An African success: the case of conservation agriculture in Zimbabwe

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This paper highlights the limiting factors of agricultural production in Zimbabwe and presents conservation agriculture (CA) as a potential solution to address many of these challenges. CA, based on the three principles of minimum soil disturbance, crop residue retention and crop rotations, targets low soil fertility, moisture deficits and low management standards through the use of soil-fertility-enhancing technologies (precision fertilizer application, crop rotations, sequencing and interactions), improved moisture use efficiency and higher standards of agronomic management practices. The paper also explains the role of CA in natural resource conservation as increasing productivity will reduce the land under crop production and increase the area under natural vegetation. Trends in the development of CA in the past five years and its current status in the country are explained, with the roles of different stakeholders outlined. Evidence on the impact of CA on both food security and the environment is presented. In conclusion, the paper looks at the various factors that may affect the spread of CA to different agro-ecological zones in the country.

Keywords:

Current situation

Yield levels and productivity of most small-holder farmers in sub-Saharan Africa are generally low and have a declining trend in the region (Thierfelder and Wall, 2009). Most small-scale farmers depend entirely or largely on their own cereal production for their food security. Due to low production levels, in many cases farmers cannot guarantee food security from their own production and very few small-scale farmers are able to sell some surplus to generate income. This makes them extremely vulnerable, and, in case of a drought need, outside assistance in the form of seed, fertilizer or food aid is required.

In Zimbabwe, farmers therefore often try to compensate low yields through extensification (increasing cropping areas wherever possible) rather than intensification to meet the basic household food requirements. This leads to a spreading of already thin resources of labour and production inputs, and of land degradation, because farmers move into marginal and fragile environments, thus compounding the problems.

Most communal/small-holder farmers apply unsustainable soil and crop management practices; in many cases land preparation is at a low standard, planting is often delayed and crops are not well managed (Elwell and Stocking, 1988). Additionally, erratic rainfall patterns, which have become frequent over the years, have affected production further and yields have declined tremendously overall, with complete crop failure in some areas in years with extended dry spells (Nyagumbo et al., 2009). Apart from water constraints, degradation of soil resources (due to salinization, water logging, soil erosion and nutrient depletion) affects the sustainability of food production across sub-Saharan Africa (Waliyar et al., 2003).

The loss of top fertile soil through erosion caused by conventional tillage and the expansion of cropping into unsuitable areas (e.g. steep slopes, riverbanks)
has also contributed to fertility decline and yield reductions. There is a growing understanding that the major cropping systems in sub-Saharan Africa are not sustainable (Benites et al., 1998). Rockstrom and Falkenmark (2000) also suggest that very substantial opportunities exist to increase small-holder farmer yields through improved soil and water management. Conservation agriculture (CA) as defined and practised in Zimbabwe today is based on the simultaneous application of three main principles: minimum mechanical soil disturbance; maintenance of ground cover with organic matter; and diversification of crop species grown in rotation, grown in sequence or association (Kassam et al., 2009), complemented by improved management of the various components through intensive participatory extension support.

CA tries to remove unsustainable parts (tillage, residue removal and monocropping) from the conventional agriculture system, thereby addressing most of the issues restricting yield increases. These issues are the following:

- High water losses through surface run-off from agricultural lands are addressed through factors that increase infiltration and reduce water evaporation (minimum soil disturbance and maintenance of soil cover).
- Soil fertility decline is addressed by increasing soil carbon through the use of organic materials as soil cover and the increased efficiency of fertilizer use through precise application.
- Rotations with legumes and agro-forestry species in rotations and interactions further add fertility to the soil.
- Poor management in conventional agricultural systems is addressed through attention to details and complementing extension support during CA promotion.
- Increased crop productivity in CA systems removes pressure from marginal areas as CA farmers are able to meet their food requirements from smaller land units.

CA in Zimbabwe tries to increase productivity by improving the management of agriculture, using available resources and technologies. This approach is complemented by research into the suitability of the various CA options in the different agro-ecological zones of the country. In the long term, the role of agro-forestry in adding fertility to CA farming systems is recognized and some research in the region has shown the benefits of some agro-forestry tree species in CA systems in increasing soil fertility (GART, 2008). Agro-forestry is also being viewed as a possible solution to address the competition for stover between CA crop farmers who use crop residue for soil cover and livestock farmers who use the stover as cattle feed. Suggestions have been put forward to use leaf litter from certain agro-forestry tree species as fertility amendments.

**Processes**

CA was first implemented by Brian Oldrieve at Hinton Estates in northeastern Zimbabwe in the late 1980s. The farm and surrounding areas were able to tremendously increase yield levels and successfully reduce soil erosion through the use of conservation farming (comprising reduced tillage and mulch retention) (Oldrieve, 1993).

The composite technology, now defined as CA (see www.fao.org/ag/ca), is a modification of this earlier farming system to address factors that have been identified as the main causes of the extremely low yield levels in the small-holder farming sector. CA was introduced to the small-holder sector by donors and non-governmental organizations (NGOs) in the 2003/2004 agricultural season to sustainably address the low productivity of farmers and improve their food security and overall cereal production.

The CA option that has been mostly promoted in Zimbabwe is a manual system based on planting basins that act as planting stations for the crops (Twomlow et al., 2006). This option was promoted mainly to address the draft power shortages in the communal farming sector, which delays planting and consequently negatively affects final crop yields. This technology using planting basins is locally labelled as ‘conservation farming’ to differentiate it from the other CA practices promoted in the region.

This strong focus on planting basins is currently shifting in Zimbabwe as more and more organizations are interested in also serving more resource-endowed farmers with animal- and tractor-drawn CA options. Currently, a variety of ripper tines and animal traction direct seeding equipment are being evaluated by farmers, NGOs, international research institutions and agriculture extension services of the Zimbabwean government.
The recognition of the positive impacts of CA on crop productivity generated in other parts of the world led to its intensive promotion by many NGOs in 2003. The need for coordination of CA activities emerged during these early stages, which resulted in the formation of the CA Task Force in 2003 at the request of donors to set up technical guidelines for implementing CA. Membership is currently made up of NGOs, CGIAR centres, universities, the Ministry of Agriculture and the Food and Agriculture Organization of the United Nations (FAO). The CA Task Force has been able to come up with implementation guidelines for CA activities, and monitors and disseminates information on CA (ZCATF, 2009). Partnerships between the FAO, international research centres, NGOs and the government, mainly the Ministry of Agriculture, have improved the visibility of CA promotion in the country because the government, including the President, is now officially supporting CA. The coordination role of the FAO has also helped in harmonizing training, implementation and monitoring of activities.

The introduction of CA in the small-holder farming sector has resulted in the formation of social support groups that take various forms, including savings clubs and other social support groups (Mazvimavi et al., 2007). The involvement of the private sector to supply inputs in some CA projects (i.e. The Union Project) has helped to initiate a market-oriented agricultural production system. In The Union Project, some private companies supply inputs (seed, fertilizer and technical support) to farmers, who will then sign contracts to sell the produce to the input supplier. The private sector is also being involved in the evaluation and manufacture of CA equipment, and strategic alliances between CIMMYT, GROWNET, HASTT and AGVENTURE have been formed.

Outcomes

In recent years, there has been a rapid increase in the number of farmers practising CA technologies involving planting basins (Figure 1). Due to the critical inaccessibility of inputs by small-holder farmers in the country during the past eight years (post-land reform period), CA promotion by different partners involved the supply of input packages (fertilizer and seed) to farmers who were willing to set up CA demonstration plots. Although this approach may be seen as discouraging adoption, many other farmers have adopted the technology despite the absence of input support. The improvement in Zimbabwe’s economic situation changed CA promotion in the country, which focuses its efforts more on training of extension personnel and farmers than input support. In this regard, over 600 extension officers and over 8000 farmers were trained in CA in 2009

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**Figure 1 | Conservation agriculture trends in Zimbabwe from 2005 to 2010**

*Note: Number of HH and wards where CA was practised.*
through an FAO-coordinated trained programme (FAO, 2009a, b).

Figure 1 shows the progressive increase in the number of farmers and the total number of wards (local administrative units) that are practising CA over a period of five years and the increase in the average number of households per ward (smallest administrative unit) during the same period.

The yield benefits observed by farmers on CA demonstration plots increased the number of experimenters without any input support. However, the actual numbers of these unsupported farmers have not been established. The numbers of wards where farmers are practising CA without support (557) outnumber those where farmers are practising CA with input support (503). Although CA demonstrations in Zimbabwe have been supported with inputs, farmers have nevertheless attributed the yield benefits in CA to several factors, which include timely planting of CA fields, availability and precision placement of fertilizers and better moisture conservation (Nyagumbo et al., 2009). These benefits have encouraged many experimenters as indicated by the number of unsupported wards, which indicates a general appreciation of the benefits of CA by farmers. Altogether, there are farmers practising CA in 1060 rural wards out of a total of 1500 rural wards in the country. This corresponds to two-thirds of rural wards. These numbers, however, do not equate to the proportion of area under CA because individual farmers have the tendency of putting very small proportions of their farm lands under CA, citing labour constraints mainly for weeding but also for basin preparation. Farmers are facing challenges in retaining crop residues in the field as a result of communal grazing systems. Crop rotations have also not been adequately implemented by CA farmers (ICRISAT, 2009). In 2009, it was estimated that Zimbabwe had a total of 15,000ha under CA (FAO, 2009a, b), constituting about 1 per cent of the total area that was put under cereals in the same year.

Animal-powered CA studies on sandveld soils in Zimuto, Masvingo by CIMMYT have shown that the yield benefits from CA progressively increase in the long run compared to conventional tillage under the same fertilizer management regime (Figure 2).

Yield advantages in CA systems compared to conventional systems have also been observed across several agro-ecological regions of the country (ICRISAT, 2009), although these may be partly attributed to fertilizer as farmer fields used for comparison may not have received the same amounts of fertilizer (Table 1). However, the yield increases observed were higher in region 3, which is a lower-rainfall area.
compared to region 2. This may be attributed to the waterlogging effects that may be experienced in CA basins when they are used in high-rainfall areas (ICRISAT, 2009). Total CA production is, however, limited by the area under CA. The small CA plots limit the impact and contribution of CA production to household food security.

The impact at national level may not be very significant as a result of the limited area under CA in relation to the total national cropping area. Farmers have cited labour constraints for basin preparation and weeding as the major constraint for not expanding the area under CA. The inclusion of mechanized CA systems has now been adopted by many NGOs and the government after realization of this impediment for up-scaling.

With the rapid increase in the numbers of farmers implementing CA that has so far been observed, and the continued active role being played by the government, it is expected that more and more farmers will turn to CA as a more sustainable way of ensuring some reasonable harvests during years with moisture stress. The actual area under CA for this season has not been established as yet, but indications suggest that it may reach close to 100,000ha nationally. One of the eight provinces in the country has recently reported an area of 20,000ha under CA for this season (Ministry of Agriculture, Mechanization and Irrigation Development, 2010a, b). These statistics are, however, still to be confirmed.

It is important to note that CA is also being promoted for its long-term impacts on the environment. Recent studies from both local and international research have shown positive changes in soil quality in terms of physical structure, infiltration rates and carbon content. The longer-term benefits of CA systems will have an impact on mitigating the effects of climate change, land degradation and soil fertility decline.

**Climate change factors**

Climate change factors of increased temperatures and erratic rainfall patterns are being addressed through increased rainfall use efficiency by employing technologies that increase water infiltration and reduce moisture evaporation from the soil. Reducing soil movement and soil disturbance ensures that soil moisture is kept on-site and more water is available for crop consumption (Thierfelder and Wall, 2010a).

Overall, CA systems have a higher adaptability to climate change because of the higher rainfall use efficiency due to higher infiltration, minimized flooding and soil erosion as well as greater soil moisture-holding capacity. The soil moisture conditions in rooting zones through growing seasons under CA are better than under conventional tillage (Kassam et al., 2009).

The positive effects of CA on climate change mitigation are evident even from local reports from across the country. Observations in some parts of the country indicate that maize crops under CA had higher germination rates and better resilience to moisture stress compared to those under conventional tillage agriculture systems (Ministry of Agriculture, Mechanization

### Table 1 | Average maize yields from CA and non-CA fields across 15 districts during the 2008/2009 cropping season

<table>
<thead>
<tr>
<th>Natural region</th>
<th>District</th>
<th>Maize yield (kg/ha)</th>
<th>CA</th>
<th>Non-CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR II</td>
<td>Murehwa</td>
<td>2132</td>
<td>1412</td>
<td></td>
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<tr>
<td></td>
<td>Bindura</td>
<td>1490</td>
<td>1208</td>
<td></td>
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<tr>
<td></td>
<td>Seke</td>
<td>1635</td>
<td>962</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1752</td>
<td>1194</td>
<td></td>
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<tr>
<td>NR III</td>
<td>Mt Darwin</td>
<td>1190</td>
<td>877</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chirumhansu</td>
<td>1428</td>
<td>914</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Masvingo</td>
<td>2439</td>
<td>1355</td>
<td></td>
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<tr>
<td></td>
<td>Average</td>
<td>1685</td>
<td>1048</td>
<td></td>
</tr>
<tr>
<td>NR IV</td>
<td>Nyanga</td>
<td>1308</td>
<td>874</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gokwe South</td>
<td>1433</td>
<td>713</td>
<td></td>
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<tr>
<td></td>
<td>Nkayi</td>
<td>1579</td>
<td>792</td>
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<tr>
<td></td>
<td>Insiza</td>
<td>1646</td>
<td>1105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>1492</td>
<td>871</td>
<td></td>
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<tr>
<td>NR V</td>
<td>Chivi</td>
<td>1658</td>
<td>874</td>
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<td></td>
<td>Hwange</td>
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<td>1262</td>
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<td></td>
<td>Binga</td>
<td>1384</td>
<td>868</td>
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<tr>
<td></td>
<td>Average</td>
<td>1383</td>
<td>870</td>
<td></td>
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<tr>
<td>Average for 15 districts</td>
<td></td>
<td>1546</td>
<td>970</td>
<td></td>
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</tbody>
</table>

*Note*: Zimbabwe is divided into five agro-ecological zones based on the total amounts of annual rainfall received as follows: region 1 (>100mm), region 2 (750–1000mm), region 3 (650–800mm), region 4 (450–650) and region 5 (with rainfall less than 450mm).

*Source*: ICRISAT (2009).
Q6 and Irrigation Development, 2010a, b). In other words, crops under CA systems could grow more continuously towards maturity without major drought stress as compared to crops under conventional tillage. In addition, the period in which available nutrients can be taken up by plants is extended due to higher available soil moisture, thus increasing the efficiency of use. Due to the improved moisture regime, crops under CA require less fertilizer to feed the crop (Kassam et al., 2009). Untilled soils also act as carbon sinks by sequestering amounts of carbon that would otherwise be released to the atmosphere and contribute to temperature increases.

Mitigating land degradation
CA aims to increase productivity per unit area, which will ensure that farmers can produce enough food on land that is currently being used for agriculture without clearing more land that is under natural vegetation. In conventional agriculture systems, soil losses of up to 50t/ha/year through sheet erosion and water losses of the order of 30 per cent of seasonal rainfall have been estimated by Elwell in 1985. It is also estimated that along with the lost soil and run-off, there are large losses of applied fertilizer nutrients and organic carbon in arable communal lands (Elwell and Stocking, 1988). In mulch ripped CA systems, soil losses of less than 5t/ha/year were recorded at the Institute of Agricultural Engineering (Nyagumbo, 2002)

Soil carbon content
Research from long-term regional trials in Monze, Zambia has shown an increase in carbon by up to 9.4 per cent in CA systems and a decrease by up to 7.3 per cent in conventional tillage systems in the first 30cm (Thierfelder and Wall, 2010b) (Figure 3). Local research across farmers’ fields in Zimbawe by Nyagumbo et al. (2009) has shown a higher carbon content in CA systems (0.609 per cent) as compared to conventional systems (0.397 per cent), although often fertilized CA systems were compared with unfertilized conventional control plots.

Soil aggregates are groups of soil particles that are accumulated as a result of soil development. They can be bound together due to increases in organic matter but can also develop through swelling and shrinking in undisturbed soil conditions. The ability of soil aggregates to resist disintegration from forces associated with tillage, water or wind is referred to as aggregate stability, and an increase in the aggregate stability serves as a sign of increase in soil quality and soil health. A general increase in soil aggregate stability has been observed in CA systems over several years in similar trials by researchers from CIMMYT, as shown in Figure 4 (Thierfelder and Wall, 2010b).

Regional trials have shown the positive evidence of CA on water productivity (Thierfelder and Wall, 2009; Thierfelder and Wall, 2010a). Higher water infiltration rates have been recorded in CA systems as compared to conventional systems, as shown in

Figure 3 | Increase and decrease of soil organic carbon in the first 30cm soil depth in a conventionally tilled treatment and three conservation agriculture treatments, Monze Farmer Training Centre, Zambia, 2005/2008
Source: Adapted from Thierfelder and Wall (2010a, b).
Figure 5. The increased infiltration is a result of improved soil physical structure due to minimum soil disturbance, reduced surface run-off and surface crop residue retention. Some local researchers have also highlighted these differences, as shown by the results from research by Nyagumbo (2002) at Domboshawa Training Centre (Table 2).

The key beneficiaries of CA to date are communal farmers in marginal areas with low soil fertility and low rainfall amounts if they are located in Natural...
Region 4 and 5 of Zimbabwe. These farmers have been targeted by organizations promoting CA and have had more exposure to the technologies. The passive role played by the government in the initial stages of the development of CA (2004/2005) has seen many farming sectors being left out and having very little exposure to CA technologies. This has recently changed due to the active role of the government and its involvement in CA promotion. It is expected that all farming sectors will be covered by future interventions.

Options for spread, greater resilience and more productivity

Spreading CA to other agro-ecological zones or countries
- Constant dialogue with farming communities implementing CA should be held and their concerns should be taken seriously by NGOs and researchers to try and adapt the technology to local conditions. Blanket recommendation and ‘recipes’ will not work for CA promotion due to its site-specific nature.
- In Zimbabwe, farmers practising CA have voiced concerns on the labour demands for both basin preparation and weeding. There is a need to develop locally adapted machinery to move from full manual systems to animal traction systems to finally reduce the labour demands in manual CA systems. All available CA options should be availed by farmers, and farmers should be in a position to make an informed decision on which option to adopt. It is also very important that CA fits within existing farming systems to avoid farmers perceiving CA activities as bringing in extra labour (maize could be introduced as a rotational crop in cotton farming systems).
- The collaboration with the private sector should be continued in order to develop standard technologies and equipment that will be acceptable to all stakeholders. Programmes of machinery development, whether by the government or NGOs, should always involve the private sector. Investment in developing effective weed management strategies is a major pre-requisite for any meaningful increase in area under CA in the country.
- Accessibility of CA information to farmers is also a requirement. This will involve availing of user-friendly extension materials by farmers and training of extension service providers in CA.
- There is a need for hard evidence on the performance of various CA technologies in different agro-ecological zones and soil types in the country. Implementers should offer a variety of options that cater to all farming sectors and allow for flexibility so that farmers can choose the technologies that suit them best.
- Farmer innovations on CA systems should be recognized and encouraged. Indigenous farming methods similar to CA technologies should be identified and used as entry points in communal areas. Active involvement of government systems in both research and extension will ensure sustainability.
- Available research on technologies or components that make up a CA system (i.e. no tillage, soil cover, crop rotations, interactions, integrated pest management) should be recognized and the results disseminated to act as evidence for CA. The involvement of regional bodies can help influence policy and allow for lesson sharing among countries in the region.

Key elements of processes and actions that build system outputs and resilience
In Zimbabwe, the process of institutionalization is being prioritized with key government institutions mainstreaming CA into regular activities. Currently, a CA module is being drafted to be used for teaching CA in agricultural colleges. The research and extension departments in the Ministry of Agriculture have incorporated CA activities in their regular programmes. The training of government and other extension staff, which has been going on in Zimbabwe, should be a continuous activity. Over 2000 individuals have been trained since July 2008.

There are over 10 demonstration sites across Zimbabwe to showcase the benefits of CA. Demonstrations
are an essential part of any technology dissemination as beneficiaries learn best through seeing the benefits of a technology. To increase adoption of CA, technologies should not be packaged but flexibility should be allowed for farmers to adopt the technologies to suit their environments.

Key conclusions from this project
We conclude that CA has the potential to significantly increase yields and agricultural productivity in a sustainable manner even for poor resources farmers, improving their food security and often enabling them to sell surplus.

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