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GHG Mitigation through Climate-Smart Agriculture in Southern Africa: Mitigation co-benefits in the crop sector

brief

Abstract

This brief explains the major sources of GHG emissions related to crop production in Southern Africa, approaches and technical options to reduce GHG emissions from crop production, and examples of mechanisms that could help scale adoption of climate-smart crop production practices with mitigation co-benefits in Southern Africa.

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GHG Mitigation through Climate-Smart Agriculture in Southern Africa: Mitigation co-benefits in the crop sector

Key messages

- Agriculture is a significant greenhouse gas (GHG) emission source in the Southern African Development Community (SADC) region and is one key driver of deforestation and emissions related to land use change.
- Climate smart agriculture (CSA) pursues the triple objectives of increasing productivity, enhancing resilience to climate change, and reducing GHG emissions.
- This information note describes CSA options that serve both adaptation and mitigation objectives and highlights challenges and opportunities for upscaling adoption of CSA options by farmers.
- Most CSA options are knowledge intensive, making capacity building at different levels pivotal for success.
- Scaling mechanisms that harness private sector innovation, market demand pull, and climate finance can help spur CSA adoption.

About this document

This information brief on mitigation co-benefits of Climate Smart Agriculture (CSA) in agricultural cropping systems is one of four information briefs that highlight the relevance of greenhouse gas (GHG) mitigation as a co-benefit of CSA in Southern Africa. This brief explains

ü the major sources of GHG emissions related to crop production in Southern Africa
ü approaches and technical options to reduce GHG emissions from crop production, and
ü examples of mechanisms that could help scale adoption of climate-smart crop production practices with mitigation co-benefits in Southern Africa.

þ Climate-smart crop production

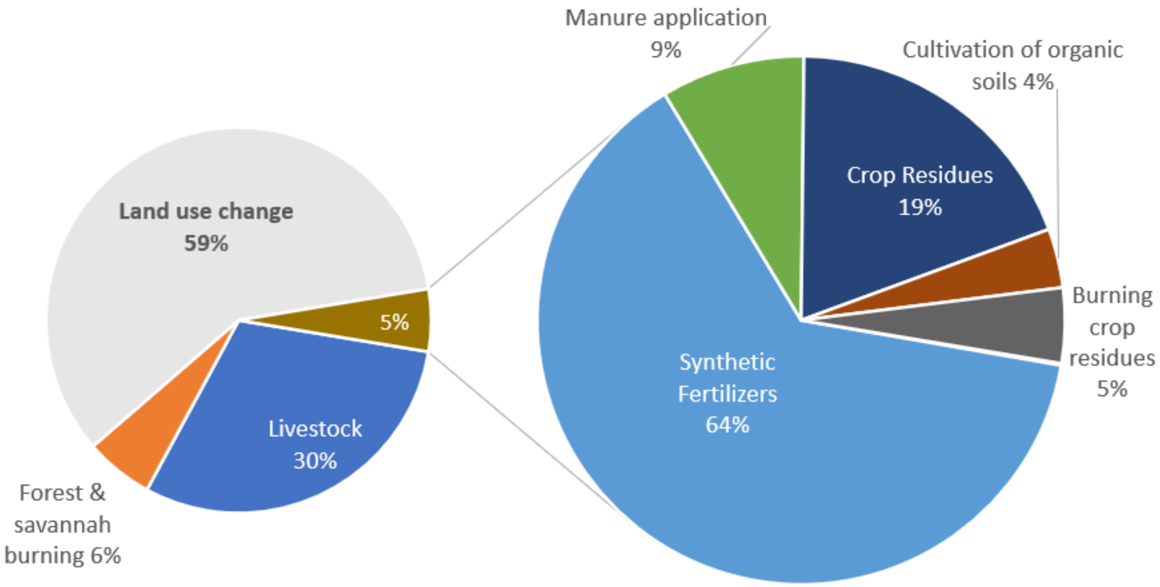
Other briefs in this series:
o Climate Change Mitigation through CSA: Challenges & Opportunities
o Climate-smart livestock
o Climate-smart landscapes

Agricultural GHG emissions in Southern Africa

Seventy percent of the population in the SADC region currently relies on the agricultural sector for income and employment and agriculture is a major contributor to national economies. Crop production in the region is primarily rainfed with limited inputs and is highly susceptible to the effects of climate change and climatic variability, including drought, flooding, and heat waves. Crop production is also a major source of GHGs. A growing population and changing diets put additional pressure on already scarce productive resources. National and regional climate policies generally prioritize adaptation and increased resilience to meet food and nutrition security objectives. However, more efficient production in terms of GHG output per unit produced, as well as reduced loss and waste within the food system, are key aspects of climate change mitigation. Many, but not all, climate change adaptation measures in agriculture offer mitigation co-benefits (depending on context). Measures with multiple economic, environmental and social benefits have the greatest chance to be adopted at scale.

Agriculture, forestry and other land uses (AFOLU) are closely interlinked. The AFOLU sector was responsible for approximately 1,280 million tonnes of carbon dioxide equivalent (tCO_2e) of GHG emissions in 2018.[1] Land use change – in particular deforestation – was the source of more than half of these emissions, livestock accounted for about 30%, while crop production emitted only about 5% of total AFOLU emissions (Figure 1). However, cropland expansion is one of the main drivers of land use emissions. Within crop-based agriculture emissions, almost two thirds are due to CO_2 and N_2O emissions from synthetic fertilizers, and 20% due to N_2O emissions from crop residues. In recent years, there has been a slight upward trend in GHG emissions from crop production in the region, mainly driven by increasing use of synthetic fertilizer (Figure 2).

Figure 1: Sources of agriculture, forestry and other land use GHG emissions in Southern Africa in 2018



Source: *calculated from data in FAOSTAT 2021 (http://www.fao.org/faostat/en/#data/GT)*

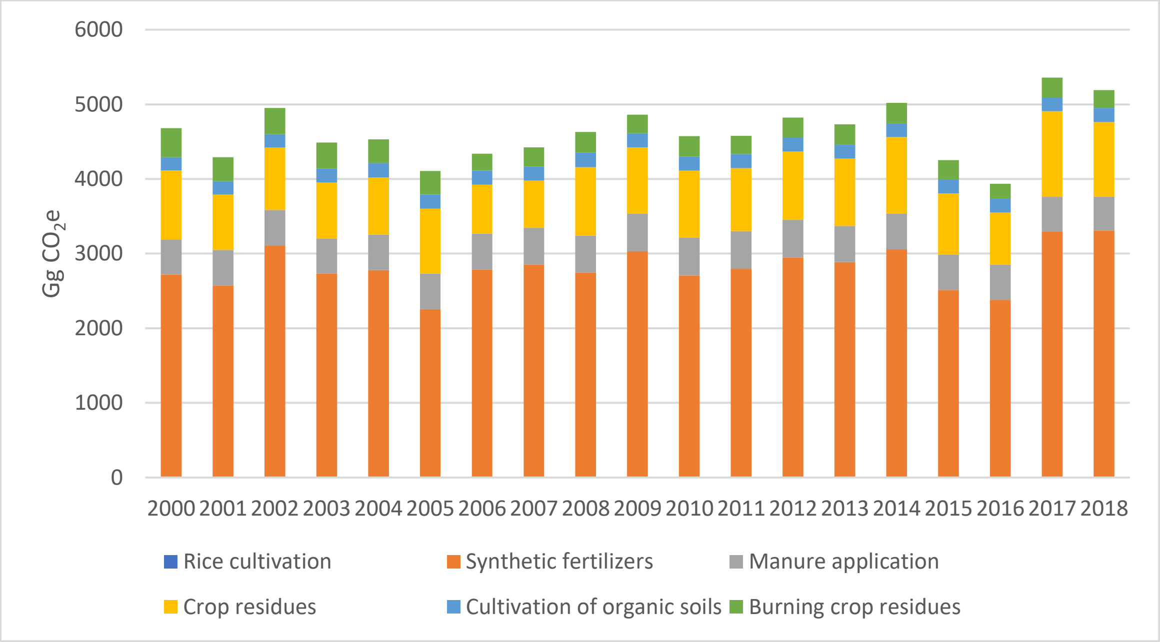
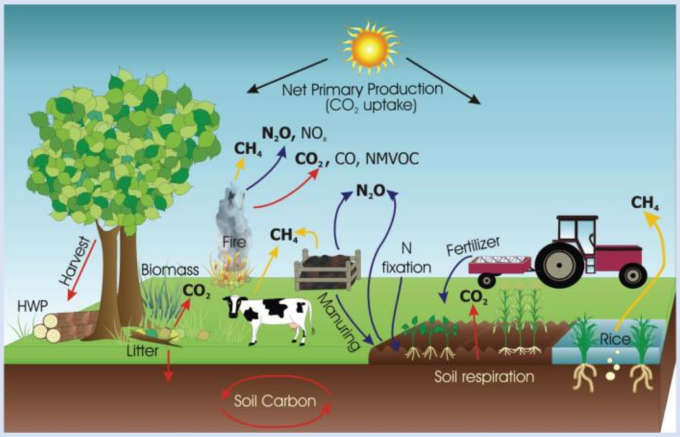


Figure 2: Development of GHG emissions from major agricultural sources in Southern Africa over the period 2000 - 2018. *Source: FAOSTAT (2021)*

Box 1: Agricultural GHG emissions and removals



Source: IPCC, 2006

Agriculture is not only affected by climate change, but is also an important driver of global warming through the emission of GHGs. Dominant GHGs in agriculture and their sources are:

Carbon dioxide (CO_2)

- application of urea releases CO_2 from the fertilizer into the atmosphere
- burning organic matter (e.g. slash and burn practices for clearing land; burning of crop residues)

Methane (CH_4)

- enteric fermentation from ruminants (i.e., cattle, sheep, goats)
- manure left on pasture
- anaerobic conditions in soils (e.g., paddy rice cultivation)
- burning organic matter

Nitrous oxide (N_2O)

- nitrification and denitrification due to application of synthetic fertilizers and organic manure to soils
- burning organic matter

Emissions are generally expressed in CO_2 equivalent (CO_2e), whereby the warming effect of CH_4 and N_2O over 100 years is converted into equivalent units. CO_2 has a global warming potential of 1, CH_4 is 28 units of CO_2e and one unit of N_2O equals 265 units of CO_2e. For example, one kg of nitrogen fertilizer releases 0.02 kg of N_2O, which is equivalent to about 5.7 kg CO_2e per kg nitrogen applied.

Agricultural activities can also remove CO_2 from the atmosphere by sequestering CO_2 in soils or shrubs and trees on agricultural land.

Common policy strategies in Southern Africa focus on agricultural commercialization, intensification, and enhancing resilience to climate change. However, the need for climate change mitigation is recognized in SADC member countries, especially in terms of the mitigation co-benefits of climate change adaptation. At the national level, agriculture has a prominent role in climate change policies, National Adaptation Programs of Action (NAPAs), National Adaptation Plans (NAPs), and Nationally Determined Contributions (NDCs). Agriculture and rural development policies and strategies include further details on how to address climate-related challenges and opportunities at sectoral level. In some SADC countries, such as Zambia, Zimbabwe and Lesotho, these strategies have been concretized in the form of Climate Smart Agriculture Investment Plans (CSAIP).[2]

One key question is how to achieve food security and adaptation objectives while also realizing mitigation co-benefits from agricultural development and adaptation? Climate-smart agriculture (CSA) aims to tackle three objectives simultaneously (‘triple wins’): (1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate change; and (3) reducing and/or removing GHG emissions, where possible.[3] CSA is an approach that helps to guide actions needed to transform agricultural systems to effectively support development and ensure food security in a changing climate.

Agriculture GHG mitigation options

In general, there are three broad approaches to GHG mitigation in crop production:

1. **Reducing GHG emission intensity**: Producing more agricultural output with fewer GHG emissions per unit of agricultural production, or 'producing more with less'. This approach is well aligned with agricultural development objectives, which often prioritise meeting the food security needs of growing populations. Enhancing resource use efficiency, e.g. through intensification of production or reduction in food loss and waste, is aligned with reducing GHG emission intensity. However, even if GHG emission intensity decreases, total absolute emissions may continue to increase.
2. **Sequestration of CO_2 in agricultural systems:** Even if agricultural emissions increase due to greater input use to boost food production, increases from some emission sources can be balanced against increased carbon sequestration in soils and trees in croplands or the wider agricultural landscape.
3. **Reducing GHG emissions from land use change:** Agricultural expansion is a major driver of land use emissions in Southern Africa. Intensification of agricultural production, and maintaining soil fertility or restoring degraded cropland soils can all reduce the pressure on farmers to expand the cropland area. This can have indirect GHG mitigation effects by reducing a key driver of deforestation and forest degradation, or by limiting the conversion of other ecosystems to cropland.

Table 1 lists a selection of widely recognized CSA practices, indicating the manner in which they contribute to the triple objectives of productivity, adaptation, and mitigation. The following sections give examples of practices that illustrate the three main approaches to GHG mitigation as a co-benefit of CSA.

Table 1: Major Climate Smart Agriculture (CSA) practices

CSA practice	Contribution to triple CSA objectives		
	Productivity	Adaptation	Mitigation
Soil and water management			
• Conservation agriculture	ü	ü	+
• Water harvesting	ü	ü	O
• Progressive terracing	ü	ü	O
• Integrated soil fertility management	ü	ü	+
Crop management			
• Improved fertilizer efficiency, micro-dosing	ü	ü	Δ
• Organic manures, composting	ü	ü	+
• Intercropping legumes, leguminous cover crops	ü	ü	+
• Stress tolerant varieties	ü	ü	O
Agricultural landscapes			
• Agroforestry	ü	ü	+
• Integrated Watershed Management	ü	ü	+
Risk management			
Climate information services	ü	ü	O
Insurance	ü	ü	O
Value chain options			
• Reducing food loss and waste	ü	ü	Δ
• Renewable energy and energy efficiency	ü	0	+

Note: ü = positive effect on productivity or adaptation; o = no effect on GHG mitigation; Δ = positive effect on GHG emission intensity; + = positive effect on absolute net emissions

Reducing GHG emission intensity

Fertiliser micro-dosing: In many parts of Southern Africa farmers do not use adequate nutrient inputs to maintain soil fertility. This can lead to a vicious cycle of nutrient depletion, declining yields, an even lower capacity of farmers to invest in fertilizer inputs. A precision-farming technique called 'micro-dosing' can make the best use of fertilizer inputs. Micro-dosing involves the application of small, affordable quantities of fertilizer with the seed at the time of planting. Typically, 6 g doses of fertilizer are applied per planting hole, translating into about 35 kg of fertilizer per hectare (exact amounts depend on soil types and fertility levels). In depleted soils, these micro amounts have the potential to double crop yields.[4] While the practice leads to a slight increase in GHG emissions compared to no application of synthetic fertilizer, GHG emission intensity (i.e., GHG emissions per unit of crop yield) are reduced (see also CCARDESA Decision Tool 21 on Climate Smart Fertiliser Application Options, https://www.ccardesa.org/knowledge-products/climate-smart-fertiliser-application-options). Fertilizer micro-dosing could also have an *indirect* mitigation effect by reducing farmers' pressure to clear additional land for agriculture.

Reducing food loss and waste (FLW): Studies have estimated that post-harvest losses account for 20-40% of the harvested yield grains, pulses, and roots and tubers in Sub-Saharan Africa.[5] Reducing FLW could make key contributions to meeting growing food demand while reducing the environmental footprint of agriculture. While FLW in industrialized countries occurs mostly at the consumption stage, in Southern Africa the handling and storage stage is prone to loss and spoilage.[6] Strategies to reduce FLW must be multi-pronged to address the various causes and factors associated with high levels of FLW. Measures that have been shown to have some positive effect in African contexts include:[7]

- Fumigants or insecticides
- Hermetic bags or silos, and
- Integrated pest management.

Beyond the farm level, there are many examples of innovations in the supply chain (e.g., new drying technologies, logistics) that can not only reduce FLW but also increase the profitability of enterprises involved in the supply chain. Legislation, regulations and other government action can also address FLW in the supply chain (Box 2).

Box 2: Engaging businesses in reducing food loss and waste in South Africa[8]

FLW occurs throughout the supply chain. It is estimated that South Africa wastes more than 20% of food passing through the production, post-harvest handling and storage, processing and packaging and distribution and retail stages. FLW can be addressed through many means.

- The Consumer Goods Council of South Africa (CGCSA) and the national Department of Trade, Industry and Competition (DTIC) have developed a Food Loss and Waste Voluntary Agreement in which companies in the food sector commit to reducing food loss and waste by 50% by 2030. Companies are encouraged to identify strategies and measures for preventing or reducing FLW and for increasing reuse of food resources and recycling.
- Western Cape has become the first provincial government to put forward regulatory measures in support of these objectives. It has issued regulations requiring municipalities to limit organic waste in landfills as a way of incentivizing businesses to find profitable solutions to reduce FLW.

CCARDESA in partnership with GIZ has also been supporting partners in South Africa, Tanzania and Zimbabwe to identify hotspots of FLW using a Rapid Loss Appraisal Tool.[9] See also CCARDESA's decision tool on Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice.[1]

Carbon sequestration in croplands

Conservation agriculture: Conservation agriculture (CA) contributes to all three CSA objectives, although to a varying extent. It has proven benefits in terms of yield increases and profitability (see Box 3), prevents land degradation, enhances resilience against heat and drought stress, and can increase soil carbon sequestration. CA is based on three principles:

- Minimum soil disturbance (e.g., use of minimum or no tillage)
- Crop residue retention as mulch (e.g., retention of dead plant material or through the use of cover crops)
- Crop rotation (e.g., planting cereals and legumes in rotation).

CA increases water infiltration and soil water holding capacity, and it protects the soil against erosion. In the longer term it also sequesters carbon leading a slow build-up of soil organic matter (SOM). This makes CA an effective climate change adaptation measure, making crops more resilient to both drought and high-intensity rainfall. Under CA, the decomposition of roots and crop residues occurs slowly, and much of the carbon is gradually incorporated into the soil profile rather than being released into the atmosphere. While direct mitigation benefits may be relatively modest, productivity and profitability increases CA can reduce farmers‘ pressure to clear new land to replace degraded plots and CA can therefore also have *indirect* mitigation benefits.

Box 2: Economic benefits of conservation agriculture in Malawi, Zambia and Zimbabwe

Conservation agriculture can bring direct financial benefits to farmers who adopt the practices, and also have positive spill-over effects into the macro-economy. The financial benefits of CA are largely due to increased yield and reduced labour requirements. In Southern Africa, maize is the primary food crop, and average yields among smallholders in Zimbabwe are less than 1 t/ha and around 2 t/ha in Malawi and Zambia. In combination with complimentary good agriculture practices, CA increases yields, so farmers have a larger surplus to sell, increasing household income and reducing expenditure for supplementary purchases of maize. Increase in local production further strengthens maize value chains, reduces the need for food aid and imports, and ultimately results in enhanced national food security and resilience.

A feasibility study conducted in 2018 provided concrete evidence of the economic benefits of CA compared to farmers' usual practice of growing maize after soil tillage as the sole crop with no intercropping or rotation with legumes.[10] Table 2 shows cost-benefit results from on-farm pilots in Zambia, illustrating the superiority of CA maize over the conventional practice in terms of net present

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[1] https://www.ccardesa.org/knowledge-products/climate-smart-post-harvest-management-options-maize-sorghum-and-rice-climate-0).

value (NPV), returns to labour (ROL), returns to investment (ROI), payback period and internal rate of return (IRR). Increased soil carbon accumulation is a co-benefit of CA practices.

Table 2: Economic benefits of maize based conservation agriculture in Eastern Zambia

Site	CSA	NPV (12%)	NPV (30%)	ROL ($)	ROI ($)	Payback (years)	IRR (%)
Vuu	Conventional maize	251.97	172.99	1.1	7.6	1.4	69
	No-till, sole maize	685.47	548.12	2.2	18.7	0.5	102
	CA maize-cowpea intercrop	777.83	613.24	2.4	20.5	0.5	97
	CA maize-cowpea rotation	673.38	534.05	2.3	20.9	0.6	99
Hoya	Conventional maize	277.72	221.95	0.9	6.5	2.2	82
	Ripline seeding CA, sole maize	500.50	380.97	1.6	14.1	0.8	87
	Ripline seeding CA, maize-soy rotation	620.24	460.35	2.0	17.8	0.6	102

Source: Thierfelder, 2019, Notes: NPV = Net Present Value; ROL = Returns to Labour; ROI = Returns on Investment; IRR = Internal Rate of Return

Agroecology – a transformative approach to climate resilience: [11] Alongside CSA, several innovative approaches fostering transformation towards sustainable and climate-resilient agriculture and food systems have emerged in recent years. One of these is agroecology. While climate-smart agriculture focuses on the triple wins of adaptation, mitigation, and the sustainable intensification of production, agroecology centres around ecological principles, socio-cultural aspects and the political dimensions of agri-food systems. Measures based on agroecology focus on enhancing agrobiodiversity, improving ecological processes and the delivery of multiple ecosystem services, as well as strengthening local communities and knowledge systems. Economic diversification and the consideration of social values and food traditions are further key aspects of agroecology. Agroecological principles such as nutrient recycling, synthetic input reduction and soil health offer entry points for climate change adaptation, but also mitigation due to the sequestration of carbon.

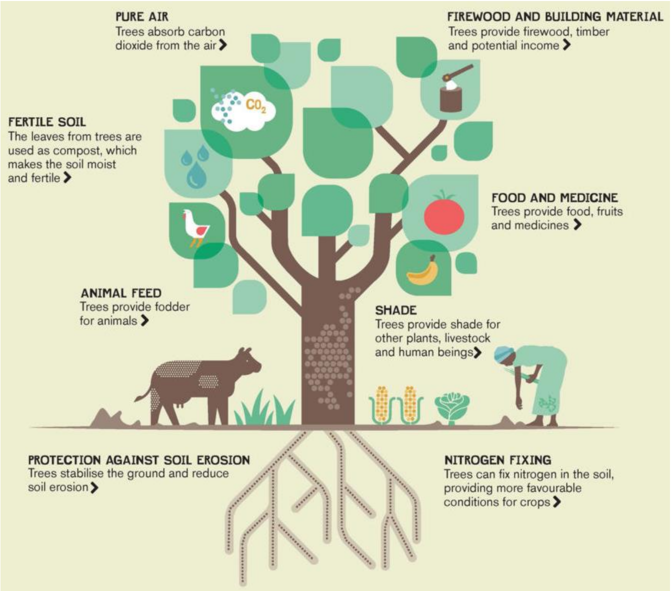

Figure 3: The multiple benefits of agroforestry
Source: *Vi Agroforestry*

Agroforestry: Agroforestry is a collective term for land use systems in which trees or shrubs are deliberately integrated with crops and/or animals on the same piece of land, either in a spatial mix or in temporal sequence.[12] While there is great variation in agroforestry systems, trees in agricultural landscapes can have multiple benefits for crop production, including carbon sequestration (see Figure 3). Improved fallow involves planting leguminous tree or shrub species ('fertilizer trees') in rotation with cultivated crops, such as maize. In Southern and Eastern Africa, more than 20,000 farmers are growing *Sesbania sesban*, *Tephrosia vogelii*, or *Cajanus cajan* in two-year fallows followed by maize. The practice can boost maize yields to about 6 t per hectare, which is comparable to conventional maize yields under fertilization. Another method is not removing existing trees, shrubs and root systems, but instead systematically keeping and regenerating these. This practice is referred to as Farmer Managed Natural Regeneration or Assisted Natural Regeneration and is a low-cost alternative to planting trees that includes land users beyond farmers[2]. While data on mitigation benefits are limited, the growing literature shows that improved fallows increase soil carbon sequestration and reduce GHG emissions.[13] Improved fallows are also a source of fodder during dry periods and provide substantial biomass for charcoal production. The latter yields additional mitigation benefits in terms of avoided deforestation for charcoal production. See also CCARDESA's decision tool 12 on Climate Smart Agroforestry Options forMaize, Sorghum & Rice[3].

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[2] https://www.wvi.org/development/publication/farmer-managed-natural-regeneration

[3] https://www.bing.com/search?q=climate+smartagroforestry+optionsformaize%2C+sorghum+%26rice&form=EDGEAR&qs=PF&cvid=c0bfab02dddd477c87d8682fedefae8f&cc=US&setlang=en-US&elv=AQj93OAhDTi*HzTv1paQdniB83IpEaucpPgGLIAetiBairJtCBB9OiA4IBNt0Hk0puGBZBJRuWfjlPZgMz4Pa4afPKuE9pY3SIq2dsI2ZWe*

Reducing GHG emissions from land use change

Agricultural intensification can reduce forest clearing and associated loss of carbon stocks and GHG emissions. A study based on a large-scale survey in Zambia found that reduced deforestation is associated with increased use of improved seeds and fertilizer inputs, but that fertilizer on its own is not linked with reduced deforestation.[14] The study also found stronger associations in more fertile soils, suggesting that efforts to increase soil fertility along with intensification of farm inputs is compatible with both increasing food security and reducing deforestation. Similar findings have been reported in relation to seed and fertilizer subsidies in Malawi, suggesting that agricultural intensification can change farmers' decisions about clearing new land.[15]

Further information on landscape approaches to reduce GHG emissions in agricultural landscapes is given in another information brief in this series GHG Mitigation through Climate-Smart Agriculture in Southern Africa: Climate-smart landscapes.

Challenges in scaling agriculture GHG mitigation options

CCARDESA has previously assessed constraints and options for upscaling adoption of CSA in Southern Africa.[16] Since measures with GHG co-benefits also have benefits for adaptation and productivity, the challenges in scaling CSA are the same for GHG mitigation options (Box 3). However, there are also some challenges that are specific to realizing the potential benefits of CSA practices for GHG mitigation.

Box 3: Challenges in scaling CSA in Southern Africa

Knowledge constraints

- At farm-level, common constraints include **lack of farmer awareness** of CSA practices and lack of access to training or other information on knowledge-intensive CSA practices, such as CA.
- At planning and policy levels, the lack of localized evidence of CSA benefits limits the ability of decision-makers and other supporting actors to promote CSA practices.

Constraints on production inputs

- **Farm labour:** Some CSA practices are relatively labour intensive, such as direct-seeding using a dibble stick or jab planter as part of CA; intercropping; micro-dosing of fertilizer; or cutting 'fertilizer trees' in an improved fallow system. Other practices, like minimum or no tillage in manual production systems on the other hand, reduce labour.• **Access to finance:** Access to finance is a major constraint to farm-level investments in improved storage technology or solar-powered irrigation, and to farmer purchase of inputs such as improved seed or fertilizer.
- **Access to inputs:** Especially in drier areas of Southern Africa, the adoption of CA can be constrained by shortage of crop residues or other organic material to maintain soil cover; furthermore, in integrated crop-livestock systems, crop residues may be an important source of feed. Specialized equipment, such as jab planters that facilitate direct-seeding under CA and micro-dosing of fertilizers, or other CSA technologies may not be locally available.

Institutional constraints

- **Insecure land tenure:** Any long-term investments in soil fertility enhancement, such as agroforestry practices or CA, can be hampered if land tenure is insecure. If farmers cannot be sure to reap the benefits of their investments, they tend to adopt soil-mining practices aimed at short-term benefits.
- **Weak institutions and policy environment:** Although national policies often support promotion of CSA, there are a number of constraints to delivering on policy goals, such as limited funding for extension services and weak coordination across different departments.

Specific to GHG mitigation, additional constraints include:

- **Lack of data on GHG effects of CSA practices:** The Evidence for Resilient Agriculture (ERA) database has summarized the available evidence on CSA practices in Southern Africa.[17] It includes 226 studies in croplands in Southern Africa, 90% of which are about grains, pulses, roots and tubers. Most of the data relate to benefits for productivity or resilience, with few studies on GHG emissions or carbon sequestration. The effects of a single practice on GHG emissions can vary significantly depending on soil types, climate and other factors. As a result, there is insufficient knowledge to estimate how much GHG emissions could be reduced from specific interventions in different places.
- **Challenges in quantifying GHG benefits:** To harness climate finance for investment to support adoption of mitigation options, GHG benefits need to be quantified. Most national GHG inventories in Southern Africa use relatively simple GHG quantification approaches (the 'IPCC Tier 1 method') that are not well

suited to accurately reflect the effects of change in adoption of CSA practices on GHG emissions. A significant challenge is the lack of accurate and regular data on changes in farming practices. Improved GHG quantification at national level can be supported by improvements in national agricultural statistics and data management systems. Many CSA initiatives operate at a local or sub-national scale. At these scales, there is some experience with GHG quantification. Box 4 gives an example of one approach to quantify GHG emission reductions from CSA activities, which has been used to generate finance from the sale of carbon credits. The next step will be to find ways to link multiple sub-national initiatives with national measurement and reporting systems.

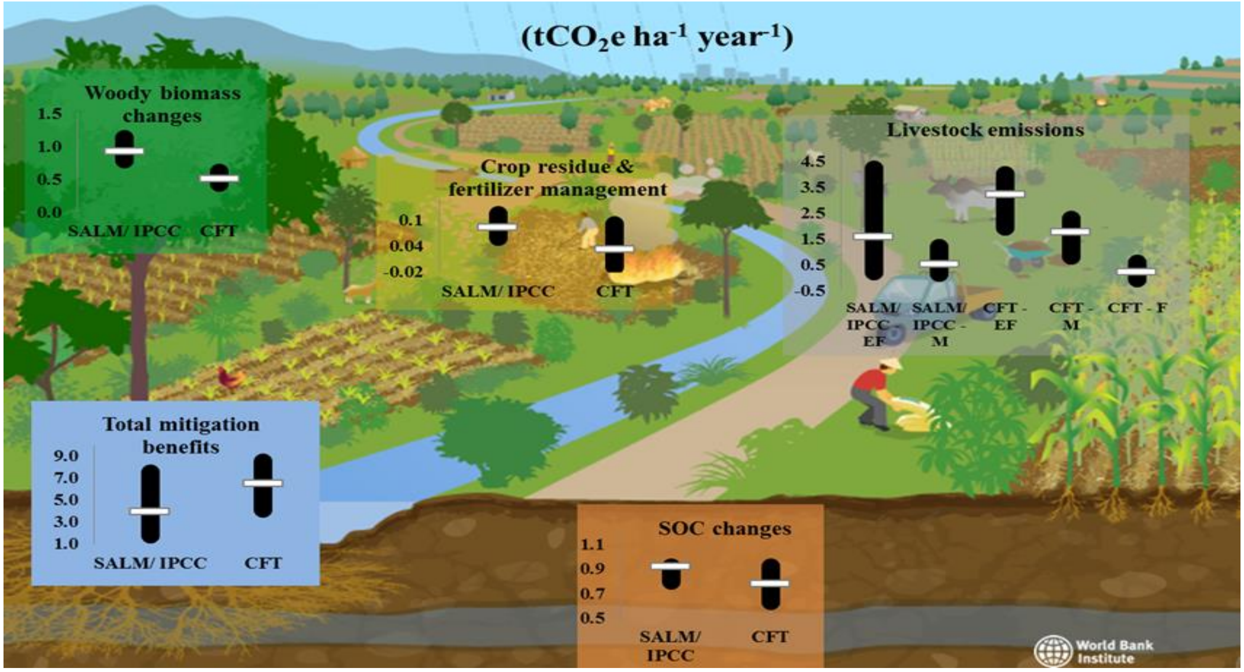
As a result of these challenges, policies in the Southern Africa region often recognize the relevance of GHG co-benefits of CSA, or state commitments to achieving mitigation outcomes, but practical measures and systems for measuring their outcomes still need to be developed. Both governments and donors are often unfamiliar with programs and projects that target GHG co-benefits of many CSA activities. More pilot initiatives can help generate experience and develop innovations to overcome these constraints.

Box 4: Kenya Sustainable Agriculture Land Management Project[18]

The Kenya Sustainable Agriculture Land Management Project was developed and implemented by the NGO Vi Agroforestry and registered and certified in the voluntary carbon market under the VCS Standard. The project targets 60,000 farmers with 45,000 hectares of cropland, organized in 3,000 registered farmer groups. The project is breaking new ground in designing and implementing climate finance projects in the agricultural sector. While increasing agricultural productivity and enhancing resilience to climate change, smallholder farmers receive benefits for greenhouse gas (GHG) mitigation based on the adoption of Sustainable Agricultural Land Management (SALM) practices such agroforestry, crop residue management, intercropping and cover crops, reduced tillage, composting, management of manure and improved livestock feeding and management (e.g., zero grazing). A farm level accounting after 2 years of project implementation was conducted using two different GHG accounting tools – the VCS SALM Methodology and the Cool Farm Tool.

Whole farm quantification in 2011 compared to the baseline conditions in 2009 demonstrated that adoption of SALM had a significant impact on emission reduction and removals. The mitigation benefits ranged between 4.0 and 6.5 t carbon dioxide equivalent (CO_2e) per hectare per year. This carbon is converted into carbon credits where each tonne of CO_2e yields one carbon credit.

The carbon credits sold to companies and other buyers are sufficient to finance either small direct payments to participating farmers or the annual costs of extension services to farmer groups. For farmers, the income from carbon credits is only seen as a small bonus. The biggest benefit is the increase in crop yields, which leads to more food on the table and higher income from the sale of the surplus. The project thus generates not only environmental benefits but also financial and social benefits for tens of thousands of families.



Annual carbon benefits in smallholder farms in Western Kenya (tCO_2e/ha/year); SALM/IPCC = SALM methodology and IPCC emission factors; CFT = cool farm tool; EF = enteric fermentation; M = manure management; F = emissions from feed characteristics; (Source: World Bank Institute)

Scaling agricultural GHG mitigation options

Scaling CSA practices requires a combination of technology, skills and capacity building of institutions as part of a multi-stakeholder, multi-level approach in supply chains and across administrative levels.[19] The same principles apply to the successful scaling of the mitigation co-benefits of the CSA practices presented here.

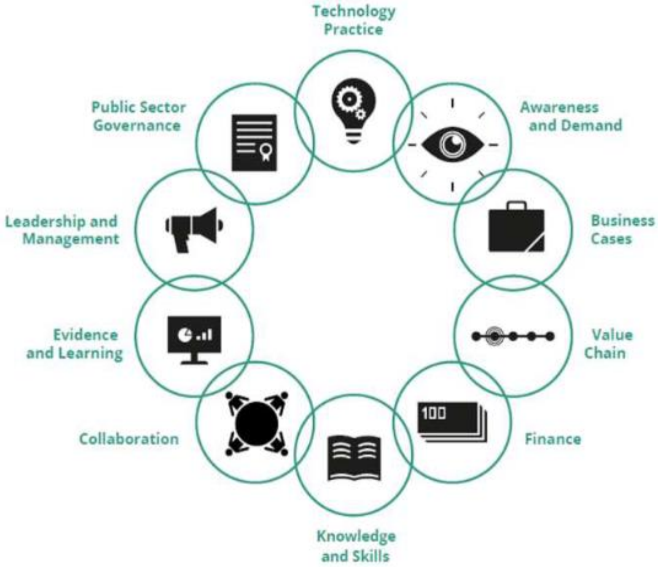


Figure 4: Ten ingredients for successful technology scaling

Source: *Jacobs et al., 2018: The Scaling Scan. A practical tool to determine the strengths and weaknesses of your scaling ambition*

The Public Private Partnership (PPP) Lab and the International Maize and Wheat Improvement Center (CIMMYT) have developed a tool, the Scaling Scan, to assess the different building blocks of a scaling strategy in a systematic way.[20] It involves a rating exercise of the ten scaling 'ingredients' shown in Figure 4.

Business partnerships with rural communities, farmer field schools, and participatory integrated landscape management approaches are promising and profitable mechanisms to support the development of a productive, resilient, and low-emission agriculture sector. Two initiatives from Sub-Saharan Africa are described in Boxes 5 and 6 as examples of how CSA practices are being taken to scale. In both these cases, the private sector and markets play key roles in enabling the scaling of CSA practices.

Box 5: Solar-powered irrigation in Kenya: SunCulture and Futurepump[21]

Kenya's smallholder farmers largely rely on rainfall to irrigate their crops, as only six percent of farmland in the country is irrigated. As the climate changes, farmers will need to increase their resilience to changes in rainfall patterns. Irrigation can provide this resilience while increasing farmers' incomes, as it allows for growing high-value, nutritious vegetables such as tomatoes and cabbage. Expansion of irrigation capacity in Kenya has thus far been dominated by traditional pumps powered by diesel or petrol. These cause pollution and leave farmers vulnerable to fluctuations in the price of fuel.

Using strategic injections of public funding, the Renewable Energy and Energy Efficiency Partnership (REEEP) mobilises private investment to advance market readiness for clean energy services in low- and middle-income countries. REEEP supports SunCulture and Futurepump, two private sector service and technology providers pioneering the sale of solar-powered irrigation pumps to small farmers in Kenya.

The main barrier is consumer financing. Most pumps on the market are relatively expensive, which puts them beyond the scope of traditional microfinance programmes. Loans from mainstream financial institutions are largely unavailable to smallholder farmers, as banks find the risks and transaction costs too high, and small farmers are often unable to provide the required collateral.

SunCulture and Futurepump now provide 'Pay-As-You-Grow' schemes, which allow farmers to pay back only at harvest time when they have more disposable income. Good after-sales support is crucial. However, providing this support is expensive and logistically complicated when customers live far apart in remote areas. Both SunCulture and Futurepump's latest models include remote monitoring sensors, so that the companies and their distributors can more effectively organise troubleshooting and give advice on optimal use of the pump based on usage data.

With these mechanisms in place, farmers can reap significant cost savings from solar-powered pumps: over 10 years, total purchase and running costs amount to US$ 668 as compared to US$ 2,046 for a petrol-powered pump. Solar pumps save 196 kg of CO_2 emissions per year. REEEP estimates that broad expansion of this technology could result in nearly 3 million tCO_2 emissions avoided each year by 2030.

Box 6: Toward zero-deforestation cotton in Zambia[22]

Many food companies are now pledging to reduce deforestation in their supply chains. In the palm oil and wood fibre sectors, these companies represent a large percentage of the sector's production. But in agricultural commodities, deforestation-free commitments cover only a small percentage of the market.

Extreme poverty and dependence on agriculture drive deforestation in Zambia's Eastern Province. Improving productivity through soil fertility measures is a key strategy to address deforestation, because poor production practices and soil depletion cause farmers to expand cultivation into forest areas. The root causes of declining soil fertility are poor farming practices, such as burning crop residues and repeated planting of cereals without incorporating soil enhancing crops. Extension services provided by governments, NGOs and agribusinesses tend to be very limited.

Once land productivity has declined, farmers look for new areas to cultivate, clearing forests in the process. Between 2000 and 2014 in Eastern Province, 156,000 ha of forests were lost. Maize has been the dominant crop for many years, but cotton production is increasing rapidly, driven by increasing demand from national and international traders that export to South Africa and beyond.

The **Competitive African Cotton Initiative (COMPACI)** was formed by an international group of cotton companies representing US$ 65 million in annual turnover. The initiative includes four members operating in Zambia: Alliance Ginneries, Cargill, NWK Agri Services, and Continental Ginnery. Among other social and environmental sustainability targets, COMPACI requires its members to eliminate the clearing of primary forest. To achieve this, they must boost productivity, since farmers will not stop deforesting if it means reduced income.

COMPACI members have different ways to reach suppliers. Some employ lead farmers who advise their neighbours on improved practices. Others establish demonstration plots to promote best farm management practices in four key areas:

- **inorganic fertilizers:** input financing for small farmers to buy inorganic fertilizer that boosts yields;
- **improved soil management practices:** training on minimizing soil disturbance, preparation of planting basins, permanent organic soil cover, crop rotation;
- **agroforestry:** planting nitrogen fixing trees;
- **integrated pest management** using intercropping and molasses traps instead of chemicals.

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Further reading

CCARDESA Knowledge Products on CSA

CCARDESA Decision Tool 21 on Climate Smart Fertiliser Application Options[4]

CCARDESA's decision tool 13 on Climate Smart Post-Harvest Management Options for Maize, Sorghum & Rice[5]

CCARDESA's decision tool 12 on Climate Smart Agroforestry Options for Maize, Sorghum & Rice[6]

CIMMYT Infographics on Scaling-Out Climate Smart Agriculture in Southern Africa

Vi Agroforestry, 2014: Sustainable Agricultural Land Management

FAO: Conservation Agriculture: overview, impacts, practical guidance, case studies

Infonet biovision: Concise introduction to conservation agriculture, agroforestry, and other sustainable agricultural practices

Further information can be found on the website Agroecology – Adaptation Community

World Bank, 2020: Addressing Food Loss and Waste: A Global Problem with Local Solutions

CCAFS, 2019: Is solar irrigation set to take over Africa?

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