IFAD
Investing in rural people

How to do

Designing and implementing conservation agriculture of IFAD investments in sub-Saharan Africa

Environment and climate change

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Originators

Stephen Twomlow
Regional Climate and Environment Specialist – East and Southern Africa
Environment and Climate Division
E-mail: s.twomlow@ifad.org

Robert Delve
Senior Technical Specialist – Agronomy
Policy and Technical Advisory Division
E-mail: r.delve@ifad.org

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Contact

Maria-Elena Mangiafico
Knowledge Management and Grants Officer
Policy and Technical Advisory Division
E-mail: PTAKMmailbox@ifad.org

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List of acronyms

CA	conservation agriculture
FAO	Food and Agriculture Organization of the United Nations
LUSLM	Lower Usuthu Sustainable Land Management Project (Swaziland)
NGO	non-governmental organization
PPP	public-private partnership

Introduction

This "How To Do" note offers guidance on the design, implementation and scaling up of a CA programme or project in sub-Saharan Africa. It begins with a summary of the key issues and associated questions – as raised in the Teaser – and follows this with lessons gained from experience (for more detail, see Lessons Learned). The detail in this How To Do Note flows from the recommendations in the Lessons Learned document.

It may be asked: Why is careful design so important in CA? Four reasons can be put forward over and above the obvious point that a careful design is always required to underpin good programmes.

- First, CA introduces a series of new agricultural operations, especially through its emphasis on no tillage.
- Second, CA has very often been promoted insensitively in sub-Saharan Africa, and uptake – with notable exceptions – has been generally disappointing.
- Third, CA programmes need to be carefully designed if they are to address IFAD's target group of poor rural people.
- Fourth, there has been considerable controversy regarding the design and promotion of CA in sub-Saharan Africa and its overall potential in Africa: the aim here is to clarify these issues.

Throughout this current document, an eye is kept on IFAD's Strategic Objectives (Box 1). As an *aide memoire*, the three principles or "pillars" of CA are presented in Box 2.

Box 1. Conservation agriculture and IFAD's strategy

Conservation agriculture can make an important contribution to IFAD's strategic efforts to focus on poor rural people, their livelihoods and food security through small-scale agriculture.[1] Women can be major beneficiaries through reduced labour, increased crop production and improved systems resilience. Two of IFAD's strategic objectives are clearly reflected:

Strategic objective 1: Increase rural people's productive capacities.

Strategic objective 3: Strengthen the environmental sustainability and climate resilience of the economic activities of rural people.

It is also important to note that conservation agriculture is a specialized form of "climate-smart agriculture" with its combination of improved crop production, increased carbon sequestration and better climate resilience, which IFAD strongly supports.[2]

The steps followed in How To Do Note are simple and logical. The summarized "key issues/questions" and the "lessons from experience" bring the reader broadly up to date with the situation regarding CA in sub-Saharan Africa. These are followed by design guidelines, conclusions and strategic recommendations and, finally, some suggestions for additional resources.

Key issues/questions

Conservation agriculture, especially in relation to sub-Saharan Africa, raises numerous issues and questions. Below are the most important. These were raised in the Teaser and answered to the extent possible in Lessons Learned.

Box 2. The three principles of conservation agriculture

- Continuous minimum mechanical soil disturbance.
- Permanent organic soil cover.
- Diversification of crop species grown in sequences and/or association.

Source: Food and Agriculture Organization of the United Nations (FAO).[3]

1. Purism or pragmatism?

Giller and colleagues published a provocative article in 2009: *CA and Smallholder Farming in Africa: the Heretic's View*.[4] Their basic argument is that sub-Saharan Africa cannot simply follow a prescribed "transfer of technology" course and adhere to its strict principles. But can there be "gradations" of CA tailored to particular situations?

2. Residues versus fodder – mulch or other uses?

In much of Africa, particularly in semi-arid zones, there is a high opportunity cost in not using residues as fodder for livestock or fuel. How then is it possible to break into the cycle of CA, where many of the benefits and the sustainability of the system depend on residues remaining on the ground?

3. Fertilizer and fertility management – can yields be sustainably improved?

Improving soil fertility in Africa is essential for any crop improvement system. The infertility of the continent's soils means yields in the early years of CA can be lower than under conventional tillage. This is a significant disincentive to farmers. How can soil fertility enhancement be ensured under CA?

4. Weeds: a manageable menace?

CA has grown worldwide alongside the use of herbicides. But in sub-Saharan Africa the logistics of spraying with herbicides are beyond most smallholders – and under CA burying weeds through ploughing is not permitted. How can farmers be best helped to control and manage weeds?

5. Crop rotation – what to do where the market for legumes does not exist?

Crop rotations conventionally include a legume crop in the cycle. But is this realistic if holdings are very small and if a reliable market does not exist? Are there suitable alternatives for the African situation, for example, intercropping with legumes or agroforestry with indigenous tree species?

6. Labour – does CA ease the hard work?

Seventy per cent of power on sub-Saharan farms comes from manual labour. It hardly needs repeating that women do most of this work. Thus the question is: Does CA reduce labour requirements or do early-season weeding burdens actually increase them? If so, what could be done.

7. Water harvesting – can CA play a role?

Throughout the semi-arid zones of sub-Saharan Africa, water harvesting provides food where rainfall is inadequate. Water harvesting depends on leaving areas of land bare for catchment – yet this appears to contradict the principles of CA. Can the two be reconciled, for example, by focusing mulch selectively in the vicinity of the planted area?

8. Soil and water conservation structures – are they still needed under CA?

Many of the areas where CA is being introduced have existing soil and water conservation structures – earth bunds and contour grass strips. Do they still have important and complementary roles to play, not just for conservation, but as important locations for planting fodder, mulch or agroforestry species?

9. Livestock – how can they best be integrated into CA systems?

Few African farming systems are based on crops alone. The competition for crop residues has already been noted. So, how can livestock be best accommodated within a CA system? Can livestock herders be brought into the picture? Should zero-grazing be promoted alongside CA?

10. Mechanization – can CA help take the burden out of farming?

In sub-Saharan Africa, the two common forms of primary operations for CA are basins dug by hoe and rip-lines opened by oxen. Tractors with direct drills may be feasible in some situations. But lack of appropriate machinery is a real constraint: Can simple and cheap machines and tools be manufactured in adequate numbers locally?

11. Incentives – are they starters, bribes, shared costs, rewards or compensation?[5]

It is almost inevitable that farmers will need a kick-start to help them on their way towards sustainable systems of CA. There are multiple set-up costs involved, for example, new equipment, herbicides and fertilizers. How can support be given without incurring a “dependency syndrome”? What about microcredit?

12. Scaling up – how to break out of the project/pilot enclave to reach the majority?

Many reports testify to the promise of CA projects, while uptake remains low. CA thrives best where it picks up a critical mass of participating farmers. Thus, the question remains: How is the scaling up to the community level and beyond best stimulated? How can scaling up (institutionalization) be achieved?

13. Triggers – what fires the starting gun?

In most cases of technology adoption, it is possible to identify a trigger or driver that stimulates the process. The problems farmers face can often provide these triggers, labour or input shortages, for example. So, do we know enough about farmers’ primary constraints – the things that can guide us towards entry points?

14. Socio-cultural issues – do we focus too much on technology?

CA may appear to be a case of a new technological approach that, once adopted, provides clear benefits. But it may be that the burning of residues is valued for hunting small animals. How readily will people break with the age-old tradition of ploughing? Are such factors taken adequately into consideration?

15. Extension and advocacy – in what ways can change agents become more relevant?

CA is knowledge-intensive, so it is vital that extension staff and change agents are brought up to speed with developments. To influence farmers, farmer field schools have worked well in sub-Saharan Africa. But what about community-to-community exchange visits and even internships where CA thrives?

16. Research – can the scientific community add value?

CA offers a particular opportunity for applied research in sub-Saharan Africa. Researchers may find publication easier with CA gaining so much international renown. Could it also be that innovative farmers and communities have important contributions to make as they test and try the system for themselves?

17. National campaigns – pulling together to bring about change. The only way to create real impact?

Government, the private sector, non-governmental organizations (NGOs), research institutions, farmers' associations and communities all have to contribute to the scaling up and extending of CA. But they can only be brought together by a strong and sustained national campaign, endorsed at the highest level. How best can this be achieved?

Lessons from experience

What follows is a summary of some of the most important lessons applicable to programme or project design, which were presented in full in Lessons Learned.

Poor adoption, with notable exceptions

CA has had a poor record of adoption in sub-Saharan Africa, although there are some notable exceptions. There are multiple reasons for this and it is simplistic to think there is an easy solution. In southern Africa, there have been notable successes due to strategic campaigns based on location-specific approaches, characterized by "systems thinking" and project responsiveness. For CA to succeed there needs to be a focus not just on the three principles, but also on the introduction of key supplementary practices and an enabling environment, as depicted in Figure 1 (from Lessons Learned). These ensure that farmers' constraints are addressed and that there is support at all levels. This concept forms the basis of the guidance for design.

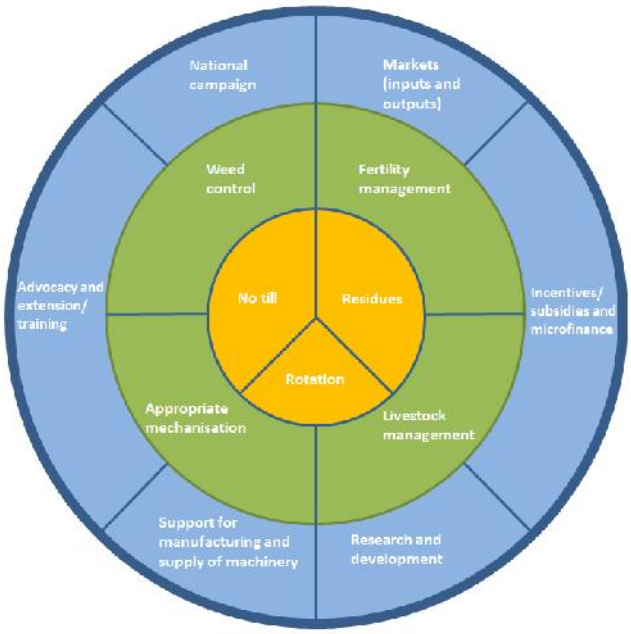

Figure 1. Conservation agriculture: principles surrounded by practices within an enabling environment (developed from a CA principles graphic: African Conservation Tillage Network)[6]

Not all reasons for failure or success are peculiar to CA

Many of the reasons for failure (e.g. mixed messages, inappropriate incentive levels, too short a programme duration), and a number of the factors behind success (e.g. concerted campaigns, common platforms, farmers' concerns addressed) are not peculiar to CA. They echo past experience with the introduction of technological innovation in sub-Saharan Africa.

Some constraints to farmer uptake are CA-specific

Nevertheless, there are some new constraints specific to CA, including increased weed burdens, soil fertility problems, the need for specialized machinery and equipment, and better control over livestock movement. These can be overcome much more readily when a critical mass of farmers has adopted CA. Above all, that makes the supply of inputs a more attractive proposition for the private sector.

Farmers' priorities must take precedence

CA has often been introduced – optimistically – as a complete and defined technological package. This is on the basis of its technical merits in improving, inter alia, soil health, but without first considering farmers' primary problems and constraints, which are seldom addressed by CA principles alone. CA will only succeed when it is introduced on the basis of "pull" factors (farmers actively wanting it to overcome constraints) rather than "push" (agencies convinced that farmers should adopt it for their own good). CA must appeal quickly to farmers for it to spread initially: once it has been practised for several years, the incremental benefits of better yields, more residues available, increased organic matter in soils, fewer weeds and reduced labour can help ensure its sustained use.

Sub-Saharan Africa is heterogenous; a "one-size-fits-all" approach to CA is inappropriate

Sub-Saharan Africa is extremely heterogeneous in climate, farming systems and traditions. A "one-size-fits-all" approach has never had a good record in terms of technology adoption, and CA is no exception. Where CA has worked best, it has been tailored to the local context, not introduced under a simplistic transfer of technology paradigm. Sometimes "partial" CA can still deliver benefits (e.g. where ground cover is poor and/or legumes are not fully integrated into a rotation).

CA can open up a series of secondary challenges that need addressing

Smallholders have often run into secondary problems after starting CA, for example, availability of suitable machinery (especially ox-drawn drills), fertilizers, herbicides and open access grazing on their fields. Programmes that have not addressed these constraints have made limited progress.

Residues for mulching are a major limitation

Residues for mulching pose a particular challenge because of their alternative value as animal fodder and fuel, especially in semi-arid areas. This issue has seldom been adequately confronted and remains problematic. Farmers in some areas have resorted to biomass transfer, bringing in grasses and reeds from forests and wetlands, for example. While this might help to "prime the system" for a few, there may be dangers of increasing degradation elsewhere, especially on common lands.

Crop rotation needs to be approached with creativity

Crop rotation is central to CA, being one of its three principles. It can be achieved in a variety of ways, but without market development, for legumes in particular, standard whole-plot rotation options have not often proved economically attractive to farmers. Crop associations and agroforestry are more promising.

Herbicides are necessary in most situations

Weeds have proved a major issue under CA. Herbicides – with associated equipment and skills – are a prerequisite for all but the smallest plots; otherwise, the weed burden exacerbates one of the most common farmer constraints, namely, shortage of labour.

Soil fertility management is an essential companion to CA

Soil fertility improvement must go hand in glove with CA. Inorganic fertilizers and manures are indispensable to effective CA and its adoption in sub-Saharan Africa. This is the only way yields can be improved in the short term, and without this, farmers will become discouraged. It has long been a development mantra that farmers will only respond to new ideas if they receive benefits rapidly. It is no different with CA.

Incentives are crucial; but pitched too high lead to "pseudo-adoption"

Incentives are invariably provided to give farmers a lift into the "virtuous cycle" of CA benefits. But it is clear that incautious use of handouts can mean they are sometimes the sole reason for farmer uptake, and farmers may abandon the system when handouts are withdrawn. There appears to be little articulated experience with provision of microcredit for CA programmes in sub-Saharan Africa. This is surprising, as it offers an alternative to incentives and can help ensure sustainability post-programme.

Careful design is necessary to reach IFAD's target group

IFAD's target group of poor rural people – in sub-Saharan Africa these are mainly smallholder farming families, many headed by women – is not the easiest constituency to reach with CA. Despite its merits, CA is no simple "silver bullet" that can be quickly, cheaply or easily taken up in its full form. Experience over the last two decades indicates that success can result, but this is only possible with careful and targeted design.

Guidance for design, implementation and scaling up

Conceptual framework: programme phases, processes and progress

A generic problem path was presented in Lessons Learned and is reproduced here. It will be noted how this feeds into the conceptual framework introduced on the next page.

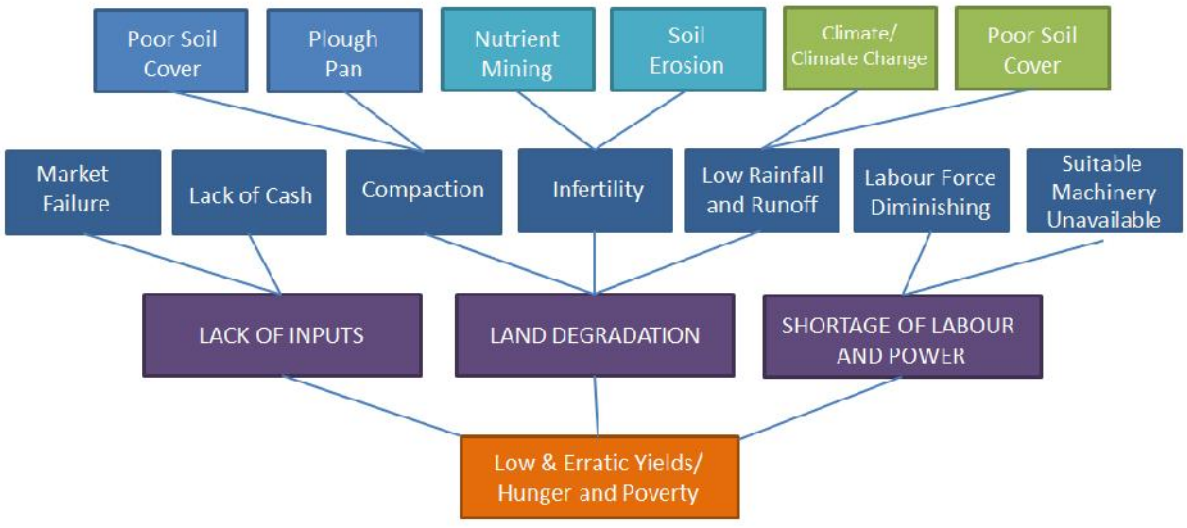

Figure 2. Generic problem path of smallholders in Africa

The conceptual framework that has been developed shows how CA helps to bring about a rural transformation from low and erratic yields, with hunger and poverty among poor rural people, to a situation where sustainable intensification of production through graduation to (at least) semi-commercial production is achieved (Figure 3). This framework is a generic model, but it serves to show how CA, accompanied by supportive practices and an enabling environment, can drive the processes that lead to the desired outcome.

Figure 3. Conservation agriculture in sub-Saharan Africa: a conceptual framework

Design procedures

Introduction and guiding principles for design

Lessons learned about CA in sub-Saharan Africa have demonstrated that designing a CA intervention as part of a broader project requires a systems approach. This means mixing and matching various aspects of technology and support to provide "best fits"[7] once the problems to be overcome have been identified and prioritized. It also implies an initial design-stage analysis of what is currently happening with CA in that country, as most countries in sub-Saharan Africa have some experience with CA. There is no single type of CA that will satisfy all farmers, even in apparently similar agroecological and socio-economic situations. Thus, the task of the designer is to remain flexible, provide a basket of ideas and be ready to guide farmers towards their goals – whether these be self-sufficiency, semi-commercial production or fully commercial enterprises.

With the emphasis on IFAD's target group of poor rural people, it is understood that farmers' ambitions change over time. These changes need to be tracked as farmers follow an incremental investment in CA and improve their farm productivity overall. This is especially so if they begin by adopting "partial" CA, with not all the principles being strictly adhered to at first and graduation to complete CA systems coming later.

This section looks at farmers' constraints, and thus the potential entry points where CA can make a difference, and gives an overview of the main systems that are likely to form the basis of CA enterprises – categorized by their source of power: hand, oxen or machine. The section then moves on to design considerations using Figure 1 as a framework. Taking the three CA principles at the core of the graphic, it then considers the four key associated practices. Finally, it concludes with the six aspects of an enabling environment that are considered crucial to establishing a sustained programme within a country and to laying robust foundations for scaling up of CA.

Identifying farmer constraints – looking for entry points

Three basic causes of poor agricultural production in sub-Saharan Africa are illustrated in Figure 2. These are:

(i) lack of inputs (caused primarily by cash shortage and market failure);

(ii) land degradation (with multiple causes, including soil fertility decline); and

(iii) shortage of labour and farm power for land preparation and planting (migration of labour away from farming, lack of draught animals and lack of appropriate mechanization).

During project design, it is essential to trace key primary constraints – usually there will be information available from other projects or agencies. Often constraints, which also represent potential entry points, will fall into one of the above three categories, though there may be others. If one (or more) of these expressed concerns/constraints is identified, and then specifically targeted as a priority by a CA programme, this can act as a trigger for adoption; to turn this around, if primary constraints are *not* addressed, then CA will simply not take off. Lack of inputs will require either incentives, where farmers are short of cash, or provision in the short term, of the inputs themselves on a loan basis. Land degradation will almost always be present, and breaking out of the vicious cycle implies increasing natural resource management and fertilizer use as well as manures and composts alongside CA. Improved yields then provide more residues and so forth. Shortages of labour and farm power should be addressed automatically by CA because land preparation will take less time.

Figure 4. Preparation of planting basins in Zambia

The conceptual framework (Figure 3) shows how a primary response to these constraints through CA and associated support may open up a second level of bottlenecks or secondary constraints. Then a second-level response is required, specifically directed at these fresh constraints, though many of them can be pre-empted by anticipating them. For example, a shortage of mulch may be addressed indirectly through a zero-grazing programme for livestock, or through better land tenure arrangements on common land to prevent free grazing of harvested fields.

Selecting a basic system of conservation agriculture

In sub-Saharan Africa, there are broadly three types of operational alternatives for CA, as defined by the power unit: hand, oxen or machine.

Hand systems – making a start with basins

Hand systems depend on the hoe and are based on planting pits, where seed, fertilizer and compost are concentrated (see Figure 4). These basins are broadly spaced and the land between the holes (around 85 per cent of the field's surface) is untilled – this is where weeds are sprayed or hand pulled and where residues protect the surface. Such basin planting is employed in drier areas. In the driest zones (semi-arid),

where water harvesting is required, the basins may be larger and more widely spaced with mulching only applied around the basin itself. This constitutes the *zaï* (or *tassa*) technique widely copied from the West African Sahel. Alternatively, in wetter zones, a "jab planter" may be used to constitute a manual direct-seeding system. Hand systems are often the only option for the poorest farmers; thus, many of IFAD's target groups at least begin this way. It should be the case that hand systems are gradually replaced by animal draught or machinery: that progression should be a project objective.

Oxen draught – with modified ploughs or specially designed drills

Oxen draught systems will be mostly adopted by farmers already using oxen to plough the land. The "Magoye ripper" is a local adaptation of the standard plough, and much in evidence in Zambia and Zimbabwe. It is also possible to use unadapted ploughs as furrow openers rather than soil inverters. The slits in the land, opened through a carpet of residues in a well-developed system, are then hand seeded and fertilized: this is a rip-line seeding system. Alternatively, there are a variety of drills that can be pulled by oxen – simultaneously shallow ripping, seeding and fertilizing – but most are imported (often from Brazil; see Figure 5) and are therefore expensive. Those able to afford such direct seeding systems are likely to be semi-commercial farmers with larger areas of land. Both hand and oxen draught systems make use of knapsack sprayers for the application of herbicides.

Figure 5. Imported ox-drawn drill in Zambia

Tractor-drawn equipment – commercial production on large units or hiring out to smallholders

Four-wheel tractors and direct drills are characteristic of commercial farmers with large areas of land. Tractors will normally be locally assembled, but drills will usually be imported complete. Boom sprayers and straw choppers are additional equipment, and will also usually be brought into a country ready to use. A key point here is that imported equipment must be supported by the availability of spare parts and trained expertise for maintenance. Otherwise, there is a real danger of making the same mistakes of 50 years ago when tractors were imported into Africa from multiple countries for government-operated tractor hire schemes and quickly fell into abeyance for want of replacement parts (and other reasons). It is important to note that commercial hire systems are an alternative to ownership: thus where there are multiple smallholders with one hectare or more of land, they can also be included under a mechanization scheme. In this case, a project may choose to promote hire units (including spraying services) operated by young entrepreneurs, which can become independent and privately owned for sustainable livelihoods.

Figure 6: Intercropped maize under CA in Swaziland

Two-wheel tractors are a promising alternative (see Lessons Learned), but currently suitable models and associated equipment are not widely available. In Uganda's northern region, IFAD's Project for Restoration of Livelihoods in the Northern Region intends to test a two-wheel tractor model and to incorporate CA into crop production systems, but there are no results available yet for replication. It should be noted that hand hoe systems may also be used alongside oxen or machine-powered CA systems; it may be that a small plot, close to the home, is prepared by hand very early in the season, while the main field is prepared by oxen or tractor (see Box 3).

Box 3. Case study of a recent conservation agriculture design by IFAD in Swaziland

Having introduced conservation agriculture (CA) under its Lower Usuthu Sustainable Land Management Project (LUSLM), with considerable success in terms of adoption of the concept, IFAD is currently designing a follow-up under the Smallholder Market-Led Project/Climate-Smart Agriculture for Resilient Livelihoods initiative. There are two strands to the new CA involvement, which picks up where the previous project left off. The first type of CA falls under the "climate resilient households" theme, where the aim is to encourage 12,000 families to create homestead CA plots of 0.1 hectares each, based on hand-dug basins. The aim here is to plant early and fertilize the plots with home-produced compost. Resilient food security is the objective. The second type of CA will cover the same number of families, but at an average of one hectare each. The aim is commercial production of maize and legumes. Mechanized CA will be used, with tractors and direct drills available through hire units run commercially by young entrepreneurs: the project has set aside funds to assist them to set up their enterprises. While such machinery is available in the region, experience under LUSLM has led to an insistence that any machinery should be serviceable and spare parts available. Fertilizer rates have been calculated at 150 kg/ha basal dressing and 100 kg/ha top dressing. It is planned to use the herbicide glyphosate as a pre-emergence treatment. Yields are estimated at around 2,000 kg/ha maize and 500 kg/ha beans, grown as a mixed crop. Rotations have not yet been fixed, but will be responsive to the market. It has been calculated using the Ex-Ante Carbon-balance tool that an average of 0.36 t/C/ha/yr will be sequestered over 20 years using CA. The commercially oriented production will be helped by the dedicated designed "pull" of the Smallholder Market-Led Project.

Note: see also an overview of Swaziland and CA in Lessons Learned.

Figure 7 is an attempt to categorize, very broadly, the main typologies of CA that are possible and likely to be found or to emerge under various circumstances. Thus, crop selection and rotation depend on agroclimatic zones and the market: there are various other crops that can be grown – and agroforestry tree species, too. Likewise, weeding is likely to be a combination of mainly manual work, with some herbicides among the poorer farmers. Mechanization tends to be associated with semi-commercial (or "emerging-commercial") farmers, but, equally, promoting mechanized systems in suitable conditions may help farmers graduate towards commercialization. Above all, the typologies help to demonstrate that even when the climate, lack of farm power and the market (including input supply) are adverse to semi-commercial and commercial systems, it is still possible to promote CA based on what farmers have access to. But it is essential to understand first what their primary constraints are. The design aim should be first to choose an appropriate CA system that improves reliability of production, and then one that helps farmers climb a ladder towards producing a surplus for the market.

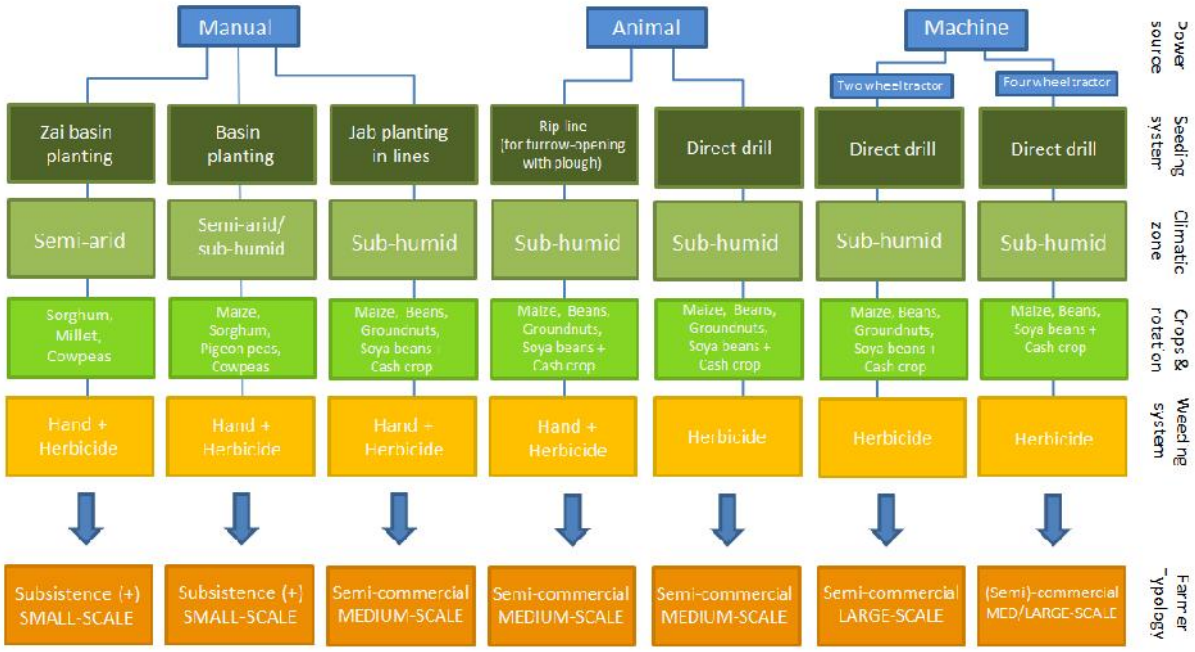

Figure 7: Main systems of CA in sub-Saharan Africa and their characteristics[a]

[a] These distinctions between systems are indicative: there are multiple system variations and combinations to be found in sub-Saharan Africa. This is simply a broad, simplified categorization.
Source: CIMMYT (2014).

Designing systems to address the three principles

The three central principles of CA, given in Box 1 and discussed at length in Lessons Learned, are briefly repeated below. With respect to design, the requirement is to find a balance between what is ideal (according to the theory of CA) and what is possible for an individual household, and how they can make incremental investments to achieve full CA.

Minimal soil disturbance basically means opening planting stations, either linear (by a tine) or a basin (by hoe) and not ploughing all the soil. This can be achieved by all of the operational alternatives set out in the preceding section. Even basins excavated by hoe (taking the spacing specified for Zambia in the national manual)[8] disturb less than 15 per cent of the land's surface.

Permanent soil cover is much more difficult to put into practice. A good crop cover can be achieved if fertilizers and manures are used, but to achieve a reasonable cover of residues is problematic in sub-Saharan Africa for various reasons, for example, competition with use of residues as livestock fodder. When designing a CA programme, this should be addressed. Options to ameliorate the situation, which are best combined, are:

(i) integrating a livestock development project alongside CA to control open grazing;

(ii) growing mulching materials along field boundaries or on soil conservation structures in-field; and

(iii) *temporarily* bringing in *a sustainable* harvest of mulch from an outside source, such as a closed-off grazing area in order to "prime" the system.

Diversification of crop species grown in sequences and/or association is the third principle, and has been already discussed at length in this toolkit. Because the introduction of a legume might be problematic for a very small farm (competing for space with the staple cereal) or because there is no ready market, it may be more realistic to promote mixed cropping with legumes. This is one of the few aspect of CA that relates directly to African tradition, and this acts in its favour. It is also an opportunity to bring nutritious legumes into the farming system: pigeon peas (*Cajanus cajan*) are a case in point. Yet another option, or supplementary practice, is encouraging farmers to use agroforestry systems based on leguminous trees, especially (where it grows) the indigenous *Faidherbia albida,* another African tradition (and one that spans parts of West, East and Southern Africa). This is a current focus of the Zambian CA programme.

Designing systems to give sufficient attention to supplementary practices

Conservation agriculture must not be thought of as being complete simply by putting the three principles in place. There are supplementary practices that, together with the principles, can be said to constitute "CA+", though in reality they are integral to CA itself. These are as follows:

Fertility management is an essential complementary practice. No-till without extra fertility brought into the system has been shown to depress yields in sub-Saharan Africa, and this acts as a direct disincentive to farmers to adopt CA. Thus, provision must be made for improving access to, and use of, compost, manure, inorganic fertilizer and liming (where needed) to accompany the introduction of CA (see Figure 8). Precision placement is facilitated by the rip-lines or basins used under CA, and this makes the most efficient use of these supplements, directing them at the crop and not the weeds. Integrated soil fertility management is urgently required in sub-Saharan Africa anyway: for CA to work optimally, it is obligatory.

Figure 8. Microdosing with inorganic fertilizer in Zambia

Weed management is of fundamental importance. While it is claimed that sufficient mulch may eventually dispense with the need for a herbicide,[9] in at least the early years, a herbicide must be an integral part of a CA package to avoid vigorous early weeds competing with the crop. Hand pulling or slashing may be options on the smallest plots, and roller-blade machines may be another possibility under fully mechanized systems, but herbicides (glyphosate as a pre-emergence application, supplemented, if necessary, by a selective herbicide post-emergence) applied by a knapsack sprayer will almost always be necessary (see Figure 9).

Figure 9: Knapsack spraying of glyphosate in Zambia

Livestock management has been touched on above in respect to the clear link between competition for residues to be used as mulch or fodder. However, the integration of livestock into CA is a broader issue, because better control, breeding and nutrition of cattle, goats and sheep can add extra value to CA – and improve farm incomes simultaneously. Either intensive forms of livestock production, including zero-grazing or partial stall-feeding, or extensive forms of pasture/range management with controlled grazing can keep livestock away from cropland (reducing loss of residues and compaction), and in the case of intensive systems, produce a valuable nearby source of manure. CA and livestock management are rarely discussed together, but they could work synergistically through skilful project design.

Mechanization, and making it appropriate and available, is fundamental where CA is thriving best – in Australia, Latin America, the United States, and, increasingly, in China. While almost all CA in sub-Saharan Africa will begin with what is currently available on-farm, CA can help raise up farming systems much more rapidly if improved tools and equipment are made available to farmers. The main issues have been examined in various studies[10] and recommendations made regarding: (i) policy (reducing tariffs on imported steel or even ready-made equipment); (ii) stimulation of local manufacturing and/or supporting local hire units run by young entrepreneurs; and (iii) issue of e-vouchers to farmers to enable them to hire equipment. While in the short term hoes can be used to dig basins and existing oxen ploughs can be used to open rip-lines, CA cannot bring the significant benefits associated with early planting and reduction in labour costs unless the mechanization issue is tackled in project design.

Designing systems to help create an enabling environment

Depending on the nature of the programme or component to be designed, it may be necessary to become involved in aspects of the enabling environment in which a CA component can thrive. Six aspects of an enabling environment have been identified in Figure 1, and these have all been discussed in Lessons Learned and at various other places in this toolkit. Thus, the following acts to highlight and summarize the most important design points.

National campaigns have proved powerful in the countries where CA has taken off in sub-Saharan Africa. Both in Zambia and Zimbabwe there has been central support and a platform driven by key agencies (the Zambia National Farmers' Union Conservation Farming Unit and the Zimbabwean Conservation Agriculture Task Force). The standardization of recommendations – and of incentive structures – is facilitated. It is no coincidence that these countries have handbooks on CA. Recognition at the national level helps in related policy formation (including, for example, climate change policy, which can recognize CA for its role in carbon sequestration, and trade policy, with its role in setting tariffs on steel imports). Exit strategies are enabled and sustainability of efforts given a boost. Thus, scaling (i.e. institutionalization) must be an integral aspect of any national CA programme or any attempt to establish one.

Advocacy at the national level can be a strong tool, and this then leads into training and capacity-building. For most extension staff, and other change agents (and administrators), CA will be a new methodology, and until they understand the potential benefits, there can be no effective extension, and outscaling is impossible to achieve. Because CA is so new, and so different, it is essential that visits are organized to see its impact on the ground, and to witness the various processes. Thus, a very important element of any CA programme is cross-visits. These can be of different forms: peer-to-peer visits within a country (where part of the country already has a CA programme), or visits to other countries (where the home country has no strong experience). It is worth considering season-long placements or internships for staff or even farmers in another country, perhaps within a farmer field school.

Incentives to farmers embarking on CA for the first time are almost always required in sub-Saharan Africa. None of the widespread successes with farmers that constitute IFAD's target group have occurred without them being given a hand-up through subsidized or free inputs. This is true of the two biggest small-scale farmer country programmes, namely, Zambia and Zimbabwe. However, incentives can be a double-edged sword, depending on how they are used: the aim must be to stimulate the farmers to use specific inputs and thereby to gain access to the self-sustaining incentive of increased yields and profitability. CA differs from many other interventions in that rapid rewards to farmers are not always forthcoming without material support for inputs, especially fertilizer and herbicides. However, the golden rules are: (i) incentives should be pitched at just the right level; (ii) for the right period; and (iii) be consistent between organizations. Thinking towards sustainability and scaling up post-project, microfinance from the private sector has an essential role to play, as was learned by the Conservation Farming Unit in Zambia during the initial phases of CA promotion using contract farming.

Markets, it is said by some, are the strongest "pull" factor behind improved agriculture in sub-Saharan Africa. Market failures, on the other hand, have led to the collapse of production systems in various countries. The essential role of the market is not just to be available to buy produce, but also to supply inputs. With respect to CA, the required inputs range beyond standard crop production packages because they include specific legume seeds, herbicides and specialized equipment (for spraying, but also for land preparation and planting). On the output side of the marketing equation, certain products – legumes in particular – need to attract a good price to entice the farmer to plant them in a rotation. Project design should be aware of market potential and make sure that recommendations and profitability calculations are based on reality. It may well be worth considering value chain studies, especially where there is potential for value addition either through processing or branding, or both.

Manufacturing of equipment is tied into the need to mechanize CA, make it less labour intensive, and to bring farmers up to a semi-commercial (or even commercial) level. While it has been stressed that a lack of specialized equipment need not be an impediment to beginning to practice CA (see previous section on system selection), the unavailability of locally manufactured ox-drawn furrow openers/rippers and drills prevents farmers moving up a level. Project design should always seek to support local manufacture and avoid the temptation of importing ready-made equipment that cannot be maintained, and whose supply dries up on cessation of the intervention. The private sector should be stimulated: it is a livelihood opportunity. Mention has been made of lobbying to reduce tariffs on imported steel, but there can be proactive moves also, including cross-visits of small-scale manufacturers to their peers in neighbouring countries.

Research and development (R&D) can be extremely important in fine-tuning a national campaign in CA. This links back to the firm conclusion from Lessons Learned that CA cannot be subjected to a simple transfer of technology paradigm, but needs to be modified and tailored to a variety of situations, even within one country. R&D needs to be firmly based on data from the field. But in common with most development initiatives, CA programmes and projects have weak monitoring and evaluation systems and therefore a paucity of basic data. Even basic parameters such as fertilizer and compost use, labour input (disaggregated by gender) for weeding, quantities of residues applied and yields are poorly recorded. Adoption levels (and "dis-adoption") are rarely monitored closely. Whichever agencies are involved in CA programmes, whether research stations, NGOs, the private sector and/or universities, they need to help projects with better monitoring and evaluation. The next step is to test improvements; and these can stem from practitioners too. Local "informal" innovation must not be ignored. As pointed out already, because of the international interest in CA, researchers find publication relatively easy – that's an important incentive.

Conclusions and strategic recommendations for design

In many ways this toolkit shows that design of a CA programme or component is little different from other technological introductions. However, as has been pointed out throughout, CA brings with it some unusual elements. The chief of these is that farmers need to adopt a fresh mindset about how they cultivate the land: a major challenge. This is testified to by the fact that CA programmes have had a poor record in sub-Saharan Africa, although there are exceptions. It is these successful exceptions that have informed the design process laid out here. Rather than an exhaustive list of lengthy recommendations, a few key strategic points that the designer needs to keep in mind are presented below. They will help ensure that a CA programme is put together in a knowledgeable way, with these strategic elements in mind.

- Be aware of what exists already: ensure that change agents and farmers make cross-visits to successful examples of CA, at home and/or in neighbouring countries.
- Think "pull" rather than "push": CA should address farmers' constraints – and the answers CA provides will then help "pull" farmers to adopt.
- CA can only work when the principles are introduced together with essential associated practices and these are set within an enabling environment.
- There must be some rapid and visible "payback" to farmers or they will reject change: soil fertility improvement is one essential component of this.
- CA should be looked upon as a means of helping the rural poor enter a virtuous cycle that can lift them from vulnerability into security and into productive income-earning enterprises.
- Without an improvement to farm labour constraints, transformation is unlikely to happen. Reducing labour – especially of women – and improving farm power has to be a priority.
- Campaigns and platforms should be encouraged to harmonize approaches among a coalition of partners.
- The private sector will be a vital partner in various ways, including input provision, marketing of produce, manufacturing of equipment and microcredit. Bring them on board.
- Always maintain a flexible and responsive systems approach: CA will not thrive if it is presented as a transfer of technology blueprint.
- An exit strategy can only be successful when incentives have been withdrawn and farmers are benefiting from the "real" incentive of CA's virtuous cycle – supported by the market.
- Check that the main thrust of the CA design is directed at IFAD's target group of poor rural people – and that vulnerable groups, including women, will be the main beneficiaries.

Additional resources

Websites

Food and Agriculture Organization of the United Nations (FAO) Community of Practice for Conservation Agriculture: www.fao.org/ag/ca.

Manuals and books

Sub-Saharan Africa/Global

Goddard, T, Zoebisch, M., Gan, Y., Ellis, W., Watson, A. and Sombatpanit, S. 2007. *No-Till Farming Systems*. World Association of Soil and Water Conservation. Special Publication No. 3. Bangkok, Thailand

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Leaflets and technical bulletins

CIMMYT. Undated. Technical Bulletin Series. Harare, Zimbabwe. Titles including:

- The Problem of Soil and Land Degradation.
- Conservation Agriculture – A Sustainable System. Technical Bulletin. Harare, Zimbabwe.
- The Role and Importance of Residues. Technical Bulletin. Harare, Zimbabwe.
- The Importance of Crop Rotations. Technical Bulletin. Harare, Zimbabwe.
- Manual and Animal Traction Seeding Systems in Conservation Agriculture. Technical Bulletin. Harare, Zimbabwe.
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Kassam, A., Friederich, T., Shaxson, F. and Pretty, J. 2009. The Spread of Conservation Agriculture: Justification, Sustainability and Uptake. *Int Journal of Agric Sust*, 7 (4): 292-320.

Shaxson, F., Kassam, A., Friederich, T., Boddey, B. and Adekunle, A. 2008. *Underpinning Conservation Agriculture's Benefits: The Roots of Soil Health and Function.* Background document for Workshop on Investing in Sustainable Crop Intensification: The Case for Improving Soil Health. July 2008, FAO, Rome.

Sims, B. and Kienzle, J. 2015. Mechanisation of Conservation Agriculture for Smallholders: Issues and Options for Sustainable Intensification. *Environments*, 2: 139-166.

Twomlow, S., Hove, L., Mupangwa, W., Masikati, P. and Mashingaidze, N. 2008. *Precision Conservation Agriculture for Vulnerable Farmers in Low-potential Zones.* Proceedings of the Workshop on Increasing the Productivity and Sustainability of Rainfed Cropping Systems of Poor, Smallholder Farmers, Tamale, Ghana, 22-25 September 2008.

Cartoon booklet

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Videos

Critchley, W., Di Prima, S. and Tuyp, W. 2012. *Sustainable Land Management in Sub-Saharan Africa.* 12 training videos with information leaflets (including CA in Zambia and *zaï* pits in Burkina Faso). IFAD, World Bank Institute and others.

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Glossary of terms and concepts

Agrobiodiversity: the variability among living organisms associated with the cultivation of crops and rearing of animals, and the ecological complexes of which those species are part. This includes diversity between, and within, species and of ecosystems.[11]

Agroforestry: land-use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.[12]

Conservation agriculture: an approach to managing agroecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely: (i) continuous minimum mechanical soil disturbance; (ii) permanent organic soil cover; and (iii) diversification of crop species grown in sequences and/or associations.[13]

Climate resilience: the capacity of a socio-ecological system to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.[14]

Climate-smart agriculture: promotes production systems that sustainably increase productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) and enhances achievement of national food security and development goals. (www.fao.org/climate-smart-agriculture/en)

Ecosystem approach: strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.[15]

Good agricultural practices: practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products.[16]

Landscape approaches: landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic and environmental objectives in areas where agriculture, mining and other productive land uses compete with environmental and biodiversity goals.[17]

Land degradation: the reduction in the capacity of the land to provide ecosystem goods and services, over a period of time, for its beneficiaries.[18]

Outscaling: adoption of a practice or systems of production by farmers or households. **(IFAD working definition)**

Public-private partnership: PPP refers to arrangements between the public and private sectors whereby part of the services or works that fall under the responsibilities of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure and/or public services.[19]

Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.[20]

Scaling up: expanding, adapting and supporting successful policies, programmes and knowledge, so that they can leverage resources and partners to deliver larger results for a greater number of rural poor in a sustainable way. **(IFAD working definition)**

Social fencing: a self-enforcing community agreement to protect an area of grazing land/wetland/forest (etc.) from use by livestock or harvesting by people without a physical barrier. **(Working definition)**

Sustainable land management: a knowledge-based procedure that helps integrate land, water, biodiversity and environmental management to meet rising food and fibre requirements while sustaining ecosystem services and livelihoods.[21]

Water harvesting: the collection and concentration of rainfall runoff or floodwaters for plant production or other purposes.[22]

Zero-grazing: permanently housed animals fed mainly by fodder cut and carried (term most commonly associated with dairy cows). **(Working definition)**

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International Fund for Agricultural Development
Via Paolo di Dono, 44 - 00142 Rome, Italy
Tel: +39 06 54591 - Fax: +39 06 5043463
E-mail: ifad@ifad.org
www.ifad.org
www.ruralpovertyportal.org
ifad-un.blogspot.com
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