and India. The current focus of research is on adapting CA to the needs of smallholder farmers in Africa, Asia and South America who lack the resources, particularly mechanisation, of large-scale commercial farmers.

CA is based on three principles: minimal soil disturbance, permanent soil cover and crop rotations. Its aim is to achieve sustainable and profitable agriculture which will improve farmers’ livelihoods. The practice of CA holds potential for all farm sizes and varied ecological conditions, and it is seen as particularly useful for smallholder farmers, especially those with labour and input shortages in the drier tropics.

Constraints of conventional agriculture

Conventional agriculture, either by hand or using draught power and a plough, leads to reductions in soil fertility and its physical deterioration. Continually inverting the soil dries it out and destroys its natural structure. The soil becomes prone to wind and water erosion and, in the tropics in particular, ultraviolet radiation from the sun kills beneficial microbes. Repeated passes, especially with mechanised traction, leads to the formation of a plough pan, a hard layer which roots cannot penetrate and which may impede drainage. Ploughing is very fuel or labour intensive and therefore limits participation by poor sick, or poor elderly, farmers.

Conventional farmers must wait until the first rains of the season have softened the soil before they can prepare or plough their land for sowing. Many poor farmers do not own their own tractor or animals for draught power and must wait several weeks before they get the use of that draught power and can sow their land. The Golden Valley Agricultural Research Trust (GART), Zambia, found this delay in planting to be the largest factor in reduced harvests, with 1.5% of potential maize yield lost for each day of delay after the first opportunity to plant.
What is conservation agriculture?

**Reduced soil disturbance**

Instead of ploughing, seeds are planted using methods that avoid soil inversion. Ideally seeds should be drilled directly into the soil, but for smallholder agriculture intermediate systems that use a ripper or planting basins for sowing have proved to be effective. In this way, as little as 15% of the soil is disturbed. Rippers and planting basins have the added advantage that farmers can prepare their land during the dry season in advance of the rains, which reduces the labour demand peak at the start of the rains. CA is labour intensive in the first year, but labour requirements are greatly reduced in the following years as the same planting pits or ripper furrows are used.

**Soil cover**

Crop residues are left on the ground from previous years, forming a protective mulch that prevents weed growth, releases nutrients back into the soil and builds up soil organic matter. The mulch protects the soil from water and wind erosion, avoids “capping” due to the impact of raindrops, reduces evaporation and keeps the soil at a cool, even temperature. It is possible to keep the soil covered by intercropping with low ground cover crops (ideally nitrogen fixing); for example intercropping maize with cowpeas. There can be a high labour requirement for weeding if mulch or herbicides are not used to control weeds, especially in the first year, but this reduces by season three as the soil weed seed bank declines.

**Crop rotation**

Crop rotation is a traditional practice to manage soil fertility and prevent the build-up of insect pests and soil pathogens; however monoculture farming has replaced it in many parts of the world. Poor farmers who struggle to feed their families are often reluctant to rotate their staple crops with non-staple crops, however with greater crop variety there is often a longer productive season which can continue to provide food or an income, reducing the hunger gap. Increased variety of crops can diversify farmers’ incomes and spread the risks of harvest failure. Farmers can also rotate crops with different peak labour requirements to spread the need for farm labour.
**Impacts on food security**

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) compared yields from farmers practicing CA (planting pits) with farmers using conventional techniques and found that average CA yields were 80% higher than those from conventional farming. When micro-dosed nitrogen fertiliser was included in the CA farming, yields were 340% higher than conventional farming yields. CA outperformed conventional practices every year except one year during the 30 years of comparisons.

**Figure 1.** Long term data on maize yield from CA in Zimbabwe using basins with and without fertilizers

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**Link to climate change**

Smallholder farmers in developing countries are set to face the brunt of the effects of climate change. Therefore it is important that any discussion on food security recognises the potential impact of climate change. Abnormal fluctuations in air temperature and an increase in the frequency and intensity of drought and floods as a result of climate change will have significant impact on agriculture and food production. Smallholder farmers in Africa who are already least able to cope are likely to endure an even more adverse impact.
CA was originally developed to prevent soil erosion and the practice has a number of environmental benefits that help buffer farmers from the effects of climate change. The improved soil structure, mulching with crop residues, and associated increase in soil organic matter, improve rainwater infiltration and reduce evaporation from the soil. The higher water holding capacity of the soil enables crops to reach maturity using residual soil moisture even if the rains cease before the crops have reached physiological maturity.

Further research is required to understand the carbon sequestration value of CA. Soil disturbance during conventional agriculture releases global warming gases, while reduced tillage and more soil organic matter increase the capacity of soil to capture and store carbon. Against these gains, research on reduced tillage systems indicates that denitrification rates may increase, especially under certain conditions, leading to emissions of N₂O and CH₄ which are powerful greenhouse gases. CA principles discourage residue burning and, through sustainable land management, reduce the need to clear new fields from forests and bush which releases CO₂. Soils which are minimally tilled reduce the carbon footprint of high input farming activity as there are lower requirements for fuel and artificial fertiliser.

Challenges

To forsake the plough is very difficult for farmers, and this change of mindset is probably the greatest challenge for CA adoption. However, the practice has gained status among both developed and developing countries. Weed control is a large challenge, especially in the first year, when six to seven weedings are required in the semi-arid districts of Zimbabwe. This reduces to three weedings in the second season, which is similar to conventional agriculture. In the third and subsequent years, two weedings should be adequate. Correct composting of farmyard manure or plant matter and dry season weeding are critical for weed control in Zimbabwe, though these activities are not easily adopted.

Shared labour systems can meet initially high labour requirements but also have considerable community benefits. Shared labour in parts of Zimbabwe has proven to be highly popular, with substantial benefits for social capital and knowledge sharing. Shared labour has been a critical benefit for extremely vulnerable households, particularly the elderly and chronically sick. There may be a need for herbicides for weak and elderly farmers.
There is often competition for crop residues after harvest as livestock traditionally have access to fields to graze on such residues. On marginal land, it is difficult to produce a substantial mulch cover of residue or cover crop to impede weed growth.

**Concern CA in Zimbabwe**

In 2006, Concern Worldwide introduced a version of CA which is particularly suitable for farmers lacking draught power. This is based on manually prepared Zai holes (planting pits, a technology adopted from farmers in the Sahel), in three semi-arid communal areas in low veldt districts of Gokwe North, Gokwe South and Nyanga which had been neglected during the colonial and post-colonial periods. The CA component was part of a programme that also included food aid, seed, fertilisers and tool distributions and support for vegetable gardens, primarily funded by FAO (UN Food and Agriculture Organization) and DFID (UK Government Department for International Development). For the initial CA project 1,120 farmers participated and by the 2009/10 season 4,570 farmers were taking part.

![Figure 2. Number of farmers involved in CA project in Gokwe North and South and Nyanga](image-url)
It is important to note the impact of political instability and violence on both the work and the evaluation studies. While Concern Worldwide was never forced to leave Zimbabwe, project staff could not always travel to the field to meet the beneficiaries. Some of the beneficiary farmers were forced to abandon their fields and were subjected to politically-motivated violence. Hyperinflation and poor macro-economic planning meant that inputs were unobtainable and the enforced sale of maize to the Grain Marketing Board at below market rates was a strong disincentive to increasing production above subsistence levels.

**Conservation farming methodology used in Zimbabwe**

During the dry season each farmer created a 50m x 50m CA plot, with rows of planting pits. Composted kraal manure or plant compost was placed in the prepared pits, together with basal fertilizer if available. Concern has been working with the International Centre for Research in the Semi Arid Tropics to promote “micro-dosing” of fertilizers as part of CA, maximizing the benefits of any investment in fertilizers. Farmers plant their seeds in pits with the first effective rains of the season.

The CA plot was divided in such a way that half of the area was under maize and the other half divided equally between sorghum, groundnuts and cowpeas. The sub-plots were rotated each season and farmers practiced micro-dosing of fertilizers and lime. The programme began working with selected innovative farmers (master farmers) to demonstrate the benefits of CA, before using these master farmers to train the ultimate beneficiaries of the programme – the poorest and most vulnerable farmers. From 2008, two studies reported on the impact of CA on food security and livelihoods of smallholder farmers in the low potential areas of Zimbabwe.

**Impact evaluation methodology**

Concern used a simplified version of the household economy approach (HEA) to monitor and evaluate its livelihoods security programme (2006-08) in Zimbabwe. Due to hyperinflation during the period under evaluation all the food and cash available to the beneficiaries was converted into kilo
calories and the study worked on the premise that humans need a minimum of 2,100 kilocalories (kcal) per person per day to survive.

The communities had selected the beneficiaries of the project using wealth and vulnerability criteria developed by each community. This study stratified the beneficiaries and the non-participating farmers to be interviewed as the comparison (control) groups into the “poor” and the “very poor” using the same criteria. The control groups were selected from villages in the same livelihood zones as those in the CA programme, who had benefited from food aid and seed, fertiliser and tool distributions but had not been trained in CA. Completely random sampling was not always possible as the need to pair villages and stratify beneficiaries limited the pool of suitable farmers. This was particularly a problem in Nyanga District. It had suffered some of the worst election violence and many people had migrated to the highlands or Mozambique, so the pool of potential respondents was too small to stratify the farmers into poor and very poor. The results from Nyanga have therefore been kept separate in the analysis.

Researchers interviewed participating and non-participating farmers to determine how they had obtained their energy requirements over the previous year. The calorific content of all the crops harvested was calculated, combined with the contributions from livestock, food aid, off-farm labour, wild food, remittances, sale of assets, etc. The interviewer kept a running total of the kcal contribution from each crop and activity mentioned during the interview. Until the running total met or exceeded the minimum of 2,100 kcal per person per day it was clear that not all coping strategies and food sources had been identified, and the researchers continued with their questions. This approach enabled the programme to determine quantitatively the impact of CA on the livelihoods of the poor by comparing poor and very poor farmers who had adopted CA with farmers in the same wealth groups who continued to practice traditional agriculture. It should be noted that kcal was used as a proxy measure for income and not as part of a nutritional study.
Results

Crop production

Figure 3. Production comparisons (average total crop production per farmer) between poor and very poor farmers using CA and traditional practices in Gokwe North (GKN) and Gokwe South (GKS)

Figure 4. Production comparisons (average total crop production per farmer) between poor and very poor farmers using CA and traditional practices in Nyanga District
In Gokwe North and South both very poor and poor farmers who adopted CA achieved significantly higher maize production than traditional farmers (Figure 3) however, although maize production was lower in Nyanga, crop diversity was higher among CA farmers. Poor farmers, not surprisingly, produce more than the very poor, who had additional problems (old age, childhood households, disability, chronic sickness, etc.). Yield per ha. of maize ranged from 2 tonnes ha\(^{-1}\) to lead farmers achieving 4 tonnes ha\(^{-1}\), indeed the study found that some of the most successful CA farmers were reluctant to rotate their crops because their maize yields under CA had been increasing and they did not want to break their production of a staple with a non-staple crop.

### Contribution to annual food needs

The next step in the HEA analysis is to convert crop production into kcal to look at the contribution to the annual food needs of the household.

**Figure 5.** Crop contribution to annual household food needs for poor and very poor households in Gokwe North (GKN) and Gokwe South (GKS) among farmers practising CA and traditional techniques
When converted into kcal the improved maize yields contributed to 40% or more of the annual food needs of the poor and very poor CA in Gokwe North and South, compared to a contribution of 20-25% of annual food needs among conventional farmers. There was no significant difference between the contribution of maize and sorghum to annual food needs in Nyanga, however the increased crop diversity made a significant contribution towards annual energy requirements. The low production levels were linked to lower rainfall and also to a higher level of insecurity during the election period in Nyanga, which was considered to be an MDC (Movement for Democratic Change) stronghold by the ruling party.

The final stage of the analysis is to factor in other sources of food and income and coping strategies. Typically these included off-farm employment, with payment in kind, sale of assets, remittances from relatives in neighbouring countries and, in Nyanga, working on farms in Mozambique or gold mining.
Figure 7. Sources of annual household food needs for poor and very poor households in Gokwe North (GKN) and Gokwe South (GKS) among farmers practising CA and traditional techniques.

Figure 8. Crop contribution to annual household food needs in Nyanga District among farmers practising CA and traditional techniques.
Findings

When using the household economy approach (HEA) for livelihoods analysis, meeting 100% of food needs is classed as the survival threshold (equivalent to 2,100 kcal per person per day). Based on the conditions in Zimbabwe the livelihood protection threshold (sufficient surpluses available to avoid the need to sell off assets to pay school fees, medical bills, etc) was set at 150% of the food needs, while achieving 200% of food needs provided sufficient surpluses to meet livelihood shocks, rebuild assets and invest in new assets: the asset rebuilding threshold.

During the difficult political and economic climate in which the study was undertaken, the poor and very poor CA farmers in all three districts fell under the survival threshold and required food aid to survive. However, the poor conservation farmers in the Gokwes needed 50% less food aid than poor conventional farmers. The very poor control group had to undertake much more casual labour in exchange for food to reach 100% of their annual food needs.

Towards food security

From field observations the 0.25ha CA plot has become the family food security plot. The CA plot is often situated near the home and receives regular attention such as weeding, any available manure or compost and other inputs. Land ploughed in the conventional manner, either by hand or oxen, is further away from the homestead and therefore at risk from baboons, wild pigs, theft, etc. If the rains are good and resources are available the farmer will have an additional harvest from the conventional fields as well as from the CA plot, but if the rains are poor the farmer can rely on an almost guaranteed yield from the CA plot.

A follow up study in 2009 found that CA farmers in these semi-arid districts of Zimbabwe were producing an average of 3 tonnes ha\(^{-1}\), with the best farmers producing 6 tonnes ha\(^{-1}\). These farmers were no longer production-deficit households (14% food energy deficit) but production-surplus households (108% food energy surplus). Excellent rains, a more stable political environment and the end of hyperinflation (linked to the discontinuation of the Zimbabwe dollar and the adoption of the US dollar as legal tender), leading to an improvement in the availability of inputs were contributing factors in this substantial harvest increase for this year.
Each of the participating villages produced an average surplus of approximately 78 MT (179% of the village’s annual food energy needs). It should be noted that due to the good rains even by using traditional techniques the villages would have produced an average surplus of approximately 18 MT (117% of the village’s annual food energy needs). The difference between the 18 MT surplus and the 78 MT surplus is the difference between the village having only slightly more than is enough to survive and having a surplus that enables households to send children to school, cover medical expenses and purchase adequate amounts of household items such as soap. Some accumulation of wealth was recorded, enabling households to rebuild holdings of productive assets, such as cattle.

Crucially, this volume of surplus also puts the CA villages in a position to be the bread basket for surrounding, production-deficit villages as they were in a position to sell grain to neighbouring, less food secure villages or to offer grain as payment for work. Based on an assumption of five months’ grain purchase during the peak hunger season from September to January, the 78 MT grain surplus produced in the participating village could provide the total energy needs for 164 food insecure households. If no conservation farming had taken place, only 37 households could have been supported during this period. Therefore, as a community, the participating village and the surrounding non-participating villages were more food secure.

Conclusions
These studies in Zimbabwe have established that smallholder farmers could produce significant surplus quantities of maize using CA farming techniques and that the assumptions agronomists have made on the impact of CA on food security and livelihoods hold true for the semi-arid areas (low veldt) of Zimbabwe.

Due to the success of the project, CA project wards were not targeted for food aid and only non-CA wards (a sub-division of a district) received food aid during the 2009-10 hunger gap in Zimbabwe.

The next stage will be to develop market linkages for farmers. One option being tested is for CA farmers to sell their maize surpluses to aid agencies distributing food aid. Farmers who in 2006 were receiving food aid are now in a position to provide food aid.
CA principles are easily learned and CA practice can easily spread to neighbouring farmers without the need for start up costs, leading to community-wide poverty reduction, increased food security and enhanced resilience to shocks. Meanwhile, the natural resource base is protected and enhanced. CA can also play a key role in enabling the weak and elderly to participate in productive farming activity.

**Recommendations**

With changing climatic conditions, rising energy and input prices and increased demand on land for food and biofuel production, it is all the more important that smallholder farmers are assisted in finding sustainable agricultural solutions that meet their demands and are relevant to their situations. Spending on agricultural support has increased worldwide in recent decades, but not in Sub-Saharan Africa, where investment in agriculture and agricultural output remains startlingly low.

Though there is no silver bullet to ending rural poverty and creating food security, the evidence from CA promotion in three semi-arid districts in Zimbabwe shows that with the conservation agriculture approach poor farmers can increase and stabilise yields in marginal lands, under more extreme climatic conditions, where draught power is limited due to poverty and where labour is limited due to old age, ill health or migration. Given the increasing pressure on agricultural land from growing populations and other land use needs, CA also provides a way to intensify crop production without the environmental issues often associated with intensification. Investing in CA is therefore an appropriate approach to promoting food security in similar agro-ecological zones.

The crop production levels achieved by CA farmers have exceeded conventional farming each season since the start of the project, so CA appears to provide insurance against extreme climatic variations.

The results of agronomic and environmental research have shown that in addition to increased yield, CA provides public goods, in the form of environmental services. Clearly Zimbabwe is not yet in a position to compensate farmers for environmental services but environmental payments combined with improved yields would make smallholder farming profitable, even in low potential areas, for those farmers adopting CA techniques.
Based on the results of work in CA in Zimbabwe key policy recommendations for greater food security include:

- National governments should invest in CA in the tropical warm sub-humid and tropical warm semi-arid agro-ecological zones as an effective means to increase productivity and profitability of smallholder farmers in a sustainable way, and to buffer farmers from the impact of climate change.

- International donors should invest in agriculture and ensure that the poorest and smallholder farmers are part of the investment strategy. The best way to start would be to support the adoption of CA in other tropical warm sub-humid and tropical warm semi-arid agro-ecological zones through supportive policies, research and funding arrangements.

- Assuming that farmers will only invest in long-term soil fertility when they have security of tenure, in many countries widespread adoption of CA will require the provision of land titles to smallholder farmers, and clear land inheritance and ownership rights for women farmers.

- There is a need for research into the provision of environmental services, particularly soil carbon sequestration and water infiltration, through CA systems, to develop payments to farmers for the provision of environmental services.

Endnotes

1 The authors wish to acknowledge the hard work and dedication of Mark Harper, Johannes Chikarate and the Concern Worldwide Livelihoods Team in Zimbabwe.
2 Hobbs et al. (2008)
3 FAO (n.d.)
4 Ibid.
5 Ibid.; Sebastian et al. (n.d.)
6 McKell and Peiretti (2004)
7 Hobbs (2007)
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9 Thierfelder and Wall (2010)
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