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Planning, implementing and evaluating Climate-Smart Agriculture in Smallholder Farming Systems

The experience of the MICCA pilot projects in Kenya
and the United Republic of Tanzania



11

MITIGATION OF CLIMATE CHANGE IN AGRICULTURE SERIES



Planning, implementing and evaluating Climate-Smart Agriculture in Smallholder Farming Systems

The experience of the MICCA pilot projects in Kenya and the United Republic of Tanzania

By Janie Rioux, Marta Gomez San Juan, Constance Neely, Christina Seeberg-Elverfeldt, Kaisa Karttunen, Todd Rosenstock, Josephine Kirui, Erasto Massoro, Mathew Mpanda, Anthony Kimaro, Thabit Masoud, Morgan Mutoko, Khamaldin Mutabazi, Geoff Kuehne, Anatoli Poultouchidou, Armine Avagyan, Marja-Liisa Tapio-Bistrom, and Martial Bernoux

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Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
CARE	CARE International in the United Republic of Tanzania
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CO₂	Carbon dioxide
CO₂eq	Carbon dioxide equivalent
CSA	Climate-Smart Agriculture
CSL	Centre for Sustainable Living in Kolero, Tanzania
DFBA	Dairy Farmers Business Association
EADD	East Africa Dairy Development Programme
EX-ACT	Ex-Ante Carbon balance Tool
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse gases
HICAP	Hillside Conservation Agriculture Project
ICRAF	World Agroforestry Centre
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
LDSF	Land Degradation Surveillance Framework
MICCA	Mitigation of Climate Change in Agriculture Programme
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organization
SUA	Sokoine University of Agriculture

Executive Summary

Many smallholder farmers in developing countries are facing food insecurity, poverty, the degradation of local land and water resources, and increasing climatic variability. These vulnerable farmers depend on agriculture both for food and nutrition security and as a way of coping with climate change. If agricultural systems are to meet the needs of these farmers, they must evolve in ways that lead to sustainable increases in food production and at the same time strengthen the resilience of farming communities and rural livelihoods. Bringing about this evolution involves introducing productive climate-resilient and low-emission agricultural practices in farmers' fields and adopting a broad vision of agricultural development that directly connects farmers with policies and programmes that can provide them with suitable incentives to adopt new practices.

The term 'climate-smart agriculture' (CSA) has been coined to describe the approach that aims to achieve global food security and chart a sustainable pathway for agricultural development in a changing climate. CSA seeks to increase farm productivity in a sustainable manner, support farming communities to adapt to climate change by building the resilience of agricultural livelihoods and ecosystems, and, wherever possible, to deliver the co-benefit of reduced GHG emissions. CSA is an approach that encompasses agricultural practices, policies, institutions and financing to bring tangible benefits to smallholder farmers and provide stewardship to the landscapes that support them.

On the ground, CSA is based on a mix of climate-resilient technologies and practices for integrated farming systems and landscape management. The evidence base and knowledge to determine the practices that work best in a given context continue to be expanded through the testing and implementation of a broad range of practices. This work is creating a better understanding about the trade-offs that may need to be made when striving to meet the interconnected goals of food security, climate change adaptation and climate change mitigation, and about the synergies that exist between these.

The Food and Agriculture Organization of the United Nations (FAO), with financial support from the Government of Finland, designed the Mitigation of Climate Change in Agriculture (MICCA) Programme to expand this evidence base and build CSA readiness. The Programme was also established to demonstrate that ongoing agricultural development programmes could bring co-benefits in terms of climate change adaptation and mitigation thereby increase the uptake of CSA at significantly larger scale. The MICCA CSA pilot projects (2011-2014), implemented jointly with partners in Kenya and the United Republic of Tanzania, promoted integrated and diversified farming systems and agro-ecological principles. The pilot projects linked research activities, practical work in farmers' fields and policy making at different levels to enhance the effectiveness of planning and programming for CSA on farms, throughout the landscape and at the national level.

The pilot projects were implemented in an integrated crop-livestock-tree farming system in Kaptumo, Kenya and a cereal-based upland farming system in Kolero in the United Republic of Tanzania. They were specifically designed to:

- promote an exchange of knowledge between farmers, extension agents and scientists with a view to identifying, developing and promoting an integrated package of CSA practices and technologies;
- conduct scientific research to assess the GHG emission fluxes and mitigation potential of farming practices and identify synergies and trade-offs; and
- analyse the barriers to adoption of CSA and the benefits it can deliver in order to advance the scaling up of CSA, through extension, policy support and investments.

In Kenya, these efforts were carried out in the framework of the East Africa Dairy Development (EADD) programme funded by the Bill & Melinda Gates Foundation, and in the United Republic of Tanzania through CARE International's Hillside Conservation Agriculture Project (HICAP) in collaboration with Sokoine University. In both pilot sites, the World Agroforestry Centre (ICRAF) served as the lead partner in the area of science for development. Partnerships with farmers and extension agents, scientists, development actors and national-level stakeholders including the relevant government ministries provided the opportunity to increase the uptake of CSA practices and scale up CSA from farmers' fields to the national level.

Within the pilot projects, key steps were taken to develop integrated portfolios of CSA practices and technologies and build the capacity of farmers to implement them; test CSA outcomes on sustainable agricultural production and climate change adaptation and mitigation using models (EX-ACT carbon balance analysis) and field measurements (GHG emissions, carbon stocks, rainfall efficiency and yield); and assess barriers and opportunities for the adoption and scaling up of CSA at the local and national level.

Listed below are some results of the MICCA pilot studies.

- Farmers who participated in the MICCA pilot projects reported that the main benefits of following the CSA approach resulted in higher yields, raised farm income and increased food availability. This is an indication that CSA can be an effective approach for improving food security, alleviating poverty and building more resilient livelihoods. It also indicates that smallholder farmers can be an effective part of the response to climate change and make a meaningful contribution to reducing GHG emissions.
- Scenarios, modelling and measurements serve an important role in evaluating and prioritizing CSA practices for implementation and scaling up. By building research into ongoing development activities, the assessment of CSA practices can be undertaken more quickly, and the findings can be used to prioritize efforts in projects and programmes.

- Bringing sound, up-to-date evidence into decision-making processes can help shape policy making that effectively supports CSA. The findings from the pilot activities were presented in national workshops, which allowed decision makers to become familiar with the benefits of CSA practices and develop or adjust policies, plans and programmes to better foster CSA.

Important lessons have been learned through the pilot projects undertaken by MICCA and its partners, and these lessons have provided the basis for a number of recommendations, listed below, regarding CSA, particularly the implementation of CSA at the local level.

- CSA practices need to be tailored to the specific characteristics of local farming systems, the particular socio-economic conditions, agro-ecological context and farmers' requirements.
- To ensure sustainable and long-term adoption of CSA practices, farmers need to receive immediate and long-term benefits from these practices in terms of improved food security, food production and income.
- Because the adoption of CSA practices is largely determined by training sessions and farmer-to-farmer learning, it is important to support sustainable approaches for delivering extension services.
- To design effective CSA programmes, extension strategies and investment plans, it is essential to gain a better understanding of both the gender-sensitive incentives (e.g. secure land tenure and the availability of credit, farm tools and inputs) and the barriers to the adoption of CSA practices, and to demonstrate the proven benefits of adopting these practices to support scaling up.
- The continuous engagement of local leadership increases a sense of community ownership over the new practices and supports the establishment and enforcement of required by-laws, which is extremely important as the adoption of CSA practices across landscape requires collective actions.

The MICCA project outcomes have confirmed that connecting research, practice and policy is critical for the effective scaling up of CSA. Building these connections ensures that long-term planning and programming are based on sound evidence from scientific findings and local knowledge and are aligned with broader policy frameworks. Furthermore, key results from the field can strengthen ongoing national and regional planning processes and make valuable contributions to prioritizing and guiding new investments in CSA. It is important that new climate finance instruments be integrated with traditional sources of agricultural investment in ways that can underpin the design and implementation of national action plans or programmes related to CSA. In particular, National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Actions (NAMAs) can be used to deliver a broad range of co-benefits to farmers that extend beyond climate change adaptation and mitigation, and to support sustainable agricultural development and the implementation of nationally intended contributions (NDCs).

1. Introduction

1.1 Rationale for CSA with smallholder farmers

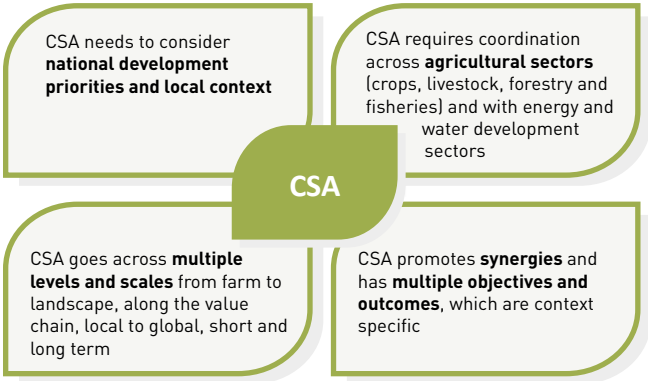
For smallholder farmers facing food insecurity, poverty, the degradation of land and water resources and climatic variability, agriculture has to meet the challenge of achieving food security and at the same time responding to climate change. The core challenge is to sustainably improve food production and increase the resilience of farming systems and livelihoods. This will mean transforming production systems by introducing more climate-resilient and low-emission agricultural practices and adopting a new perspective on agriculture that links the development of suitable incentive mechanisms for farmers with appropriate policies and programmes.

Climate-smart agriculture (CSA), as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, focuses explicitly on the triple objectives of improving food security by sustainably increasing productivity and income, adapting to climate change and reducing GHG emissions and enhancing removals where possible (FAO, 2010, 2013). This does not imply that every practice applied in every location should produce 'triple wins'. CSA seeks to identify and reduce trade-offs and promote synergies by taking these objectives into consideration to inform decisions at all scales and over the short and long term to derive nationally and locally acceptable solutions in line with the national development goals. CSA takes into consideration the diversity of social, economic, and environmental contexts, including agro-ecological zones and farming systems, where it will be applied. CSA is an approach that brings together agricultural practices, policies, institutions and financing in the context of climate change.

Agriculture has the potential to mitigate between 5.5-6 gigatonnes of carbon dioxide (equivalent) annually (IPCC, 2007), with most of this potential in developing countries. To realize this potential, agricultural development efforts will have to support the uptake of climate-smart practices at the farm and landscape levels, and along the value chain. Activities in this area will enhance the resilience of agricultural systems to ensure the best possible opportunities for adaptation and mitigation of GHG emissions will be a co-benefit.

CSA contributes to a range of national food security and development goals and requires coordination across all the agricultural sectors and other related sectors, such as energy and water. CSA covers multiple levels and provides synergies between adaptation, mitigation and food security goals (Fig. 1).

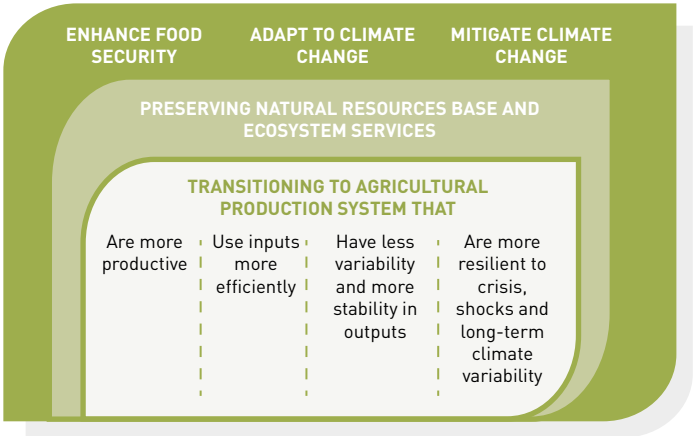
Figure 1. Principles of CSA.



Source: Authors

CSA promotes the transition to more productive agriculture systems. These production systems use inputs more efficiently and produce more stable outputs. They are more resilient to risks, shocks and long-term climate variability, and at the same time, they preserve the natural resource base (Fig. 2).

Figure 2. Objectives of CSA.



Source: : Authors based on FAO, 2013.

For CSA implementation, it is important to identify an integrated package of climate-resilient technologies and practices for the management of crops, livestock and aquaculture at the farm level, while considering the linkages between agricultural production and ecosystem services at the landscape level. Testing and applying different practices is important to expand the evidence base, determine which practices and extension methods are suitable in each context and identify the synergies and trade-offs between food security, adaptation and mitigation.

1.2 The MICCA pilot projects

FAO designed the MICCA pilot projects (2010-2014) to expand the evidence base and build CSA readiness in Africa, as it is considered to be one of the most vulnerable regions to climate change. The objective was to assess how agricultural development programmes could bring co-benefits in term of climate change mitigation. These development programmes are the

largest channels for achieving CSA at significant scale. Climate funding can complement these investments and catalyse the transformation of production systems.

CSA in the MICCA pilot projects promoted integrated and diversified farming systems and agro-ecological principles. The main goal was to improve food security and livelihoods of smallholder farmers, while testing synergies and trade-offs with reducing GHG emissions. The pilot projects also sought to demonstrate how to link research, practice and policy for the effective planning and programming of CSA.

Specifically, the MICCA pilot projects aimed to:

- promote an exchange of knowledge between farmers, extension agents and scientists with a view to identifying and developing an integrated package of CSA practices and technologies and promote their implementation;
- conduct scientific research to assess the GHG emission fluxes and mitigation potential of different crops, land uses and management practices and identify synergies and trade-offs with food production and adaptation; and
- analyse the adoption barriers and benefits of CSA to permit the scaling up of CSA practices, increase their extension and support policy development and investments.

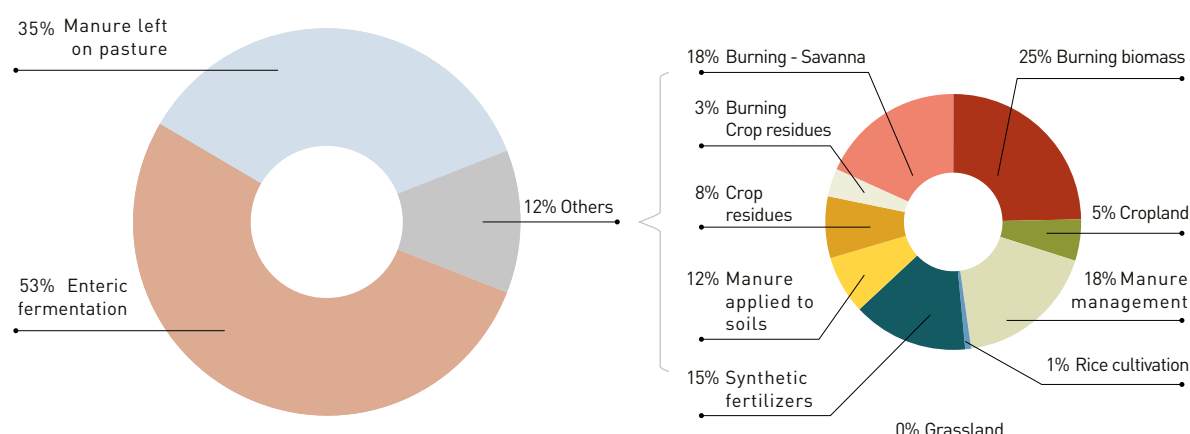
1. 2. 1. Rationale for the pilot projects selection

Integrated crop-livestock system- Kenya pilot

Livestock is an integral part of many farming systems and the largest emitter of GHGs within the agricultural sector. Ruminant livestock production is a major source of employment, income, food and fertilizer for crop production. Livestock production, both for dairy and for meat, generates about 1.5 percent of total global gross domestic product (GDP). Livestock contributes over 40 per cent of global agricultural GDP and employs about 1.3 billion people, creating livelihoods for about one billion of the world's poor (Steinfeld *et al.*, 2006). The livestock sector alone represents 14.5 percent of the global anthropogenic GHG emissions (Gerber *et al.*, 2013). The livestock sector generates 44 percent of anthropogenic methane (CH₄), mostly from enteric fermentation by ruminants, and 53 percent of anthropogenic nitrous oxide (N₂O), mostly from manure (Gerber *et al.*, 2013). Therefore, integrating climate-smart activities into livestock-based production systems is critical.

According to FAO statistics, the two main sources of GHG emissions in Kenya are enteric fermentation and manure left on pasture (FAOSTAT, 2012).

The carbon footprint of livestock varies greatly among production systems, regions, and commodities, primarily owing to differences in farming practices and the management of the supply chain (e.g. feed production) (FAO, 2013). The integration of trees in agricultural land, improved pasture management and agricultural practices are important for sequestering carbon in the soil and offsetting livestock-related emissions.

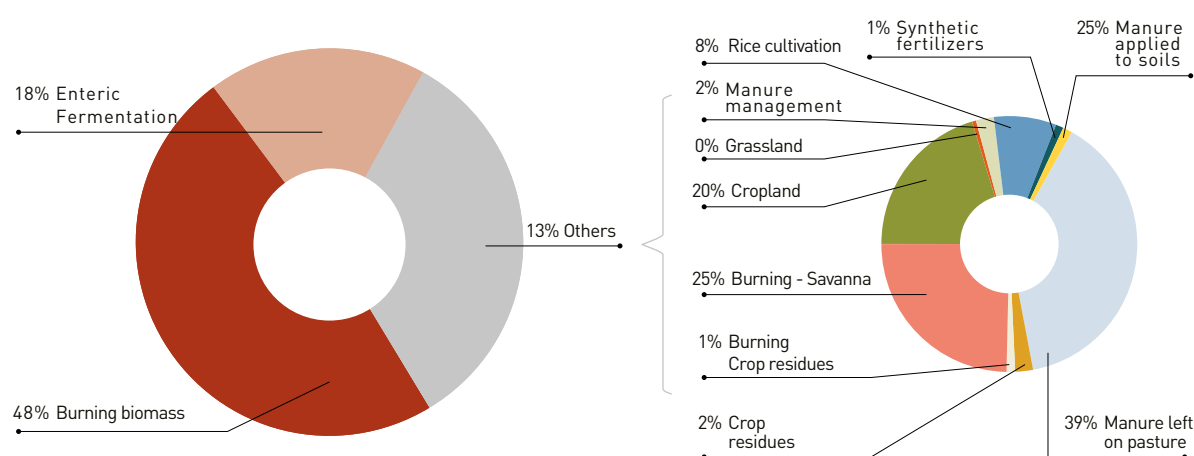
Figure 3. Emissions from the Agriculture, Forestry and Land Use (AFOLU) sector in Kenya.


Source: FAOSTAT, 2012

Cereal-based family farming in hilly landscapes – The United Republic of Tanzania pilot

Subsistence farming systems are the predominant farming systems for millions of small-scale farmers engaged in traditional agriculture practices, such as slash and burn and shifting cultivation. Agriculture expansion is still the main driver of deforestation in Africa. With population growth, the expansion on arable land will likely continue in many regions, including Sub-Saharan Africa. Population growth in combination with declining soil fertility and increasing demand for fuelwood and wood products highlight the need to develop CSA practices that can deliver multiple benefits.

In the United Republic of Tanzania, biomass burning is the largest source of CO₂ emissions (FAOSTAT, 2012) (Fig. 4). The MICCA pilot project aimed to contribute to decreasing the net GHG balance of the traditional agricultural system by promoting agroforestry, conservation agriculture, soil and water conservation and improved cooking stoves.

Figure 4. GHG emissions from AFOLU in the United Republic of Tanzania [Source: FAOSTAT, 2012].


Source: FAOSTAT, 2012

1.3 Locations and partners of the MICCA pilot projects

To achieve its objectives, the MICCA pilot projects were implemented with partners. In Kenya, the MICCA pilot project was carried out in collaboration with the World Agroforestry Center (ICRAF) and the East Africa Dairy Development Programme (EADD). In the United Republic of Tanzania, MICCA partners were ICRAF, and CARE's Hillside Conservation Agriculture Project (HICAP). The field level work was conducted from August 2011 through October 2014.

ICRAF played an instrumental role in both sites. It undertook the GHG measurements and the land health assessments, and contributed to the implementation of agroforestry and fodder activities.

EADD is a regional industry development programme implemented by Heifer International and a consortium of partners including TechnoServe, the International Livestock Research Institute (ILRI), ICRAF and African Breeding Services (ABS TCM). EADD was designed to boost the yields and incomes of millions of small scale farmers in Africa to lift them out of hunger and poverty. The programme was implemented in Kenya, Rwanda and Uganda. In Kenya, 21 farmer organizations have been established since 2008 and work through 'hubs'. These hubs provide services, such as maintaining chilling/cooling plants, providing storage, and offering agro-veterinary, artificial insemination and other services to dairy farmers.

HICAP was initiated in 2009 to improve household food security and income through conservation agriculture and develop micro-credit support for the local sustainability of conservation agriculture.

Figure 5. Locations of the MICCA pilot projects in East Africa.



Source: Google maps

The MICCA pilot projects were developed in two different farming systems and under different socio-economic conditions (Rosenstock *et al.*, 2014b; Zagst, 2012a, 2012b; Jönsson, 2012a, 2012b). In Kenya, farmers in the Kaptumo Division of Nandi County planted tea, owned dairy cattle and had access to markets, whereas in the Uluguru Mountains of the United Republic

of Tanzania, farming was characterized by subsistence agriculture, inefficient agronomic practices and poor access to markets (Table 1).

Table 1. Characteristics of the MICCA pilot projects.

Location	Kaptumo, Kenya	Uluguru Mountains, United Republic of Tanzania
	6 locations of Kaptumo division, Nandi County	8 villages of Kolero, Bungu and Kasanga wards, South Uluguru Mountains, Morogoro Rural District
Total area	8 637 ha	16 812 ha
Population	26 782 people	18 326 people
Average land size	0.9 -1.7 ha, mean 0.9 ha	0.1 - 4 ha, mean 1 ha
Coordinates	00°04'31" N, 35°04'16" E	07°15' 00"S, 37°48'00" E
Rainfall ranges	1 500 - 2 200 mm per year	1 500 - 1 800 mm per year
Long rains	March to end June	Early March to early June
Short rains	October to end November	End October to early December
Temperature ranges	16- 31 °C	22- 33 °C
Agricultural practices	Dairy cows and tea under a crop-livestock integrated farming system	Maize, upland rice, sesame and cassava produced through slash- and-burn subsistence agriculture
Development partner	EADD	CARE
Research partners	ICRAF	ICRAF

2. Mainstreaming CSA in development programmes

2.1 Framework of the MICCA pilot projects

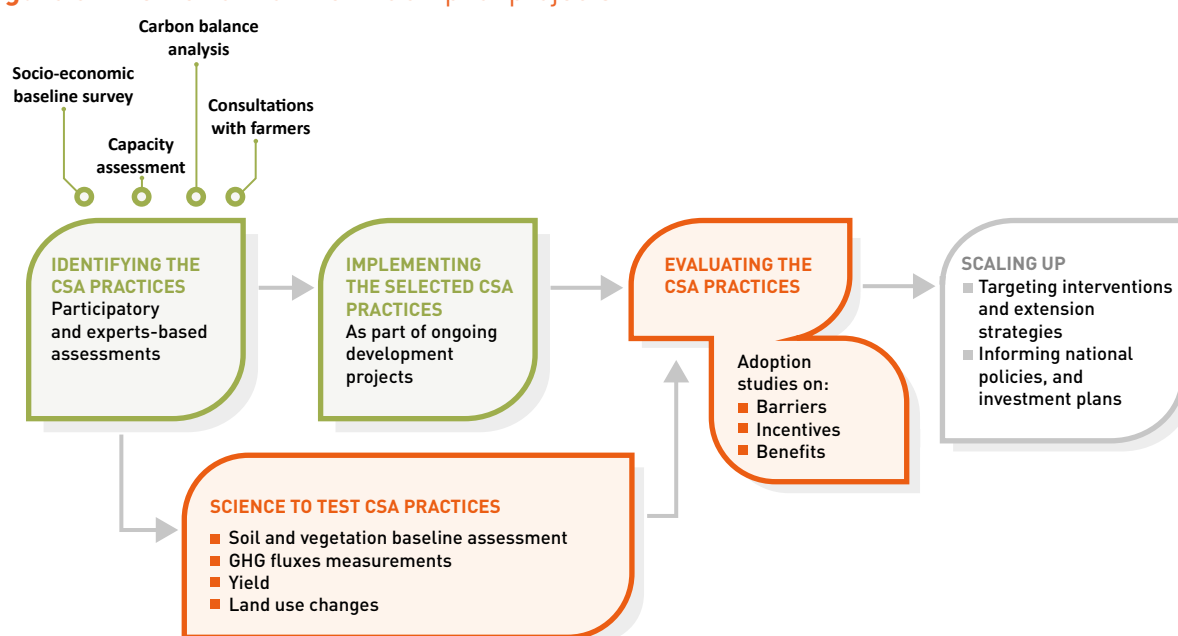
The development projects were chosen based on the following criteria: high existing GHG emissions that could potentially be substantially reduced while achieving increased benefits for agricultural production and adaptation to climate change.

The overall approach and steps taken in the MICCA pilot projects were to:

- i) develop and implement integrated portfolios of CSA practices and technologies with farmers;
- ii) test CSA outcomes on sustainable agricultural production, adaptation and mitigation; and
- iii) assess barriers and opportunities for adoption and scaling up of CSA.

Capacity development and gender are cross-cutting issues that were addressed at each step of the process. The MICCA pilot projects' findings and experience brought lessons learned and recommendations on CSA mainstreaming, and conclusions to inform CSA scaling up, future programming and policy making (Fig. 6).

Figure 6. Framework of the MICCA pilot projects.

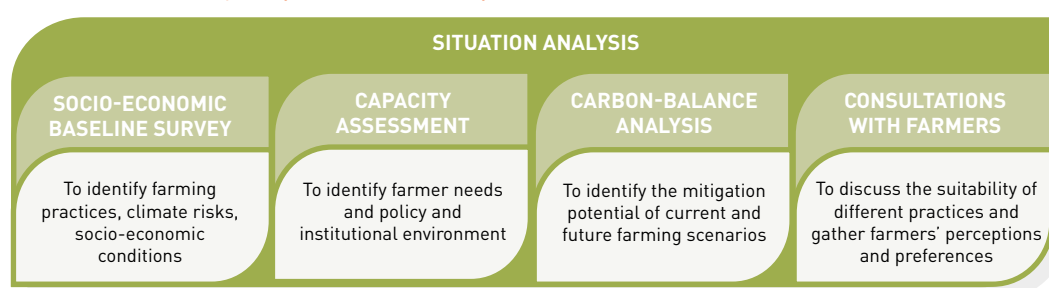


Source: Authors

The MICCA pilot projects developed a portfolio of suitable CSA practices for smallholder farmers at each site. The development of the package of practices involved site-specific participatory assessments and expert assessments. The portfolio contained some practices that were already being promoted through the partner organizations and others that contributed

specifically to reducing the overall GHG balance of the farming systems. The practices were selected based on their suitability to local farming systems, crops, soils, climate and socio-economic conditions; their mitigation potential; and the farmers' perceptions and priorities in relation to yield, contribution to climate change adaptation, environmental benefits and capital, labour, land and knowledge requirements. An assessment was also made of different GHG mitigation scenarios. Consultations were undertaken with all stakeholders to obtain feedback on the proposed portfolio of CSA practices (Fig. 7). After the assessments, the most appropriate practices for the given agro-ecological and socio-economic situation of each pilot site were identified.

Figure 7. Situation analysis prior to CSA implementation.



Source: Authors

Once the portfolios were developed and agreed on by the farmers, a series of training sessions and training materials were developed to facilitate the adoption and scaling up of the CSA practices. The package of CSA practices were also promoted through different extension approaches and incentive mechanisms. In parallel with the implementation of the CSA practices, research activities were carried out.

2.2 Steps in developing the portfolios of CSA practices

2.2.1. Understanding the socio-economic situation and agricultural practices

Socio-economic baseline surveys (Zagst, 2012a, 2012b) were carried out in representative households to collect data on current livelihoods and agricultural practices, and gain a better understanding of the impacts of climate change on smallholder farmers in the project areas. Along with identifying farming practices, climate risks, and socio-economic conditions, the surveys also included gender roles, and the availability of, and access to, labour and land. This data supported the analysis of existing practices and increased the understanding of the possible barriers to adoption of CSA practices.

An analysis of the data allowed for a characterization of the household and farm situations, the agricultural activities (both livestock and cropping) and the state of tree planting. It also identified important issues pertaining to household economics and food security. The analysis also evaluated farmers' awareness of climate change.

Kenya

At the start of the MICCA pilot project, in 2011, about 90 percent of the 357 interviewed households cultivated crops and raised livestock. Livestock is very important for the Kalenjin culture, and the majority (92 percent) of farmers owned cattle. On average, each household possessed five head of cattle. The average size of the farms was 0.9 hectares.

The baseline studies showed that livestock feeding practices were evolving from more extensive systems (34 percent exclusively grazed their animals) to semi-intensive systems (50 percent grazed their animals in open pasture lands for nine months but also did some stall feeding). Fifteen percent of the farmers mainly used stall feeding with some grazing. Farmers were aware of zero grazing, but were not practicing it.

Grass, and especially Napier grass was the main feed for cows. Feed supplements were also widely used. Crop residues were not commonly fed to cattle. Farmers were unable to produce larger quantities of fodder on their farms due to a shortage of land, limited finances and lack of knowledge. However, they were aware of the impact of improved fodder on milk production. Limited amounts of manure were used on the fields, but most was left on the paddocks. Farmers applied manure to the fodder crops, mainly Napier grass. Inorganic fertilizer was applied to cash crops, such as maize, tea and vegetables.

The most commonly cultivated crops were maize, beans, bananas and tea, all of which were consumed at home, except for tea. Tree planting has been promoted through a government programme and has been taken up by farmers who have shown a great interest in agroforestry. The baseline survey indicated that over 75 percent of the households were involved in planting or protecting trees.

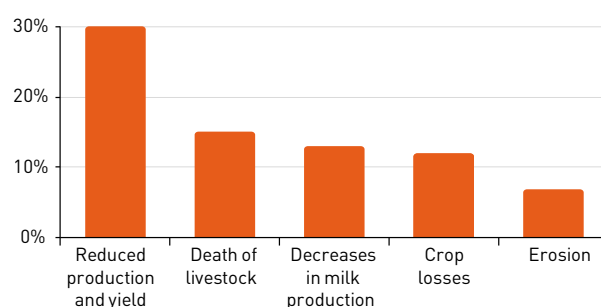
Figure 8. Example of a typical crop-livestock integrated farm in the MICCA pilot project in Kenya



© FAO/I. Rioux

The farmers' most common observations of climate variability were more erratic rainfall and longer dry seasons. As a consequence, rivers had dried up creating problems for watering cattle. Only 4 percent of interviewed farmers reported no change to the climate. The main impacts of climate change were reduced production and yield, increased livestock mortality, decreased milk production, crop failures and soil erosion (Fig. 9).

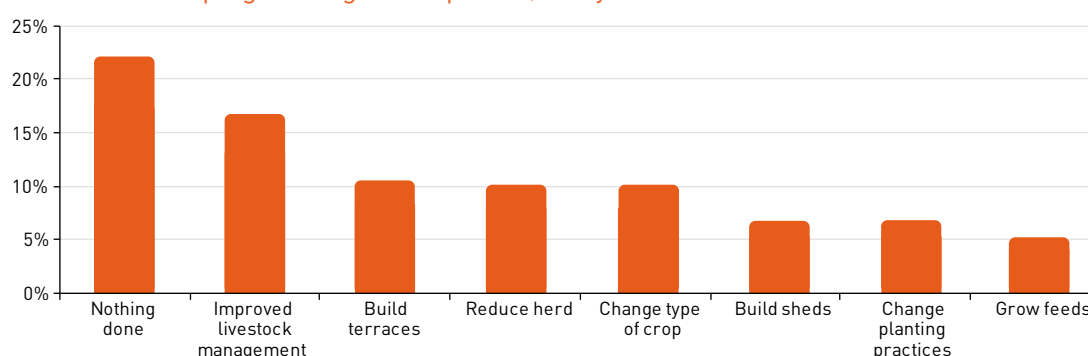
Figure 9. Main impacts of climate change on farmer livelihoods: Kaptumo, Kenya.



Source: Authors

To cope with these impacts, farmers were trying to improve livestock management, build terraces, reduce herds, change crop type, build protective sheds for livestock, change planting practices and grow feeds. However almost a quarter of the farmers were not having coping strategies in place.

Figure 10. Main coping strategies: Kaptumo, Kenya.



Source: Authors

United Republic of Tanzania

During the socio-economic baseline survey, 333 farmers were interviewed in 5 villages (Zagst, 2012b). Results indicated that about 75 percent of the farmers both grew crops and raised livestock. Twenty-five percent only cultivated crops. Livestock were mainly small animals. Most farmers were subsistence farmers, who sold any surplus. Very few farmers used irrigation systems, as rainfall is about 1 800 mm per year. Slash-and-burn agriculture was practiced by half of the farmers interviewed. Cultural and traditional beliefs were the main reasons farmers gave for continuing slash-and-burn practices, but they also cited a lack of awareness of the impacts of this practice and possible alternatives.

The average land size per farmer was one hectare with a median of 0.8 hectare and a range of 0.1 to four hectares. Half of the farmers had insecure land tenure as they were renting their

land, and one-third were paying fees to use clan-owned lands.

The main crops were maize, cassava and rice. Banana, sorghum, sesame and some fruit trees were also grown. Tree planting was not very common in the area because of the prevailing land tenure conditions. Much of the land is owned by clans, which is not conducive for farmers to plant trees. Crop diseases were a problem for a third of the farmers. Climate variability (less rainfall and prolonged dry seasons) was also a problem that reduced yields.

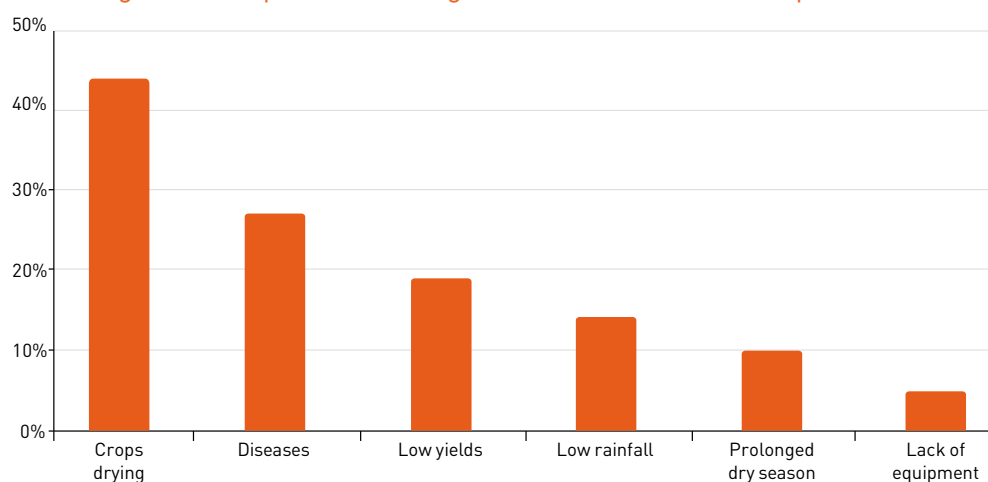
Figure 11. Kolero village, MICCA pilot project in the United Republic of Tanzania.



© FAO/J. Rioux

Farmers' most common agricultural problems are related to climate change and variability with almost 50 percent of farmers reporting crops drying (Fig. 12).

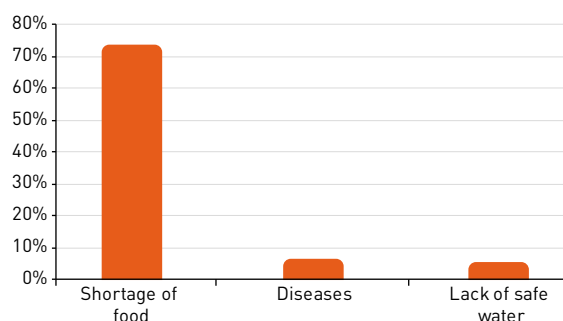
Figure 12. Main agricultural problems: Uluguru mountains, United Republic of Tanzania.



Source: Authors

Food shortages were experienced by 74 percent of households because of prolonged dry seasons resulting from climate change (Fig. 13).

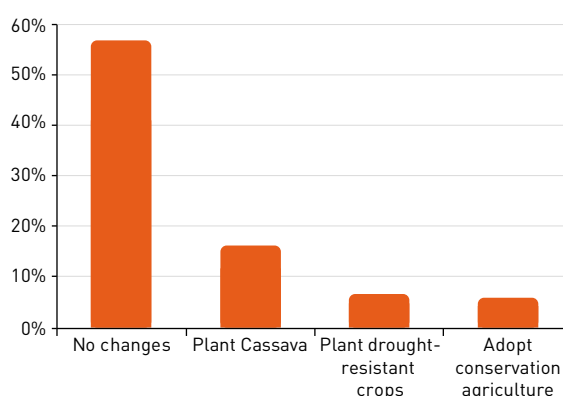
Figure 13. Main impacts of climate change on households: Uluguru mountains, United Republic of Tanzania.



Source: Authors

Fifty-seven percent of farmers did not know how to cope with climate change. Sixteen percent responded by planting cassava, and six percent practiced crop rotation (Fig. 14).

Figure 14. Main coping strategies by farmers: Uluguru mountains, United Republic of Tanzania.



Source: Authors

2. 2. 2. Identifying capacity needs and gaps related to CSA

Multi-level capacity needs assessments were carried out to identify farmers' needs and gain an understanding of the policy and institutional environment of both sites.

The capacity needs assessments (Rioux, 2010, 2011) were conducted at three levels:

- National level: stakeholder mapping and context analysis with stakeholders working on climate change-related issues in the Ministries of Agriculture, Livestock and Environment, non-governmental organizations (NGOs), research institutions and United Nations agencies;
- District/county level: consultative workshop with project staff, extension officers and district staff from the Ministries of Agriculture, Livestock, Water, Forestry, and Environment; and
- Pilot project area: focus group discussions with farmer groups, interviews with farmers and field visits.

The assessments at the national and district/county levels sought to identify the stakeholders working on climate change issues and the main policies, plans and strategies related to climate change. Through open discussions and working groups, the participants were asked about

their organization and their individual capacity needs in relation to their climate change work. A checklist of questions tailored for climate change adaptation and mitigation in agriculture was used to identify these needs (FAO, 2012).

In the field, the capacity needs assessments reviewed the range of current land uses and management practices. The assessments also considered problems related to climate and the environment, and analysed capacities and needs in relation to the adoption of improved farming and potential CSA practices (Table 2).

Figure 15. Participatory consultations with farmers in the MICCA pilot project in Kenya.



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Table 2. Farmer perceptions of the CSA practices identified during the capacity assessments.

Agricultural practices		Benefits	Needs
Kenya	Zero grazing	Reduced grazing pressure Increased milk production Easier to collect manure (to use for crop production or biogas production) Fewer diseases	Need for loans to cover initial construction costs (e.g. shed, cement, water tank) Need for water management, and canal systems Need to facilitate artificial insemination for introducing high quality breeds
	Agroforestry	Nitrogen fixing trees for improved soil fertility and fuel wood High value crops (e.g. passion fruit) Improved soil and water conservation	Participatory and scientific assessment of different tree and legume fodder Support for passion fruit (or avocado) production to women's groups Need for tree nurseries for seedlings production Training on the use of green manure from agroforestry
United Republic of Tanzania	Agroforestry	Leguminous trees for fixing nitrogen in the soil Income from fruits or wood Less risk of burning fields Improved microclimate Increased carbon and biodiversity Reduced deforestation of natural forests	Participatory and scientific assessment of different trees Establishment of tree nurseries for seedlings production Training on tree planting
	Conservation Agriculture	Improved soil fertility and increased yield Maintained crop residue in the field and decreased soil erosion Decreased slash-and-burn practices Increased yield with legumes intercropped with cereals	Better quality training on conservation agriculture More conservation agriculture demo plots in more villages Support during implementation of CA Farms visits by contact farmers, extension officers and by interested farmers Agricultural tool to facilitate the double digging to break the hard pan Training on controlling plant diseases

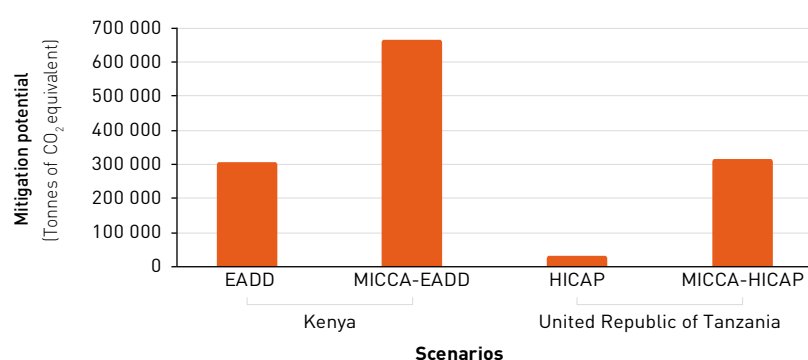
2.2.3. Exploring the mitigation co-benefits of different scenarios

The FAO's Ex-Ante Carbon-balance Tool (EX-ACT) estimates the net balance from all GHGs expressed in CO₂ equivalent that were emitted or sequestered due to project implementation as compared to a business-as-usual scenario. EX-ACT is a land-based accounting system, estimating carbon stock changes (i.e. emissions or sinks of CO₂) as well as GHG emissions per unit of land, expressed in equivalent tonnes of CO₂ per hectare per year.

Using the EX-ACT tool, a carbon-balance analysis was undertaken to estimate the GHG emissions for two scenarios. These were a reference scenario quantifying the emissions that would be expected with and without the interventions of the MICCA pilot projects. The assessments (Jönsson, 2012a, 2012b) analysed the land-use change scenarios linked to the introduction of different agricultural management practices. Much of the required quantitative data were not available at the time, so the analyses were based mainly upon qualitative and semi-quantitative data from stakeholder workshops, farmer interviews, observations during field visits and discussions with the project field team.

In both pilot projects, the scenarios indicated that MICCA activities would more than double the mitigation impact of the ongoing development projects (Fig. 16). The EX-ACT assessment over 20 years (3 years of implementation and 17 years of capitalization) found that the MICCA-EADD pilot project in Kenya had the potential to create a net sink of 663 689 tonnes of carbon dioxide (equivalent) in a conservative scenario. The net sinks mainly resulted from afforestation and reforestation and improved grassland and livestock management. In the MICCA-HICAP site in the United Republic of Tanzania, the EX-ACT assessment found that, under a conservative scenario, the project had the potential to create a net sink of 566 612 tonnes of carbon dioxide (equivalent) from a shift from monoculture production to the cultivation of diverse crops and improved agronomic practices and afforestation and reforestation.

Figure 16. The EX-ACT assessment of the potential mitigation co-benefits from different project scenarios.



Source: Authors

2.2.4. Consulting stakeholders and farmers on the proposed CSA practices

Consultations with stakeholders and farmers took place to discuss a range of suitable CSA practices and identify their perceptions and preferences regarding them. Based on an understanding of existing practices and estimates of the impacts of various practices, a

package of CSA practices that could be readily integrated into the current farming systems were identified and implemented in each pilot project.

Kenya

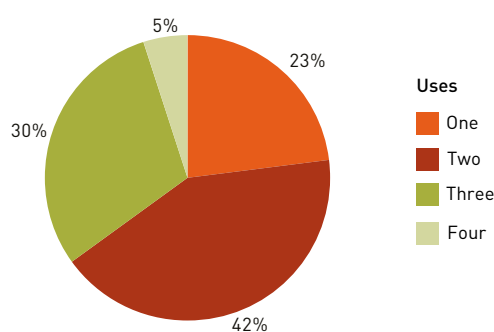
In Kenya, the project conducted rapid rural appraisals with two dairy groups to identify, list and rank CSA practices that they thought would be important for their area (Wambugu *et al.*, 2014). The lists of practices mentioned in both appraisals were very similar: better feeding and improved husbandry were mentioned as very important, as were agroforestry practices that increased tree planting on farms. Other practices highlighted in the appraisals were improved manure management, manure composting and the installation of biogas units. The potential benefits of various practices from the literature review are presented in Annex 8.4.

United Republic of Tanzania

In the United Republic of Tanzania, five focus group discussions with 5-8 participants and two plenary sessions with around 20 participants were organized to discuss agroforestry and slash-and-burn practices (Mpanda and Coll Besa, 2012). Participants were mainly contact farmers, community-based trainers, farmer field school members, village savings and loans members and other villagers not participating in the HICAP-MICCA project.

Results from the focus group discussions showed that there are 43 tree species of importance to farmers in the project area, and that 77 percent of these preferred species provided multiple benefits (Fig. 17) (Rioux, 2012).

Figure 17. The percentage of tree species with multiple purposes.



Source: Authors

Land tenure is an issue in the area. Many farmers rent their land, even on a seasonal basis. In this situation, normally only non-permanent changes, such as a shift to conservation agriculture and the cultivation of annual crops, are allowed; agroforestry and soil and water conservation structures are not. According to farmers, the main constraints are the lack of awareness of the benefits of trees, the existing forest legislation, inadequate seedling management and the lack of germplasm. Moreover, slash-and-burn practices inhibit the regeneration of trees. The overexploitation of trees for timber, construction material and firewood also put significant pressure on forest resources. Farmers highlighted other factors that hindered tree planting including, termites, wildfires, drought, land tenure systems, the absence of land-use plans at

the village level, the fear that shade will harm crops, and pests and diseases that attack the seedlings.

Slash and burn is a common practice. It is generally perceived as requiring less time and labour compared to other approaches and as a good way to control pests. Farmers emphasized the need for training on alternatives to slash and burn, such as conservation agriculture, and the creation of fire-breaks.

Figure 18. Farming in the hillsides of the Uluguru mountains in the United Republic of Tanzania degraded by soil erosion.

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Fuelwood is the main source of energy in the area. Along with slash and burn, the demand for fuelwood is perceived by farmers as a critical driver of deforestation. Participants highlighted the need for support to build capacity for the construction and maintenance of improved cooking stoves (Mpanda and Coll Besa, 2012). It

was reported that tree species such as Mivule (*Milicia excelsa*) and Mibiriti (*Senna seamea*) provide longer lasting firewood.

Training in agroforestry, strengthening awareness of conservation agriculture, promoting home gardens, as well raising awareness about environmental conservation and climate change were some of the recommendations made by farmers. Farmers also recommended the project to engage with both the local and district governments for support on land-use planning.

2.3 Research objectives, approach and key results

2.3.1. Objectives

The overall goal of the science component was to develop a framework for analysing and quantifying climate change mitigation options in smallholder systems, and to assess the effectiveness of the CSA practices and the degree to which they were climate-smart. More specifically, the objectives were to:

1. monitor productivity and resilience for different agricultural management practices along a gradient of sustainable intensification and compare these with GHG emissions to identify the synergies and trade-offs;
2. understand the GHG sinks and sources and quantify the GHG fluxes from various land uses, crops (maize, cassava, rice) and management practices in the farming systems (Fig. 19); and
3. assess the biomass and above-ground carbon for forest, agricultural land, and fallows, and compare these findings with land use and land-use change analysis from satellite images.

Figure 19. GHG emissions measurements with chamber techniques.

© FAO/J. Rioux



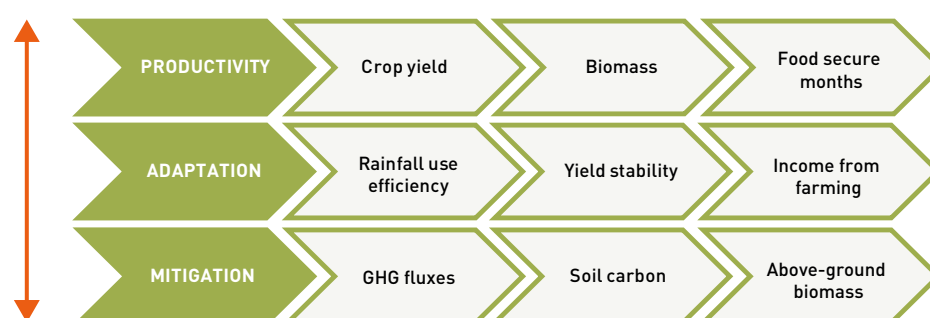
2.3.2. Approach

Biophysical and socio-economic data were combined to assess the outcomes of the different CSA practices in terms of productivity, adaptation and mitigation. Data on household characteristics and farm management were gathered in the socio-economic surveys carried out at the beginning of the project. A summary of the data analysed during the project is

shown in Figure 20. The data collected and analysed cover the field, farm, and landscape levels, as shown in Figure 21.

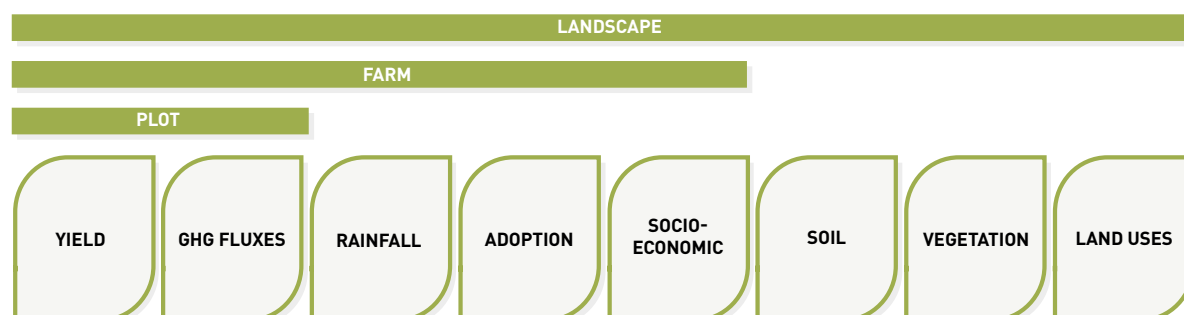
The main results of the **biophysical baseline and soils analysis** using the Land Degradation Surveillance Framework (Walsh and Vågen, 2006) are presented in Annex 8.1.

Figure 20. Variables analysed according to the three CSA objectives and their synergies.



Source: Authors

Figure 21. Multi-level data collection.



Source: Authors

2. 3. 3. Key results and implications for CSA programming

Targeting conservation agriculture in the context of livelihoods and landscapes

A simple Monte Carlo-based decision model, calibrated to global data sets and parameterized to local conditions, was developed to predict the range of yield benefits farmers may obtain when adopting conservation agriculture in the two ongoing agricultural development projects in East Africa (Rosenstock *et al.*, 2014a). The general model predicted a near equal chance of positive and negative impacts on yield. When using site-specific, socio-economic, and biophysical data, mean changes in yield were more negative. This suggested conservation agriculture is highly unlikely to generate yield benefits for farmers in the two locations. Despite comparable aggregate effects at both sites, factors, such as land tenure, access to information, and livestock pressure contrasted sharply, highlighting the need to quantify the range of livelihood and landscape effects when evaluating the suitability of the technology.

Is conservation agriculture 'climate-smart' for maize farmers in the highlands of the United Republic of Tanzania?

Four variations of conservation agriculture: reduced tillage plus mulch, reduced tillage plus mulch and leguminous cover crop (lablab), reduced tillage plus mulch and leguminous trees (conservation agriculture with trees), and reduced tillage plus mulch and nitrogen fertilizer (conservation agriculture and fertilizer) were evaluated for their effect on CSA-relevant

outcomes in highland maize production (Kimaro *et al.*, 2015). By comparison to conventional practice in the region, intensification of maize production by conservation agriculture with trees, and conservation agriculture with fertilizer increases yields by more than 75 percent. Likewise, rainfall use efficiency was highest in these three treatments and significantly greater than conventional practices. Seasonal and annual GHG fluxes were similar across all treatments. However, GHG emissions intensity (tonnes carbon dioxide equivalent/tonnes of grains) was lower in conservation agriculture with trees and conservation agriculture with fertilizer than conventional practice. The findings demonstrate that, providing other constraints to adoption are removed, conservation agriculture can deliver benefits consistent with the objectives of CSA for farmers in this region, particularly when soil nitrogen limitation is alleviated.

GHG fluxes from agricultural soils of Kenya and Tanzania

Carbon dioxide, nitrous oxide, and methane fluxes were measured at ten farmer-managed sites of six crop types for one year in Kenya and Tanzania using static chambers and gas chromatography. Cumulative emissions depended on crop type, environmental conditions, and management (Rosenstock *et al.*, 2016a). Manure inputs increased carbon dioxide, but not nitrous oxide or methane emissions. Soil cultivation had no discernable effect on emissions of any of the three gases. Fluxes of carbon dioxide and nitrous oxide were greater during the wet versus the dry seasons for some, but not all, crop types. The heterogeneity and seasonality of fluxes suggest that the available data describing soil fluxes in Africa, based on measurements of limited duration of only a few crop types and agro-ecological zones, are inadequate to use as a basis for estimating the impact of agricultural soils on GHG budgets.

Spatial and temporal tree cover change in the Southern Uluguru Mountains, Tanzania.

In a landscape-scale examination of land use and land-cover change between 1984 and 2013 around the Kolero region and its effect on above-ground biomass and carbon, Mpanda *et al.* (forthcoming) found that there has been considerable change in land cover, with a decrease in closed forest and an expansion of fallow and farms. However the estimate of carbon in above-ground biomass in the landscape was similar for 1984 and 2013. This can be explained by the fact that the increase in fallow area is estimated to store a significant amount of carbon. The study showed that improved fallows have the potential to increase carbon stocks and restore degraded lands.

3. The portfolios of CSA practices and their implementation

3.1 Micca pilot project in Kenya

3. 1. 1. Smallholder integrated crop-livestock system in Kaptumo

The MICCA pilot project aimed to reduce the overall GHG balance of the livestock production systems by improving animal breeds and their productivity, thereby reducing cattle number. Long-term sensitization processes were required about the environmental impact of livestock practices. It was also necessary to improve the availability of veterinary services for disease control and artificial insemination for more productive breeds. Farmers also required advice on husbandry practices related to food and water requirements for optimal milk production.

Figure 22. Livestock keeping in Kaptumo area, Kenya.

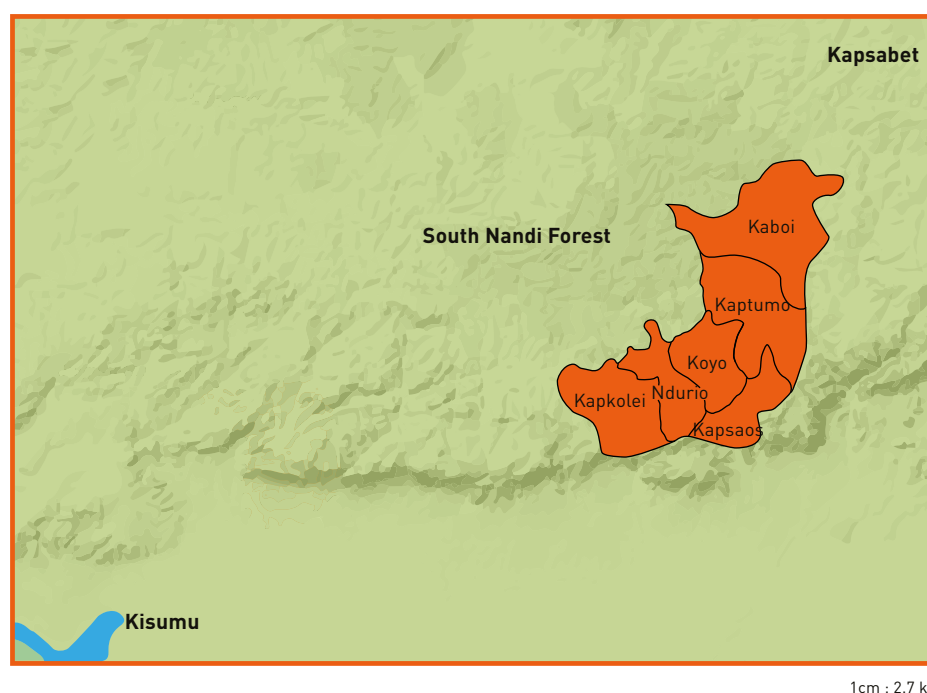
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The six locations of the MICCA-EADD pilot project were Kaptumo, Ndurio, Kapkolei, Koyo, Kapsaos and Kaboi (Fig. 23).

Figure 23. Map of Kaptumo area, Kenya.



Source: Authors

The precipitation data in the Kaptumo area showed two seasonal periods, the long rains (with the peak rainfall in April) and the short rains (with the peak rainfall in September). The total monthly average collected by the project in 2013 showed a more regular rainfall.

Figure 24. Average monthly total rainfall from 1900 to 2012 and monthly total in 2013 in Kaptumo, Kenya.



Source: Authors with data from World Bank Climate Change Knowledge Portal - <http://sdwebx.worldbank.org/climateportal>

3. 1. 2. CSA practices selected

Supporting on-farm fodder production to improve milk production in a sustainable manner, and better manure and grazing management were identified as the entry points for CSA. Awareness raising and capacity development on climate change, and the adoption of

agricultural practices to cope with climate variability were recommended by the project team, as well as the further promotion of agroforestry. The portfolio of selected practices was intended to reduce the climate change 'footprint' of dairy production systems by improving milk productivity and increasing the incomes of dairy producers and at the same time lowering the GHG emissions from the whole farm.

The practices were chosen to:

- improve feed production and conservation on farm through agroforestry and other means;
- improve cattle and pasture management (e.g. breeding and paddocking) ; and
- improve manure management through composting or biogas production (Table 3).

Leguminous fodder production and fodder crop residues provide cattle with a rich diet and improve the quality of the manure, which, when added to the soil, increases crop and fodder productivity. Using agricultural residues in this way also avoid the emissions released from burning them. The integration of perennial leguminous trees with dairy livestock production and leguminous cover crops enhance the productivity of the land by increasing the efficiency of nutrient recycling. Integrating trees with livestock production also increases soil carbon, which can compensate part of the livestock-related emissions.

Table 3. MICCA-EADD portfolio of selected CSA practices.

CSA practices	Sub-practices/species
Improved fodder production and conservation	<i>Pennisetum purpureum</i> (Napier grass) <i>Chloris gayana</i> (Rhodes grass) <i>Sorghum</i> spp. <i>Medicago sativa</i> (lucerne/ alfalfa) Cow kandy Columbus grass <i>Lablab purpureus</i> (lab lab) <i>Desmodium</i> spp. <i>Bracharia</i> spp. Hay and silage making
Agroforestry and tree nursery	<i>Chamaecytisus palmensis</i> / Tree lucerne (fodder) <i>Sesbania sesban</i> <i>Calliandra calothyrsus</i> (fodder) <i>Leucaena trichandra</i> (fodder) <i>Grevillea robusta</i> <i>Croton</i> spp. <i>Eucalyptus</i> spp.
Improved pasture management	Bush clearing Paddockking Spot and strip sowing with legumes
Improved manure management	Collection of manure Composting Biogas digester

Figure 25. Stall feeding.



Figure 26. Napier grass.



Figure 27. Tree nursery.



Figure 28. Biogas production.



3. 1. 3. Implementation and extension

Approach and results

The capacity-building activities were undertaken through the EADD programme and district extension services in the hub of the Kaptumo Dairy Farmer Business Association (DFBA), which had 3 450 members. DFBA members received training, gained more stable access to markets and could use its milk collection service and cooling plant. MICCA trained project participants on climate change and CSA practices. As the farmers had different assets and capacities, the training sessions were tailored to meet the needs of different farmer groups for carrying out the capacity-building activities. Based on the results of the situation analysis, the awareness-raising and capacity-building activities were connected with access to loans, and focused on how the CSA practices could improve incomes. Providing farmers with greater access to loans was important to ensure that they had the financial resources to implement what they had learned.

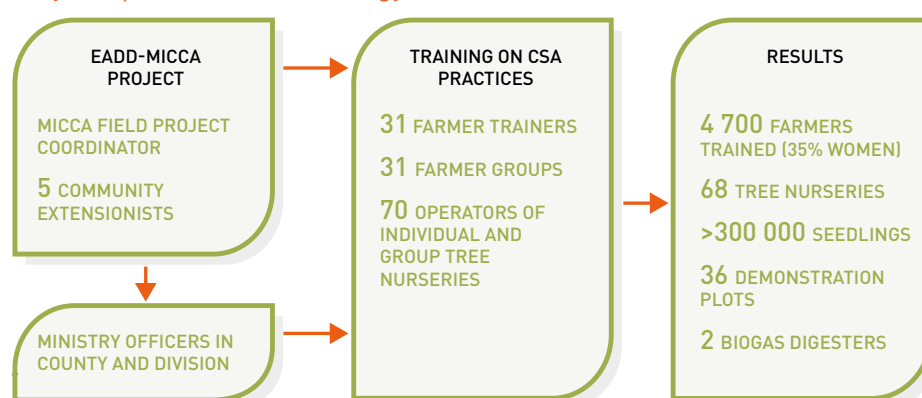
As half of the EADD active milk suppliers were women, gender was considered when planning the capacity-building activities and implementing the selected CSA practices. Awareness of climate change in agriculture and gender was done through several one-day stakeholder meetings every six months with farmer group representatives, members of Kapcheno board, and representatives from the Ministry of Livestock Development, the Ministry of Water and the Ministry of Environment from Nandi County. In total, 4 673 farmers were trained on CSA (Table 4).

Table 4. Number of farmers trained over the years in Kaptumo, Kenya.

	2012	2013	2014	Total (% women)
Farmers trained by EADD-MICCA	195	1 759	1 443	3 397 (34%)
Farmers trained by EADD-MICCA' partners	-	791	485	1 276 (n/a)
Total	195	2 550	1 928	4 673 (35%)

The project had one extension officer, who trained five community extension service providers on CSA and on specific CSA practices. The community extension service providers then trained 31 farmer trainers, and around 70 private and group tree nursery operators. These farmer trainers and trained tree nursery operators provided training to the farmers in their group. 4 673 farmers (35 percent women) participated in awareness sessions (during farmer field days, workshops and seminars) and/or were trained directly on the selected CSA practices through the establishment of 31 farmer groups (658 members, 31 percent women), 36 demonstration plots (15 in 2012, and 21 in 2013), 2 biogas digesters, 68 tree nurseries, and the planting of more than 300 000 seedlings (Fig. 29). This innovative farmer-to-farmer extension approach can reach thousands of farmers through informal interactions. Based on previous research in the area, it was estimated that each farmer trainer can engage with approximately 20 additional farmers per month (Kiptot and Franzel, 2012).

Figure 29. Kenya implementation strategy and main results.



Source: Authors

Figure 30. The Kapcheno dairy business association in Kaptumo, Kenya.



Extension and training methods

Farmer groups and demonstration plots

The farmer group approach was the main extension method employed in the promotion of CSA practices. Parallel groups were formed for training sessions on tree nurseries. In this approach, farmer trainers (also called model or champion farmers) facilitate the learning process of their peers. Farmer trainers belong to a local farmer group. With assistance from EADD-MICCA facilitators, the trainers are recruited and selected by the farmers from that group and the members of Kapcheno dairy. Once recruited, the community extension service providers trained the farmer trainers and tree nursery operators on the different technologies. These service providers were backed up by the dissemination facilitator, DFBA extension officer and the EADD-MICCA project coordinator. Continuous training was provided based on the needs of each specific farmer group. There were 31 farmer groups, with each group consisting of 18-40 members.

Figure 31. Awareness-raising session on CSA with a farmer group in Kenya.



Farmer trainers also established demonstration plots on their own farms to showcase the different practices and train fellow farmers. The farmer trainers also received 400-500 tree seedlings, 150-200 grams of high-value fodder crops seeds and potting bags to share with farmer members after the seeds germinated. The demonstration plots showcased different species and practices depending on the farm. Farming practices and crop species planted on demonstration plots were influenced by farmer preferences, soil conditions and seed availability.

Tree nursery management groups

Increasing on-farm tree cover through agroforestry was promoted by tree-planting activities, which included the establishment of individual and group tree nurseries (Table 5). The fodder trees introduced were mainly *Calliandra calothyrsus*, *Leucaena trichandra*, *Cytisus proliferus* and *Grevillea*. Groups and individual nurseries produced their own seeds of *Eucalyptus*, *Croton* and *Grevillea*.

Table 5. Number of tree nurseries and tree seedlings produced between 2012-2014 in the Kenyan pilot site.

	2012	2013	2014	Total
Tree nurseries	15	21	17	53
Seedlings	22 500	85 500	485	1 276 (n/a)

Awareness raising

In collaboration with project partners (Kapcheno dairy, Ministry of Agriculture, Livestock and Fisheries, Ministry of Environment, and the Lake Victoria Basin Management Project), workshops and seminars were organized between farmers groups and with a wider range of farmers and stakeholders to raise awareness about climate change and CSA, develop common extension messages and reach more farmers (Fig. 32). The sustainability and scaling up of the project's activities depend largely on the involvement of these partners.

Figure 32. Climate change awareness raising with multiple farmer groups.



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Exchange visits were also organized by the project team to raise awareness about CSA to the farmers in the groups and give them the opportunity to meet and share experiences with innovative farmers and model farmers (Fig. 33). In total, 200 people participated in exchange visits.

Figure 33. Exchange visit as part of capacity development activities.



3.2 MICCA pilot project in the United Republic of Tanzania

3.2.1. Cereal-based family farming in the highlands

In the Uluguru mountains, farmers are mainly subsistence crop producers. Farming practices include slash-and-burn agriculture and the annual burning of fields and adjacent forest areas (Fig. 34). These practices cause severe soil degradation, significant erosion of the steep slopes and siltation problems downstream. They also waste valuable nutrients, decrease soil fertility and reduce soil carbon. Slash-and-burn practices also contribute to the expansion of agricultural land and deforestation.

Figure 34. Maize cultivation on the hills and slash and burn for land preparation in the Uluguru mountains, the United Republic of Tanzania.



The MICCA pilot project was carried out in the framework of the CARE hillside conservation agriculture project, which worked to integrate conservation agriculture practices into smallholders' farm management. The pilot project aimed at combining conservation agriculture with agroforestry, introducing improved cooking stoves and conserving soil and water. The goal was to improve yields and livelihoods and reduce burning, erosion and deforestation. It was assumed that sustainable intensification on farmland would also increase food security. The pilot project covered the wards of Kolero, Kasanga and Bungu (Fig. 35 and Table 6).

Figure 35. Map of the Kolero, Kasanga and Bungu wards, South Uluguru Mountains, Morogoro Rural District, United Republic of Tanzania.



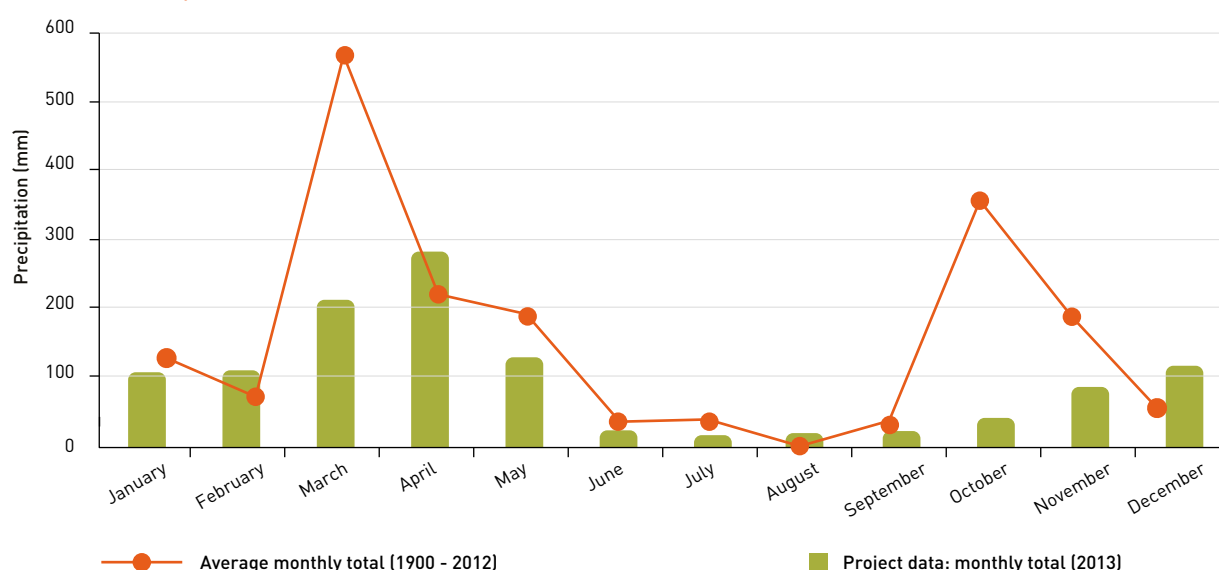
Source: Authors

Table 6. Project village locations within the Uluguru Mountains, the United Republic of Tanzania.

Ward	Villages	Altitude (m)
Kolero	Lubasazi, Mlangano	Lowland
	Lukange, Kolero	Middle land
Kasanga	Kitonga	Middle land
	Kasanga, Kizagila	Highland
Bungu	Balani	Middle land
Lowland: 333 - 350 m, Middle land: 420 - 508 m, Highland: 718 -1158 m		

The precipitation data gathered by the project followed a similar pattern to the average monthly total collected from 1900 to 2012 in the Kolero area. There are two seasonal periods, the long rains (with the peak rainfall in March) and the short rains (with the peak rainfall in October). However, it seems the short rains for 2013 were unusually low.

Figure 36. Average monthly total rainfall from 1900 to 2012 and in 2013 in Kolero, United Republic of Tanzania.



Source: Authors with data from World Bank Climate Change Knowledge Portal - <http://sdwebx.worldbank.org/climateportal>

3.2.2. CSA practices selected

To support CSA, the project team recommended raising awareness on climate change and the adaptation and mitigation potential of conservation agriculture and the impacts of slash-and-burn agriculture, and increasing tree planting and agroforestry. Based on the situation analysis, the portfolio of CSA practices implemented involved soil and water conservation combined with high-value crops, agroforestry, conservation agriculture and the promotion of improved cooking stoves (Table 7). Linked to all these interventions was the Village Savings and Loans Association, which emphasized saving and lending money to invest in CSA practices.

The portfolio of CSA practices was designed to address key drivers of land degradation. The selection of the CSA practices was based on the following assumptions: improved cooking stoves can reduce firewood for cooking and reduce the time women spend to fetch firewood; conservation agriculture can foster agricultural intensification, increase crop diversity for food and nutrition security and limit agricultural expansion and deforestation; agroforestry can increase tree density on farm and limit burning; and soil and water conservation can reduce soil erosion and improve agricultural productivity on hillsides. One more assumption was that farmers will use the Village Savings and Loans Association as a vehicle to save money and access small scale loans to invest in CSA practices. The focus was on building synergies between climate change mitigation and adaptation and sustainable food production to reduce deforestation, cope with climatic variability and improve agricultural production by limiting shifting cultivation and burning.

Table 7. MICCA-CARE portfolio of selected CSA practices.

CSA practices	Sub-practices/ species
Conservation agriculture	Minimum tillage (after double digging) Mulching Intercropping with legume Crop rotation
Agroforestry and tree nursery	<i>Faidherbia albida</i> <i>Grevillea robusta</i> <i>Leucaena diversifolia</i> Spice trees (e.g. cardamom, pepper) Fruit trees (e.g. mango)
Soil and water conservation	Terraces (>35-50% slope) Fanya juu or Fanya chini (12-35 % slope) Vegetative strips (< 5% slope)
Improved cooking stoves	Improved stoves for cooking and brewing

As part of its agroforestry activities, the project supported the establishment and maintenance of tree nurseries and provided tree propagation and management training. The project also facilitated consultations with stakeholders on issues related to land tenure, incentive mechanisms and by-laws to promote the widespread adoption of agroforestry, and alternatives to slash and burn.

Conservation agriculture practices were promoted to improve agricultural productivity and increase the carbon content in the soil (Fig. 37). The introduction of conservation agriculture was associated with these practices: no or minimum tillage; permanent cover of the soil surface through intercropping with leguminous cover crops or mulching; and crop rotation.

The soil and water conservation techniques include the construction of terraces (bench, Fanya juu and Fanya chini), and vegetative strips. Fanya juu and Fanya chini terraces are constructed by digging a trench along the contour and throwing the soil on the upper or on the lower side of the contour trench respectively. They are terraces in transition, as they are not flat at time of construction, but gradually form bench terraces.

Improved cooking stoves are upgraded versions of traditional stoves that increase thermal efficiency, which reduces the amount of wood needed and puts less pressure on forest resources (Fig. 38).

Figure 37. Conservation agriculture (no tillage, intercropping with lablab and mulching) and terraces with pineapple.



Figure 38. Improved cooking stoves.



3. 2. 3. Implementation and extension approach

Approach and results

The CARE project staff based in Morogoro and two field extension agents based in Kolero village provided support for capacity building to farmers. During village awareness-raising sessions, farmers were informed about project activities, and those who were interested could form farmer field schools or farmer groups to participate in training sessions. District and ward officials were also involved in the awareness-raising sessions and the training of trainers, so they could promote similar extension messages, and follow up with farmers to ensure the sustainability of the project activities. The training sessions targeted community-based trainers, which are composed of contact farmers and improved cooking stoves trainers (mainly women). The training of trainers was done at the Centre for Sustainable Living (CSL)

in Kolero (Fig. 42). Training for the farmer field schools and farmer groups was done in the villages. Demonstration plots were established at the CSL and in the fields of farmer field school trainers. Trainings related to tree nurseries and agroforestry were provided by ICRAF-Tanzania staff based in Dar es Salaam and a field extension officer based in Kolero village. The training included practical training conducted at the CSL on nursery techniques, and later followed by technical backstopping on sites where groups and individuals were running their own nurseries. Exchange visits were organized to promote the sharing of knowledge between different villages both within and outside the project area.

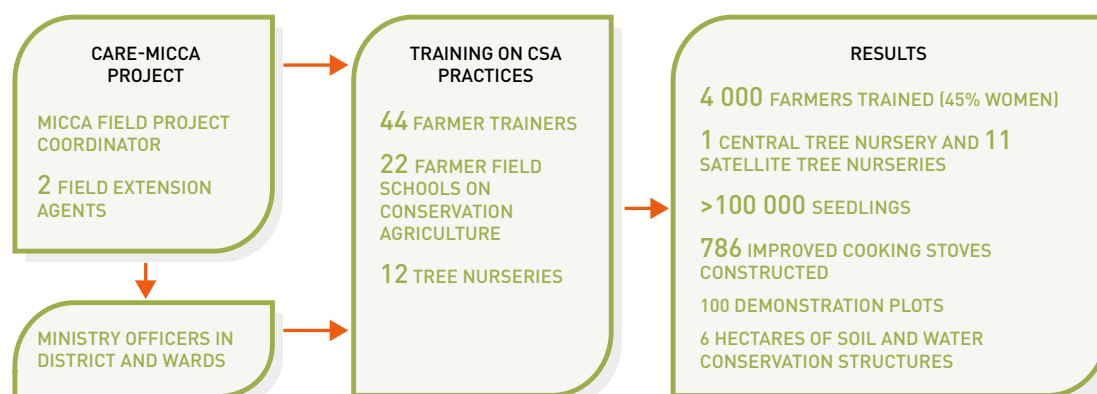
Figure 39. Demonstration plots at the CSL in the United Republic of Tanzania.



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Over a three-year period, the MICCA pilot project was implemented in eight villages through 22 farmer groups with 44 farmer trainers, and 100 demonstration plots (Fig. 43). It resulted in the establishment of 12 group and institutional tree nurseries (overall more than 100 000 seedlings were produced), including one central nursery at the CSL; the construction of 786 improved cooking stoves; and the construction of six hectares of terraces on 204 farms. Over 600 farmers started practicing conservation agriculture.

Figure 40. United Republic of Tanzania implementation strategy and main results.



Source: Authors

More than 1300 farmers (43 percent women) participated in climate change awareness sessions, and 2750 farmers (45 percent women) received training on the four practices supported by the project (Table 8). Sixty-five percent of the women were trained on improved cooking stoves. Training sessions on conservation agriculture through farmer field schools reached a total of 1 400 farmers (470 farmers in 2012; 634 in 2013; and 314 in 2014).

Table 8. Farmers trained on the different CSA practices in the United Republic of Tanzania.

	Farmers trained (% women)			
	2012	2013	2014	Total 2012-2014
Conservation agriculture	470 (41%)	634 (40%)	314 (41%)	1 418 (41%)
Soil and water conservation	-	437 (38%)	303 (40%)	740 (39%)
Improved cooking stoves	-	320 (66%)	270 (65%)	590 (65%)
Total farmers trained				2 748 (45%)
Climate change awareness				1 317 (43%)

Cultivated lands on hillsides were degraded and produced low yields due to soil erosion. With the implementation of soil and water conservation practices, farmers were able to better utilize their land and plant high-value crops (okra, groundnuts, cowpeas, onions, tomatoes, Irish potatoes, beans) on terraces and increase their income. In total, the project helped farmers construct soil and water conservation structures on 6 hectares of farmland for 204 farmers (45 percent). Terraces made up 70 percent of these structures; Fanya juu terraces, 20 percent; vegetative strips, six percent; and Fanya chini terraces, four percent.

Farmers using improved cooking stoves reduced their fuelwood consumption by 65 percent compared to conventional. The improved cooking stoves also reduced the amount of time women spent collecting fuelwood by two hours a day. Fifty of the 786 improved cooking stoves were constructed for artisanal brewing, which is a local activity that consumes considerable amounts of wood. Brewers reported using four times less wood compared to the traditional brewing stove. The trainers and builders received requests for the construction of improved cooking stoves in neighboring villages. More than 700 households are using improved cooking stoves (237 in 2013; and 499 in 2014).

Forty-two percent of the farmers who participated in the field visits expanded the area cultivated with terraces and/or conservation agriculture. Many of the farmers that went on exchange visits are now engaged in cultivating high-value crops, such as groundnuts and tomatoes. For women, these experiences were valuable, as they were able to share experiences with women from other communities. After the visits, the women farmers interacted more freely with project staff.

Extension and trainings methods

Farmer field schools, farmer groups and demonstration plots on conservation agriculture

Farmers field schools, which were used to promote conservation agriculture, were composed of farmers who met regularly, especially during growing seasons. Working as a group, the farmers experimented with new production options with the support of an extension service provider. A farmer field school is a 'school without walls' for improving the decision-making capacity of farmers and stimulating local innovation for sustainable agriculture. The farmer field schools were intended to increase the capacity of farmer groups to test new technologies in their fields, assess the results and their relevance to their particular circumstances, and interact on a more demand-driven basis with researchers and extension workers. Normally 0.1 hectares is enough to have a demonstration and control plot. In total, around 100 demonstration plots were used over the course of the project.

With the support of printed instructional materials, training sessions were carried out to assist contact farmers and community-based trainers become familiar with proper conservation agriculture principles. A special focus was given to land preparation in remote uplands through the installation of demonstration plots. By visiting farmers starting to implement conservation agriculture with the support of contact farmers and community-based trainers, the project staff could better highlight constraints and common mistakes and improve further training sessions. In the farmer field schools, farmers planted maize on two plots, one using conservation agriculture practices and the other one following conventional practices. In this way, the farmers could compare the two approaches and decide for themselves which one suited them best. Four maize demonstration plots were established and managed by school teachers and older pupils to illustrate effective techniques for improving production and land use.

Figure 41. Farmer demonstration plots in Kolero, United Republic of Tanzania.



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Soil and water conservation

The training on soil and water conservation was done in two phases, one at the CSL and the other in the respective villages of each farmers group. The practical training on soil and water conservation was field-based, and farmers actively participated. This training was primarily focused on terracing, including bench terraces, Fanya chini and Fanya juu and grass strip farming, depending on the slopes. Contour bunds with pineapples and trash lines were also introduced to the farmers during these training sessions. Sign posts were also placed close to demonstration plots and at the CSL in Kolero, with the main messages of the MICCA activities in the area.

Improved Cooking Stoves

A training of trainers session was conducted with 24 participants (89 percent women). These participants later trained others in their respective villages forming 35 improved cooking stove groups. The project provided knowledge and working tools, including the brick 'mould' used in the improved cooking stove construction. Two entrepreneurial groups with 25 and 10 members each have generated income by marketing and building improved cooking stoves, and training others.

Tree nursery management groups

The central tree nursery was strategically established at the CSL in Kolero village and served as a hub for training, demonstrations and a source of seedlings, materials, information, and technical support for satellite and individual nurseries. Assistance to the satellite nurseries was provided according to their needs. The material provided included seeds of various tree and shrub species, polybags, rakes, watering cans, polythene tubes and other germplasms (scion material for grafting), and a shade net for the central nursery in Kolero. The Tanzania Tree Seed Agency and other groups procured the supply of seedlings. The project conducted several activities:

- Training sessions were held on establishing and managing nurseries and to raise awareness on the different functions of trees and the ecosystem services they provide.
- Support was provided for stakeholder consultations between local and district authorities, and between clan landowners and farmers. These meetings sought to find joint solutions to allow farmers who rent their lands to engage in agroforestry.
- In collaboration with local and district authorities, incentive mechanisms and by-laws were identified to promote alternatives to slash and burn.
- Planting trees and shrub seeds (and scions for grafting) were made available at the CSL and seeds and seedlings were distributed to the satellite nurseries and smallholder farmers. Also, farmers hosting demonstration plots were provided with seedlings of fruit trees to develop and showcase agroforestry systems on their farms.

- Technical and training materials were developed on the establishment of tree nurseries and dissemination of seeds and seedlings, tree maintenance and grafting.

Farmers were trained on establishing nurseries and selecting species based on local conditions and access to markets. Nursery operators also received technical support on vegetative propagation (grafting and budding of fruit trees), general nursery maintenance and some silvicultural techniques, such as root pruning, hardening off and pest management. These operators were further introduced to methods for selecting, harvesting and processing mango, citrus and indigenous seeds. The training in vegetative propagation was carried out for 10 satellite nursery operators at the CSL in Kolero. These operators then trained and spread their knowledge to other operators. Tree planting received attention in lowlands where it had not been widely practiced previously. Particular emphasis was given to proper spacing and planting on farm boundaries to maximize growth. This training was done in collaboration with Mikocheni Agricultural Research Institute, which conducted additional research for testing the suitability of several improved mango varieties in the Kolero area.

Tree planting was done in several locations for a variety of purposes. Most farmers planted trees on boundaries of homesteads to maximize land use; others to reinforce soil and water conservation structures (mainly with *Grevillea robusta* and shrubs, such as *Gliricidia sepium*). Some farmers planted fruit trees to make better use of fallow lands and limit wildfire. A few farmers planted nitrogen-fixing (leguminous) trees to enhance soil fertility, which had been demonstrated in trial plots of maize at the CSL. A few larger land owners planted 10 different species of mango (100 seedlings each) on the same plot to evaluate growth of different species in local conditions and stimulate the demand for improved species.

After the training sessions, random visits to tree nurseries and farms showed high survival rates and good growth of agroforestry trees. Apart from the central tree nursery in Kolero, six group nurseries in six villages and five institutional nurseries (in the primary schools of the villages) were established with a total of 47 members (16 women) trained in establishing and managing nurseries (Table 9). More seedlings were planted, as some farmers started to produce them in their individual nurseries.

Table 9. Tree nurseries and seedlings by year, in the United Republic of Tanzania.

Agroforestry	2012	2013	2014	Total
Tree nurseries	12	12	12	12
Seedlings	19 810	40 681	55 681	116 172

Awareness raising

Awareness-raising sessions were organized with village leaders, clan landlords, ward officials, contact farmers and community-based trainers on climate change, gender, land tenure, agroforestry, and slash and burn issues. A training session on gender was held to share experiences on the impact of climate change on men and women.

A total of 302 farmers (41 percent women) participated in exchange visits to other farms to learn about the importance of tree planting and the benefits of soil and water conservation. During exchange visits, farmers shared ideas and experiences on soil and water conservation, conservation agriculture, agroforestry and improved cooking stoves. Five exchange visits were conducted within and outside the project area. In total, 302 farmers (41 per cent women) participated in exchange visits. CARE also organized study tours to encourage village leaders to participate in MICCA activities and increase their knowledge on a number of issues by showing them other areas where the project had been active. In total, 36 farmers and community leaders acquired hands-on learning experience, which successfully improved livelihoods.

At the Annual National Agricultural Exhibition in August 2014 in Morogoro, MICCA raised awareness about soil and water conservation, improved cooking stoves, conservation agriculture and climate change. MICCA, which provided communication materials and organized demonstration plots, participated at the National Agriculture Exhibition in collaboration with the Department of Land Use Planning and Management.

Figure 42. In-class training with farmers at the CSL in Kolero, United Republic of Tanzania.

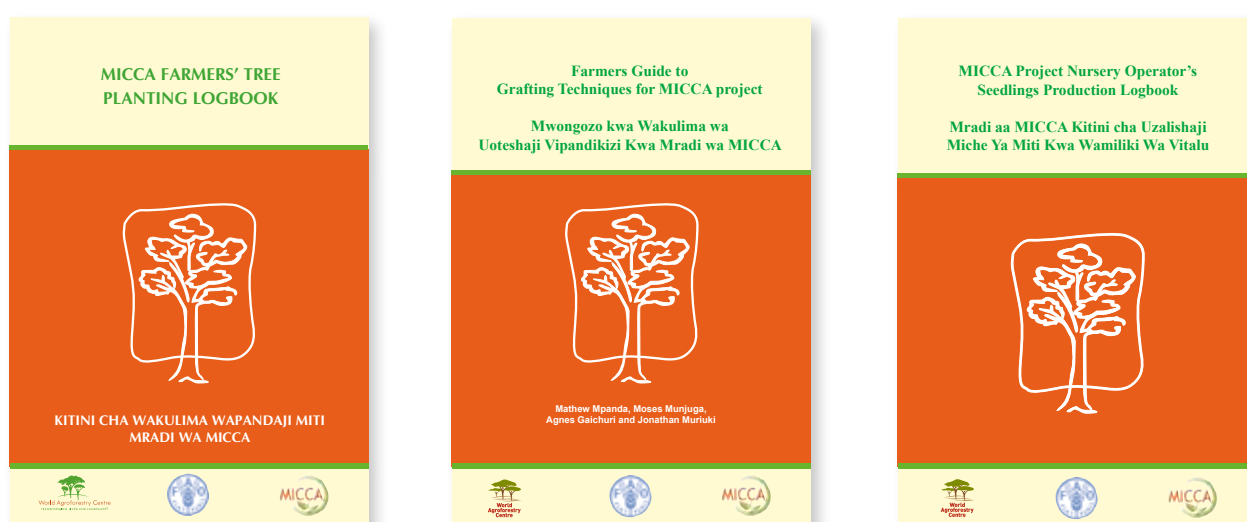


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Training material

Several practical guidelines were developed to assist farmers and nursery operators in the project area. These included: a farmers' tree planting and management logbook to keep records of the growth of trees on their farms; an operator's vegetative propagation guide and logbook; and a guide for nursery management, tree propagation and marketing (Fig. 47). The pilot project also prepared two training manuals for improved cooking stoves and soil and water conservation; farmer field school guidelines for conservation agriculture; a factsheet on energy saving; and a poster on the package of CSA practices. Existing training materials by FAO and ICRAF were also used.

Figure 43. Agroforestry training materials.



4. Evaluating the adoption and benefits of CSA practices

4.1 Objectives

To better understand the dynamics of adoption of the promoted portfolio of CSA practices in the pilot sites and support future extension and scaling up of CSA, a study was designed to identify and analyse the barriers and incentives for CSA adoption. The study gathered quantitative and qualitative data from adopters and non-adopters and assessed the perceived benefits and livelihoods outcomes of the CSA practices.

4.2 Methodology

In both pilot sites, a random sample of project participants was taken by using the proportion-to-population formula with 95 percent confidence level, 7 percent confidence interval and 0.5 standard deviation. Households were the unit of sampling for the survey. The sample was taken from project participants and proportionate among locations, as the main strata for sampling, and also balanced by gender and altitude in the United Republic of Tanzania.

In both sites, structured household interviews were conducted to collect quantitative data on household and farm characteristics; participation in MICCA project activities; the adoption of CSA practices (level, barriers and incentives); and benefits (food security, income and livelihoods). Focus group discussions (6-10 participants each) were also conducted to gather qualitative information on the determinants and benefits of CSA adoption.

In **Kenya**, household interviews (150 people, 35 percent women) and five focus group discussions took place in all six locations in the Kaptumo division (Mutoko *et al.*, 2015). The sample was proportionate to each of the six villages. The first focus group discussion was carried out with staff from the MICCA-EADD-ICRAF project and the Kapcheno dairy. The second was with male farmer trainers. The third and the fourth focus group discussions were with farmers who cultivated tea and maize respectively (mixed men and women groups), and the last focus group discussion was with female farmers who were randomly sampled from two farmer women groups. In total, 19 female and 28 male farmers participated in the focus group discussions.

In the **United Republic of Tanzania**, household interviews (169 people, 51 percent women) and five focus group discussions were held in eight villages in three wards in the Uluguru Mountains (Mutabazi, unpublished). The villages were grouped by altitude: low (333-350 metres above sea level), medium (420-508 metres above sea level) and high (718-1158 metres above sea level). The sample was proportionate to each altitude group (Table 6). Overall, 13

women and 24 men participated in the focus group discussions. The first one was with the farmers trainers (both women and men); the second and the third were with trained farmers (adopters and non-adopters, respectively); the fourth was with farmers who did not receive any training but participated in awareness-raising sessions; and the last was with the local ward officials and village leaders.

The Kenyan and the Tanzanian datasets were analysed quantitatively and qualitatively. The statistical analysis was made through a logistic regression to estimate the adoption predictors for each practice. The determinants of adoption were associated with the characteristics of both the farmer and the farm; the features of the different practices and technologies; and the social and institutional context. The current level of adoption of CSA practices was assessed by determining who had adopted the practices at the time of survey or during the last growing season. The indicators of potential benefits that were considered were: food security, household income, yield, vulnerability to climate risks, labour and time requirements, and environmental benefits.

The statistical results were also supported by the qualitative data collected from the discussions with farmers.

The tests and models used for the statistical analysis were: Pearson correlation, Binary Logistic regression and Cross tabulations with Chi-square statistics. Correlations were generated for the household information and whether the CSA practices had been adopted or not. Results are presented in Table 16 Annex 8.6.

4.3 Kenya

4.3.1. Farmer and farm characteristics

Household and farm characteristics

The majority of respondents (65 percent) who participated in the project activities were men, and most of them (90 percent) were the head of the household. Almost all (95 percent) of the respondents stated that the head of the household is the main decision-maker regarding farming activities. In most cases (86 percent), the head of the household worked on the farm. A typical household in the study site had six members. Half of the family members worked primarily on the farm; the rest were school children or adults working elsewhere. The average size of male-headed households was 6.2 people; for female-headed households it was 5.5 people. The average age of the farmers was 50 years.

Education

A third (33 percent) of farmers had only primary-level education; 45 percent had secondary-level education and 15 percent had college-level education. There was little difference by gender: 47 percent of male and 42 percent of female farmers had attained secondary education. A majority of farmers had sufficient formal knowledge to understand and implement CSA practices and technologies.

Farm size

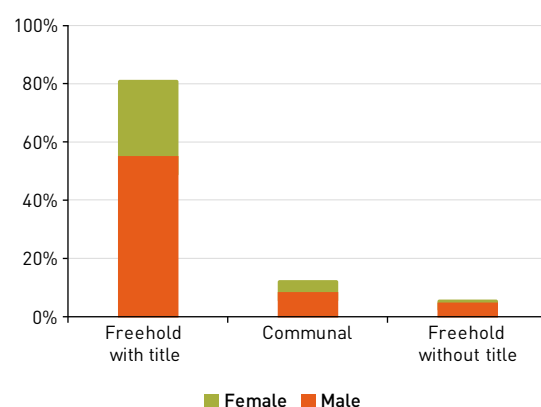
The average farm size was 1.7 ha ranging from 0.2 ha to 6.9 ha with a median of 1.2 ha. Two-thirds (66 percent) of the surveyed farmers worked an area of land less than the average size, and a few farmers had large farms.

Labour

Around half (55 percent) of farmers hired on average three farm workers over six months during the preceding year. Male-headed households hired slightly more workers but for a relatively short period of time (6 months). Female-headed households hired fewer workers but for a longer period (8 months). Labour was hired for fieldwork, such as picking tea leaves, livestock feeding and grazing.

Land tenure

The main type of land tenure was freehold with title (Fig. 44). Male-headed households were about twice as likely to have title to their land than female-headed households. According to responses from the focus group discussions with women, the majority of households had secure land tenure, but men were the custodians of land title deeds. Women and youth had limited user rights. This made it difficult for them to plant trees, as they could be viewed as 'marking out their own farm boundary'.

Figure 44. Land tenure by gender of household head.

Source: Authors

Livestock

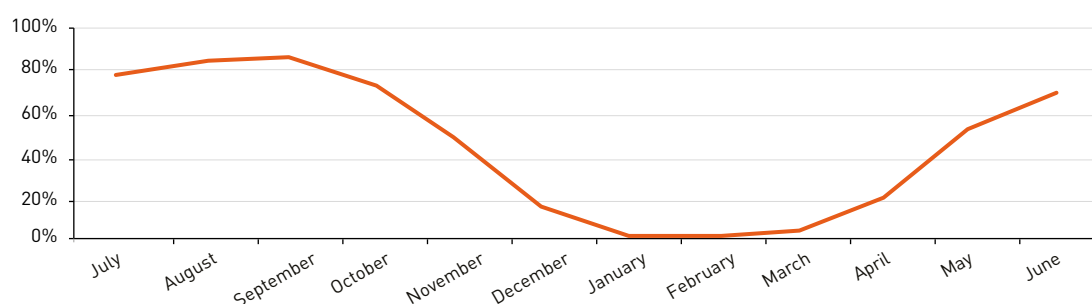
Most farmers (88 percent) owned cattle, and many had chickens. Almost all (97 percent) of the respondents practiced mixed crop-livestock systems as opposed to solely raising livestock or cultivating crops. Sixty-one percent of farmers fed their cattle only on paddocks; 18 percent on paddocks and communal land; and 18 percent on paddocks and in a stall. Most of the interviewed households (95 percent) kept at least one dairy cow of an improved breed.

Household income

A large majority (81 percent) of farmers stated that farming was their primary occupation, and for 35 percent of the farmers, it was their main source of income. Most farmers (67 percent) had three sources of income.

The main sources of agriculture and overall income were selling tea leaves (47 percent) and milk (36 percent). Farmers stated that the earnings on tea sales had tended to decline during the last several years. The income from the milk sales is higher during the wet season when more feed is available (Fig. 45). There is potential to enhance milk productivity and increase incomes by improving fodder production and conservation during the dry season.

Eleven percent of the farmers who supplemented their income by providing seasonal labour to other farms, indicated that these off-farm activities were an important source of income. Other sources of income reported by farmers were: salaried employment, occasional jobs, the sale of maize and tree seedlings, small business ventures and the sale of trees, coffee, poultry and eggs.

Figure 45. Feed availability high during the wet and low during the dry season in 2013-2014, Kaptumo, Kenya.

Source: Authors

Access to markets

Farmers took an average of 30 minutes to reach the nearest market. Motorcycles were used by 60 percent of the respondents; bus or public transport by 14 percent; and car by 8 percent. Another 6.5 percent walked, and one percent travelled by bicycle.

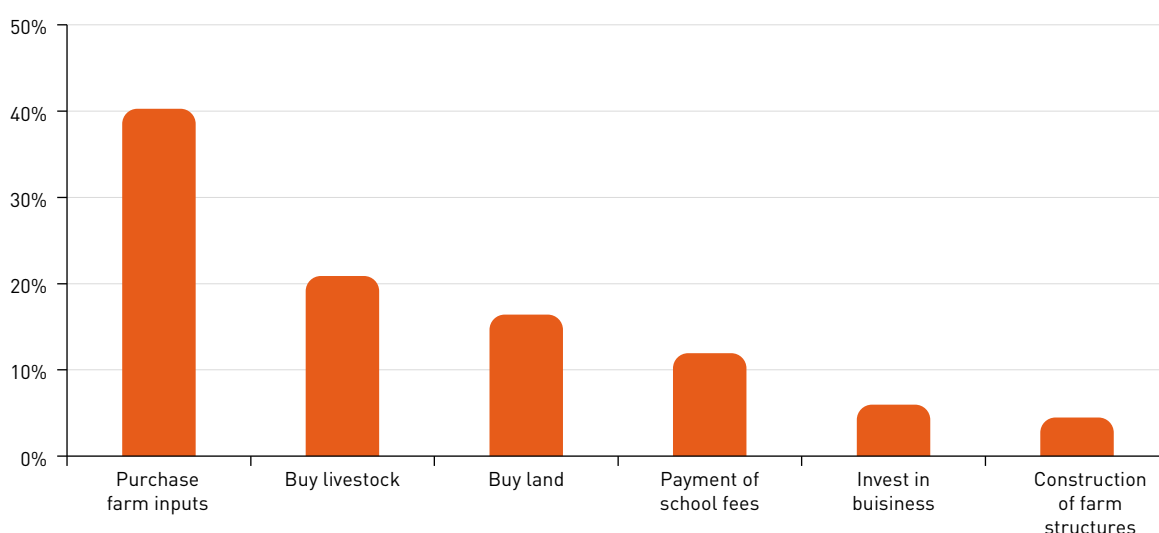
Motorcycles were mostly preferred for transportation of farm products (e.g. milk, tea leaves, vegetables) due to the low cost and speed. Most of male farmers (70 percent) used motorcycles, while female farmers mainly used public transportation.

Access to credit

Nearly half (45 percent) of the project participants had access to credit. The numbers did not differ significantly between farmers who adopted different CSA practices. Access to credit was seen as a difficulty by only 10 percent of farmers. Credit was most commonly used to purchase farm inputs (e.g. seeds, fertilizers, mineral licks) and livestock (Fig. 46). The survey revealed that a greater number of male-headed households invested their credit in farm inputs. This is because male-headed households already owned more livestock than female-headed households. Unlike the male-headed households, female-headed households used their credit for livestock.

Eleven percent used their credit to buy agricultural land and fewer than 10 percent of participants to pay school fees. Very few farmers used credit to invest in off-farm businesses or the construction of farm structures.

Figure 46. Main six uses of credit.



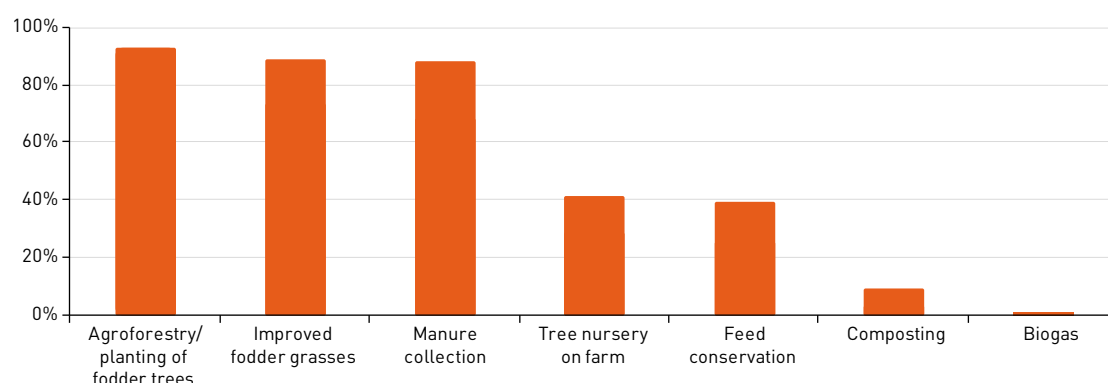
Source: Authors

4.3.2. Level of Adoption

Almost all farmers (99 percent) who participated in the project adopted at least one practice within the portfolio of CSA practices promoted. The CSA practice with the highest level of adoption was agroforestry and planting fodder trees (93 percent), followed by improved fodder grasses (90 percent), manure collection for crop and fodder production (88 percent)

and the establishment of tree nurseries (41 percent) (Fig. 47). The level of adoption for feed conservation (39 percent), manure composting (9 percent) and biogas production (1 percent) were lower because they were newer practices to farmers that required changes in the farming system. The data gathered from the focus group discussions showed that the adoption of CSA practices differed between female and male-headed households.

Figure 47. Adoption level for the package of CSA practices promoted in the Kenya pilot site.



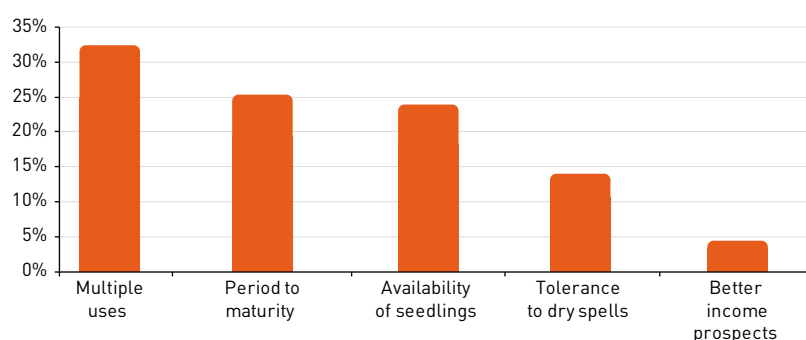
Source: Authors

The level of adoption also varied by location. Lowland households were mostly engaged in dairy farming activities, while highland households relied on the sale of tea leaves for income. Areas where tea production is predominant (Kaptumo, Ndurio, and Kaboi) and rainfall is more reliable had higher levels of adoption. Farmers in tea producing areas practiced silage making and improved paddocking. In areas where maize production is predominant (Koyo, Kapsaos and Kapkolei) adoption levels were lower. Farmers in maize production areas practiced manure composting and established tree nurseries to supplement their income.

Agroforestry and fodder trees

The main sources of tree seedlings were the project's group nurseries (65 percent) and the local market (44 percent). A few farmers obtained seedlings from neighbours or from their own tree nurseries and private nursery operators. Farmers planted trees on small woodlots, farm boundaries or terrace banks. The most commonly planted trees were *Croton*, *Grevillia*, *Calliandra*, *Sesbania*, *Leucaena* and lucerne (Figure 49).

Farmers selected trees species based on a variety of criteria. The most common reason (32 percent) for selecting species was the ability to use the species for multiple purposes (e.g. fuelwood, timber for construction). Other important criteria were the time it took the trees to reach maturity (25 percent) and the availability of tree seedlings (24 percent). Some farmers (14 percent) were also interested in drought-tolerant trees and a few farmers (four percent) chose trees that had the potential to increase incomes (Fig. 48).

Figure 48. Criteria for the selection of tree species.

Source: Authors

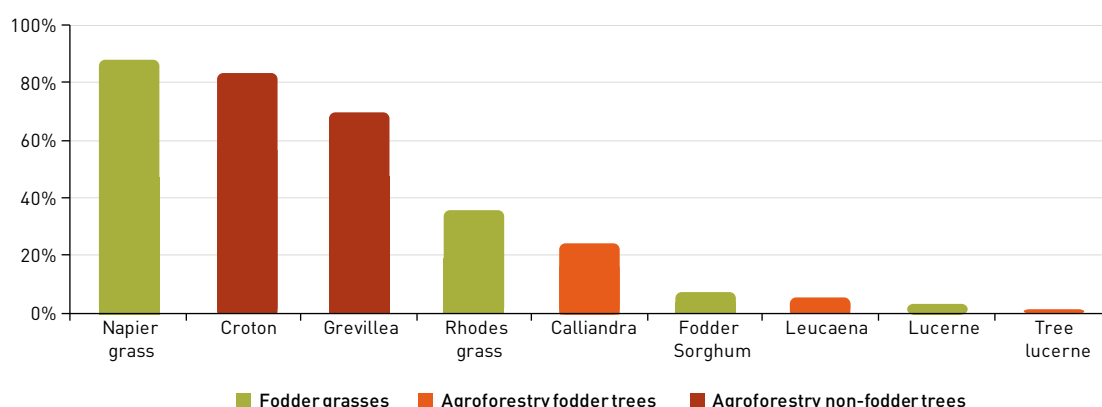
The average number of trees species planted by male-headed households was higher than it was for female headed-households. This may be because female farmers considered tree planting to be a labour-intensive activity. Important differences were also observed regarding the location of the planted trees. Female headed-households did not have much land available and tended to plant trees on the border of their agricultural fields as live fences. Male headed-households established more woodlots on their farmlands. In addition, female farmers viewed tree nurseries, which are mostly managed by women, as providing an immediate source of income through the sale of seedlings. Male farmers considered tree nurseries as a source of seedlings for planting trees on their farm in the hope of long-term economic benefits. The main source of fodder seeds and planting material was neighbouring farmers. Some farmers bought seedlings from the market, others obtained seeds from the project and farmer groups. Very few farmers produced seedlings from their own tree nurseries.

Improved fodder grasses

Most farmers (90 percent) cultivated improved fodder crops on a portion of their agricultural fields to increase productivity.

The most commonly reported fodder crops were Napier grass, Rhodes grass, *Sorghum* spp., *Desmodium* spp., lucerne (alfalfa) and lablab (Fig. 49). A larger area was planted with Napier and Rhodes grasses compared to other improved fodders.

Most farmers selected a type of fodder that could enhance milk productivity (28 percent). Other criteria that were commonly identified by farmers were: the high yield potential of the crop (20 percent); the amount of labour involved in harvesting and feeding it to animals (16 percent); the growth rate (15 percent); the availability and the cost of planting materials (seven percent); the extension advice (five percent); its tolerance to climatic stress (four percent); and its tolerance to pests and diseases (four percent).

Figure 49. The adoption level of fodder grasses, agroforestry fodder and non- fodder trees.

Source: Authors

The results also showed that the adoption of improved fodder grasses was greater in the male-headed households compared to female-headed households.

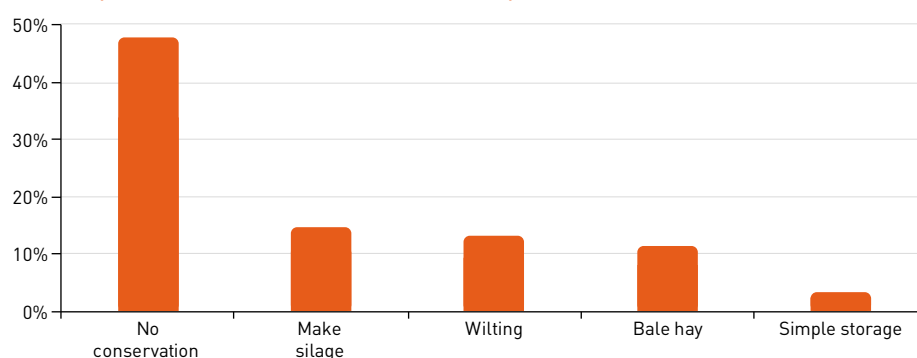
Manure collection

The data showed that most farmers followed conventional methods for managing manure. The majority of farmers stored manure under shade or in open areas. Less than 10 percent of farmers practiced composting or used improved technologies (polythene covers) to store manure.

The main use of manure was for food production (40 percent). Some farmers (35 percent) applied manure to fodder crops, while others (22 percent) used it for construction material. Very few farmers (2 percent) sold manure to other farmers, and almost no farmers (0.3 percent) used dry dung for cooking and manure for biogas production. Only one household was reported to have a biogas digester. Female-headed households were more likely than male-headed households to have applied manure to crops, while male-headed households were more likely than female-headed households to have used manure for construction material.

Feed conservation

Farmers conserved feed to stabilize milk production. Almost half of the respondent farmers were not practicing any methods to conserve feed. Some (15 percent) farmers made silage. Others practiced wilting, hay baling and storage (Fig. 50).

Figure 50. The adoption level of feed conservation practices.

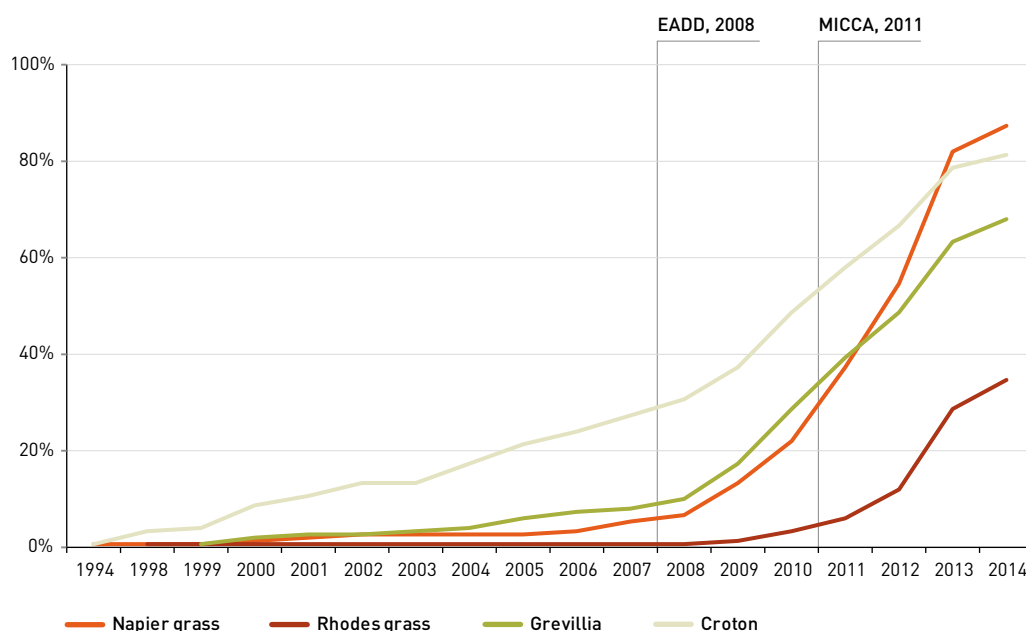
Source: Authors

A larger number of female-headed households baled hay or wilted the herbage. Male headed-households were more likely to make silage, perhaps because it was considered a labour-intensive activity.

The diffusion of agroforestry tree species and fodder grasses

The diffusion curves indicate that learning activities to increase awareness can influence the adoption of CSA practices, but the level of adoption differs by practices (Fig. 51). For instance, a greater number of farmers adopted Napier grass than Rhodes grass after 2008 when awareness raising activities started, and especially after 2011 when the MICCA project promoted them. The adoption rate of Rhodes grass was very slow in the first years after its introduction; however, since 2010, the adoption rate has increased significantly. *Grevillea* has had small but steady initial adoption since 1999, but it has only started to be adopted by greater numbers of farmers since 2008. *Croton* had a long adoption period during which awareness was built up.

Figure 51. The diffusion curves of Napier grass, Rhodes grass, *Grevillea* and *Croton*.



Source: Authors

4.3.3. Adoption determinants

This section presents the results of the models that were used to identify the determinants (barriers and incentives) for the adoption of CSA practices. The results that were statistically significant and strong enough to contribute to this discussion are presented in Annex 8.6.

The most important incentives to encourage greater adoption was increased assistance from the project team and more training and demonstration activities (25 percent). “Seeing examples from other farmers” who had already adopted CSA practices was also identified as being a key incentive for adoption (15 percent). These incentives relate to learning about CSA practices, which is an important part of any adoption process. Overall, farmer trainers indicated that the continuous involvement of the county administration and local leaders was necessary to foster local enrolment and support project implementation. The project

team needed sufficient time to connect with the local community and establish effective collaboration with other stakeholders. Time is also required to identify and motivate model farmers, who have adopted improved practices, and farmer trainers who have well maintained demonstration plots and have trained others. Being able to access credit was also identified by farmers as an incentive to adopting CSA practices (13 percent). However, it is difficult to determine whether this was an issue related to the availability or the affordability of the credit.

Determinants for the adoption of agroforestry and tree planting

The correlation results showed that the price of milk had a significant and positive effect on the adoption of agroforestry. The probability of planting fodder trees was significantly higher for farmers who could earn more from the sale of milk during the wet and dry season.

The results obtained from the cross tabulations showed that the participation in MICCA capacity-building activities had a notable effect on the adoption of agroforestry and fodder trees. Almost all of the participants who took part in the training activities adopted agroforestry and planted fodder trees on their farm.

According to the surveyed farmers, the main barriers to the adoption of agroforestry and fodder trees were the lack of seeds (24 percent) and knowledge (21 percent). The lack of suitable seeds for fodder shrubs and trees, and other trees was also noted in the focus group discussions as an important factor hindering the adoption of tree planting.

Farmers stated that incentives which would increase the adoption of agroforestry and tree planting were: increased security of land ownership (50 percent); greater access to planting materials and seeds (43 percent); increased benefits and higher farm income (38 percent); reduced cost of initial investments (36 percent); continued assistance from the project (36 percent); good examples by early adopters (34 percent); governmental support to obtain inputs (34 percent); access to cheap labour (33 percent); affordable credit (31 percent), and markets (29 percent); and remunerative markets for farm produce (27 percent).

Determinants for the adoption of fodder grasses

The model estimated a strong relationship between the adoption of fodder planting and the price of milk in the dry season (Table 16 - Annex 8.6). The likelihood of adopting fodder was greater for farmers who could generate more income from milk sales during the dry season. This suggests that the planting of improved fodder could ensure feed availability and maintain milk productivity during the dry season. The milk produced during the dry season could then be sold at higher prices. However, farmers who had limited access to markets were unlikely to earn more money from increased milk sales.

The adoption of improved fodder grasses was negatively influenced by the use of livestock manure (Table 16 - Annex 8.6).

The cross tabulations were significant for the type of land ownership, whether participants had participated in the EADD/MICCA training activities, and the education level of the head of the household (Table 17 - Annex 8.6). Survey participants who held their land freehold, which were the large majority, were much more likely to plant fodder crops than those whose land was communally held. A large majority of the survey participants also participated in EADD/MICCA training activities, which meant they were more likely to plant fodder crops. Participants with more than a primary education were much more likely to grow fodder than those with less schooling.

The three main barriers to the adoption of improved fodder were: lack of labour (48 percent); lack of information on suitable fodders (44 percent); and lack of money (41 percent). Other barriers that were cited as obstacles by surveyed participants were the small size of agricultural fields (37 percent); the lack of seeds and planting materials (26 percent); the availability of grazing pastures (11 percent); and the opportunity to buy cheaper fodder (7 percent).

The main drivers for the adoption of fodder crops were the potential for increased milk production (84 percent) and higher yielding crops (60 percent). The extent of adoption was also influenced by the amount of land available and the number of livestock owned. Farmers mentioned that remunerative markets for milk could increase the adoption of improved fodder production in about 30 percent of the cases.

Determinants for the adoption of tree nurseries

The regression model isolated two important factors that positively influenced the decision to establish tree nurseries: the cultivated area of sorghum and the household's food situation during the dry season (Table 16 - Annex 8.6). The probability of establishing a tree nursery was higher for farmers who cultivated sorghum on a larger area of their land. Also, the establishment of tree nurseries was more likely for participants who experienced food shortages during the dry season (December). The results also showed that the likelihood of establishing tree nurseries was lower when larger amounts of farm labour were hired and when the maize price was high during the short rainy season (Table 16 - Annex 8.6).

According to the respondents, the main constraints to the establishment of tree nurseries were: the lack of tree seeds (60 percent); insufficient knowledge about nursery management (21 percent); and the availability of seedlings from other nursery operators (41 percent).

Determinants for the adoption of improved manure collection

The collection of manure had a moderate positive relationship with the variable 'Rhodes grass cultivated' and weak positive relationship with the variable 'sources of seed for Rhodes grass' (Table 16 - Annex 8.6). This means that more farmers who cultivate Rhodes grass and have access to seeds also collect livestock manure. The collection of manure was strongly correlated with 'sources of seed for Desmodium'. According to farmers, the most important barriers to the use of manure for crop production were the lack of available labour (43 percent); the small quantities of manure (43 percent); and the lack of interest (14 percent).

Determinants for the adoption of composting

In the data collected from the survey and from the discussions with farmers, the most commonly reported barrier to composting was the small amount of available manure (30 percent). Other barriers that were reported were: the labour intensity of the activity in terms of time (29 percent); lack of knowledge (28 percent); lack of labour for manure collection (10 percent); lack of interest (3 percent); and lack of livestock (1 percent).

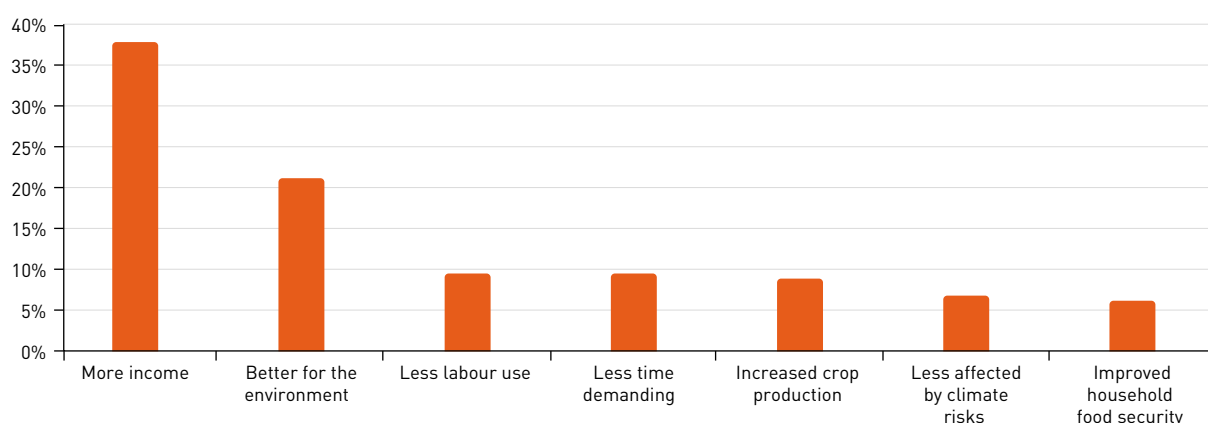
Composting was difficult because the common paddocking system demanded extra labour to collect the scattered cow dung. Most farmers did not have zero-grazing units, which made manure collection a labour-intensive activity. However, manure for crop production was becoming popular for the cultivation of organic vegetables and passion fruit because it reduced the cost of inorganic fertilizers and increased yields.

Determinants for the adoption of biogas

Over half (58 percent) of farmers stated that the lack of funds for the construction of a biogas digester, was the main barrier for using of manure for biogas production. Other barriers reported by farmers were: a lack of knowledge on biogas installation (30 percent) and the small amounts of manure available (12 percent). Due to the very low level of adoption, statistical analyses were not generated for biogas digester adoption.

4.3.4. Benefits

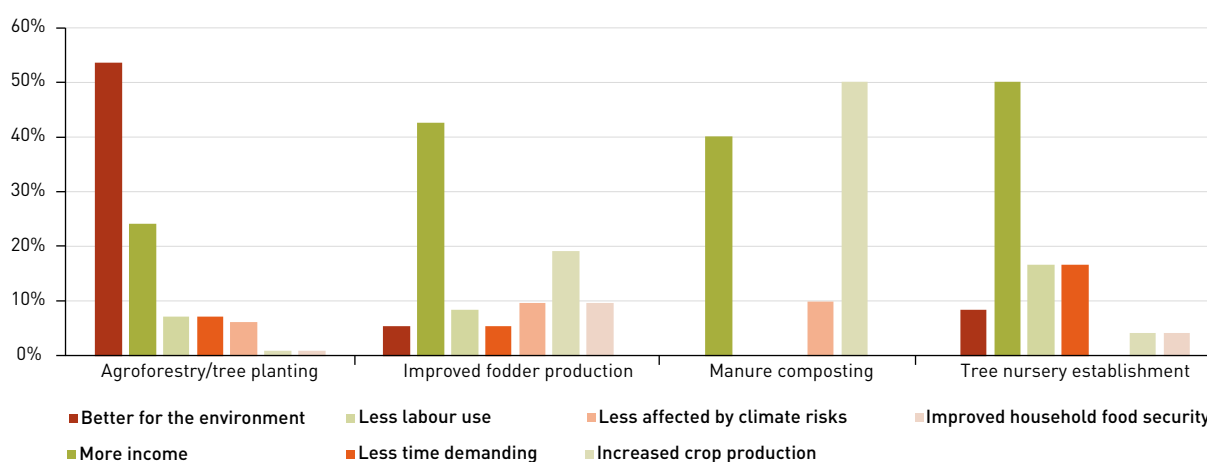
The study results indicate that farmers did benefit from the adoption of improved agricultural practices. Almost all (97 percent) of the adopters of CSA practices perceived benefits. When considering the whole set of CSA practices, the main benefit that farmers perceived was improved farm income (38 percent). This was followed by: environmental benefits (21 percent); reductions in labour and time requirements (9 percent); increased crop production (9 percent); higher tolerance to climate risks (7 percent); and improved food security (6 percent) (Fig. 52).

Figure 52. Perceived benefits of CSA adoption.

Source: Authors

As shown Figure 53, when farmers assessed the individual CSA practices separately, the two most important benefits were: the environmental benefits and increased income from agroforestry (54 and 24 percent respectively), increased income and increased crop production from improved fodder grasses (43 and 19 percent respectively), as well as increased crop production and increased income from manure composting (50 and 40 percent respectively), and higher incomes and reductions in labour and time requirements from the establishment of tree nurseries (50 and 17 percent respectively).

The two farmers who adopted biogas digesters reported that biogas reduced their dependency on fuelwood and saved them money. They also spent less time on cooking, cut down fewer trees and used the by-product (digestate) to fertilize their fields.

Figure 53. The relative importance of benefits from the adoption of agroforestry, improved fodder grasses, manure composting and tree nurseries.

Source: Authors

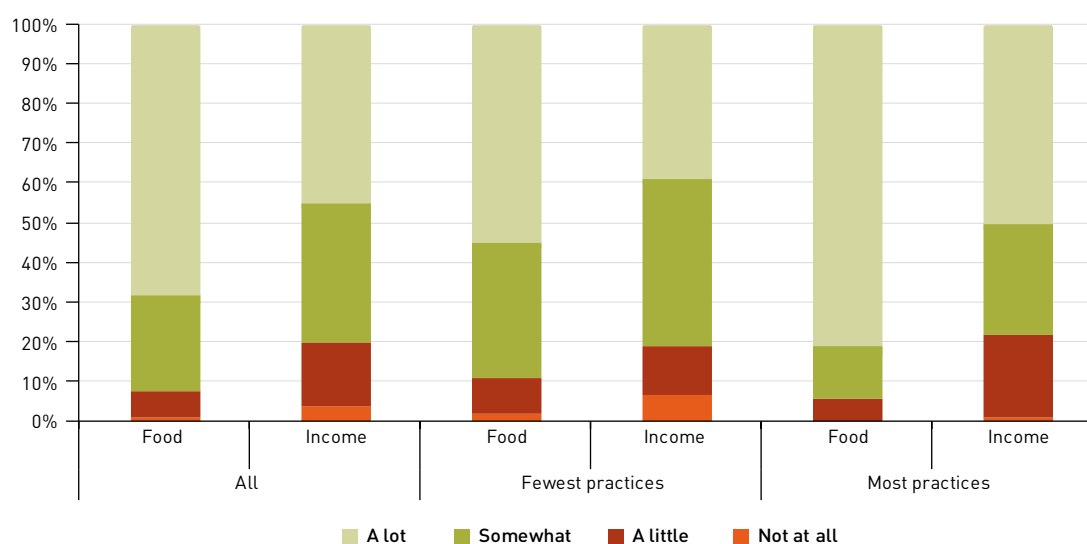
Benefits on food security and household income

The farmers who adopted CSA practices (fodder crops, agroforestry, tree nurseries, manure management, composting and biogas production) were separated into two groups: those who adopted less than the median number of CSA practices from the portfolio (three or fewer) and those who adopted four or more practices (Fig. 54).

The surveyed farmers who had adopted four or more CSA practices were those who reported to have perceived the most benefits in terms of household income and food security (Fig. 54). All farmers who had adopted four or more CSA practices perceived some sort of benefit on their food security. The large majority of these farmers (80 percent) benefited 'a lot' or 'somewhat' in terms of food security. The level of perceived benefit was lower (62 percent) for farmers who adopted three or fewer practices. Twenty percent of the farmers who adopted four or more CSA practices reported that the practices had benefited their food security situation 'a little'. Around a third (30 percent) of the farmers who adopted three or less practices saw 'a little' benefit for food security. The data showed that there was an average increase in milk production of 3.9 liters per cow per day.

Almost all farmers (97 percent) perceived some sort of improvement in household income from the adoption of CSA practices. Over two thirds (70 percent) of all farmers reported that CSA practices had benefited their incomes 'a lot' or 'somewhat'. The majority of farmers (78 percent) who adopted four or more CSA practices stated that the practices had benefited their incomes 'a lot' or 'somewhat'. The benefits that farmers perceived to their incomes were lower (63 percent) for those who adopted fewer practices. The proportion of farmers who did not benefit at all in terms of income was larger for the group of farmers who adopted less than the median number of practices compared to farmers who adopted more than the median.

Figure 54. The perceived impact of CSA adoption on food security and household income.



Source: Authors

4.4 United Republic of Tanzania

4.4.1. Farmer and farm characteristics

Household and farm characteristics

Nearly half (48 percent) of the interviewed farmers were the heads of the household, and in most cases (82 percent) the head of the household was a man. Overall, no substantial differences were found between male and female-headed farming households in terms of the size of the household and the age of household members. On average, the farming households had five members. The average age of the farmers was 39 years, and the average age of the head of the household was 46 years.

Rainfed agriculture was practiced by 96 percent of the farmers. The most widely grown crops in the area were maize and rain-fed upland rice. Usage of fertilizers and pesticides were very low. Organic fertilizer was only used by 6 percent of farmers, inorganic fertilizer by 1 percent and pesticides by 4 percent.

Maize and rice were important for both food security and income. Other crops grown in the area were sesame, cassava, sorghum, pigeon peas and vegetables. Sesame was the main cash crop. Pigeon pea and cowpeas were the main source of vegetal protein contributing to food and nutrition security. Vegetables were grown for both food and cash. Sixty-two percent of the farmers grew crops; 5 percent mixed with beans; and 9 percent mixed with vegetables.

Education

Most (80 percent) farmers had received primary education. The average number of years of formal education was six, which is less than the prescribed duration of primary education in the country. A higher proportion of male farmers (87 percent) had received primary education than female farmers (73 percent). In addition, more women were illiterate (17 percent) than men (6 percent). These gender differences in literacy are likely to be associated with the fact that more women than men drop out of school at an earlier age due to social factors (e.g. early marriage and pregnancy).

Farm size

There was no substantial difference between female and male farmers in terms of farm size and number of plots, supposedly due to the matriarchal system of land holdings in the Uluguru Mountains. On average, farmers managed 0.4 ha of land ranging from 0.04 to 1.16 ha.

The number of plots per farmer reflects the land fragmentation prevalent in the area. On average, farmers cultivated three plots, but a few farmers managed more than six plots. Forty-two percent of the farmers' three main plots were in lowland areas; 31 percent in uplands; and 27 percent on slopes. The primary plot of most (62 percent) farmers was in the lowlands.

Labour

The average household dependency ratio was 1.7, i.e. one person working supports two people not working due to illness or age. The average family workforce was four people. Family members worked on-farm or off-farm or a combination of both. There was no gender difference in terms of the household dependency ratio and family workforce.

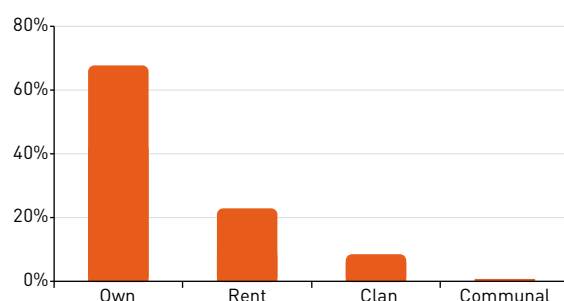
The majority of households (78 percent) had on average three members of working age (between 15 and 65 years old) who worked only on the farm. Half of these farm workers were women. Forty-one percent of households had on average two family members of working age who were engaged in both on-farm and off-farm activities.

The average farm had six people working on it per year per season. Half of these workers were family members and half were hired labour. The farming activities requiring the most hired labour (four to five people) were planting, harvesting and land preparation. Planting and harvesting were time-consuming activities, which required more labour from family members as well.

Land tenure

The majority of farmers (68 percent) owned their land (Fig. 55). Farmers who did not own their land, either rented their land (23 percent) or borrowed their fields from the clan or the community. There were no substantial gender differences in terms of land tenure.

Figure 55. Land tenure arrangements.



Source: Authors

Household income

Farmers were mostly engaged in crop cultivation. Many households raised chickens. The large majority of farmers (86 percent) earned income from their own crop production. Around half (52 percent) of farmers were involved in small businesses. Several farmers earned income from livestock (15 percent) and vegetable production (15 percent). Other sources of income were: seasonal agricultural work (13 percent), artisanal work (7 percent), occasional jobs (4 percent), government employment (3 percent), private sector employment (1 percent) and brick making and mining (1 percent). There were no gender differences in terms of household occupation. Agriculture was the only source of income for 44 percent of farmers. The mean number of livelihood activities was three.

Access to markets

The nearest agricultural market was in Kolero. Most farmers (91 percent) walked to the market. The average travel time to market was about one and a half hours. Some farmers who lived farther from the market walked between four and nine hours. A few farmers from the low- and mid-altitude villages used bicycles (six percent) or motorcycles (three percent). Farmers (mainly women and children) from the villages located in the highlands faced difficulty to reach the market.

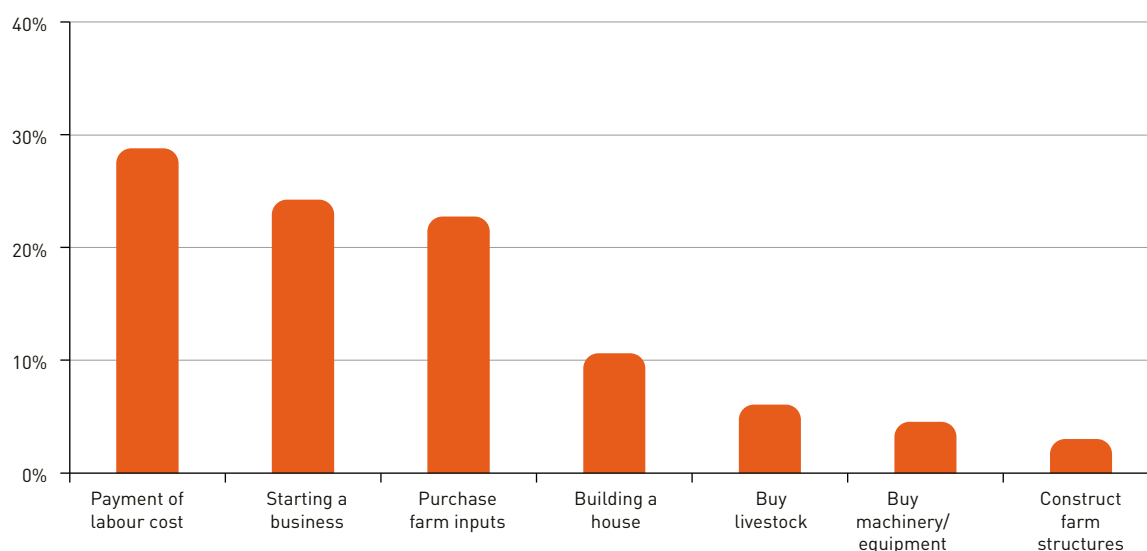
Access to credit

Thirty-eight percent of the farmers had access to credit (Figure 54). More women had access to credit than men, because women were members of the Village Savings and Loans Association, which was designed to have more women, and perhaps because women tended to have higher repayment rates than men.

Access to credit differed significantly depending on income level. The data showed that more affluent farmers with more assets to use as collateral had better access to credit compared to middle-income or poor farmers.

The majority of farmers used credit to hire labour (19 percent) (Fig. 56). Some farmers (16 percent) used credit to start off-farm business (e.g. brewing beer, selling food). Others used credit to purchase farm inputs (15 percent) or build a house (7 percent). Less than five percent of the farmers used credit to buy livestock, agricultural equipment or farm structures. There were no substantial differences between male and female farmers regarding the use of credit.

Figure 56. Uses of credit.



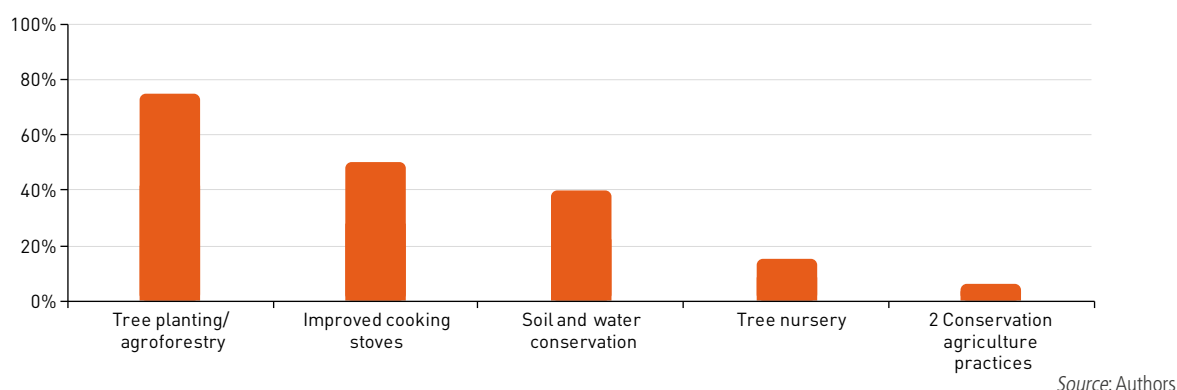
Source: Authors

4. 4. 2. Level of adoption

The data showed that all farmers who participated in the project activities adopted at least one CSA practice. Agroforestry and tree planting had the highest adoption rate (75 percent)

followed by improved cooking stoves (50 percent), soil and water conservation practices (40 percent) and the establishment of a tree nursery (15 percent) (Fig. 57). Six percent of the participants adopted a combination of two out of three conservation agriculture principles on the same plot, i.e. minimum tillage, mulching and growing cover crops.

Figure 57. The level of adoption of CSA practices.

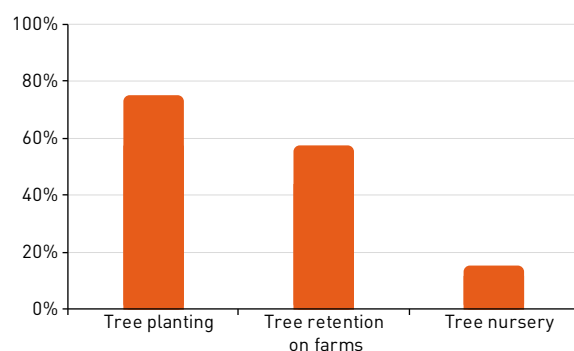


The level of adoption of CSA practices was higher in lowland villages than in villages located at middle or high altitudes. This finding suggests that farmers who had access and control to land with more fertile soil were more interested in improving their management practices and taking advantage of the benefits of CSA. It is also important to note that a greater number of affluent households with better access to credit were located in the lowlands. This also may explain the higher levels of adoption in the lowland areas. The only exception was Kitonga, a highland village, where the adoption of CSA practices was high. This was possibly because some of the CSA practices were promoted to reduce soil erosion on steep slopes.

Tree planting and agroforestry

Tree planting had the highest adoption rate (75 percent) followed by tree retention on farms (58 percent) and the establishment of tree nurseries (15 percent) (Fig. 58). Older men tended to plant more trees than younger men or women. This may be because young male farmers who had inherited their land had smaller fragmented plots and were more interested in short-term income-generating opportunities. Male farmers tended to grow or retain a larger number of trees on their farms than female farmers perhaps because male farmers were more engaged in the timber trade. The most commonly grown trees were mango (*Mangifera indica*), grevillea (*Grevillea robusta*) and African mahogany (*Khaya anthotheca*).

Figure 58. The adoption level of tree planting, tree retention on farms and the establishment of tree nurseries.



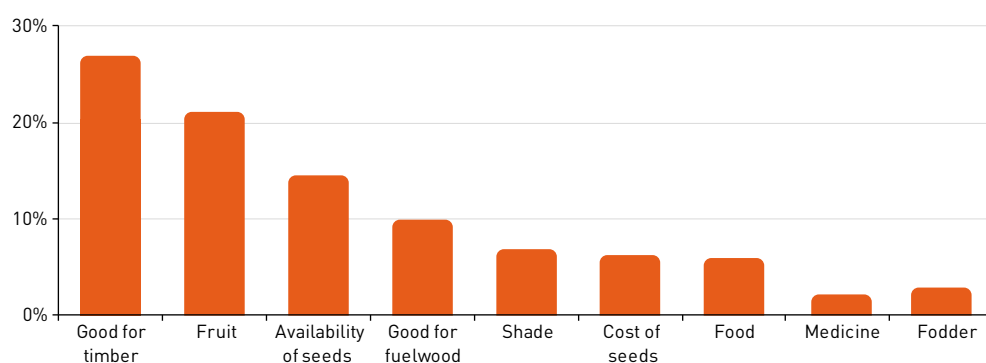
Source: Authors

One quarter of the farmers surveyed obtained tree seedlings from the MICCA tree nurseries. Thirty-five percent of the male farmers surveyed obtained tree seedlings from the project nurseries, as opposed to only 25 percent of the female farmers. Some farmers (20 percent) obtained seedlings from their own farms and a few farmers (6 percent) bought seedlings from the market. Many farmers reported obtaining seedlings from other sources (e.g. neighbours, relatives). The average age of the trees planted or retained on the farm was seven years.

Many of the farmers (42 percent) reported planting trees on land close to their homesteads. Some farmers (32 percent) planted trees as fences or living borders, and a few farmers (21 percent) integrated trees with crops on the same plot. Trees were also planted as woodlots by 4 percent of farmers.

According to farmers, the selection of tree species was based on a variety of criteria. Most respondents (27 percent) preferred planting trees for timber, followed by 21 percent of farmers who stated a preference for planting fruit trees (Fig. 59). Fruit trees were less popular than timber trees perhaps because of the lack of availability of fruit tree seedlings. According to focus group discussions, attempts to establish tree nurseries with fruit trees had failed in the past. For this reason, the availability of seeds and tree seedlings was cited by 15 percent of farmers as another important criterion in the selection of tree species. A few farmers (10 percent) chose trees for fuelwood. Criteria mentioned by less than 10 percent of farmers included shade, the cost of seeds, food, medicinal value and fodder.

Most of the farmers (91 percent) mentioned that some tree species were not available, especially trees for construction materials. Bricks are the main local construction material, and there is a great amount of brick making in the area, which uses a significant quantity of wood for 'firing' the bricks. It would have been appropriate for the project to promote more actively seeds and seedlings of trees that could be used to make building materials. However, it is unsure to assume that this would have reduced the use of brick.

Figure 59. Farmers' criteria for the selection of tree species.

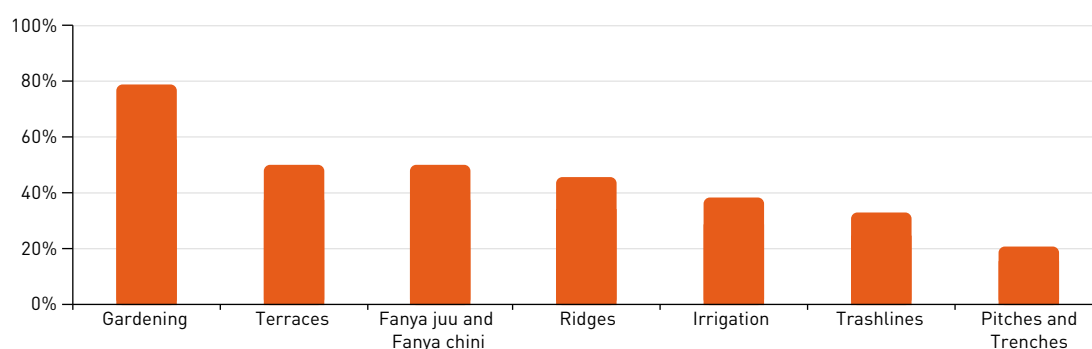
Source: Authors

Improved cooking stoves

The level of adoption of improved cooking stoves was higher for women than men. This is likely because women are largely responsible for fuelwood collection and cooking in the household, and consequently were more interested in improved cooking methods. The adoption of improved cooking stoves, which was considered as a way to reduce deforestation, was higher in households at higher altitudes, as these households were involved in forest conservation activities.

Soil and water conservation practices

Among the soil and water conservation practices promoted by the project, vegetable gardening was the most widely accepted, with 79 percent of farmers adopting the practice (Fig. 60). Other soil and water conservation practices that were adopted were terracing (50 percent), Fanya juu and Fanya chini (50 percent), ridges (46 percent), improved irrigation technologies (38 percent), trash lines (33 percent) and pitches and trenches (21 percent).

Figure 60. The adoption level of different soil and water conservation practices.

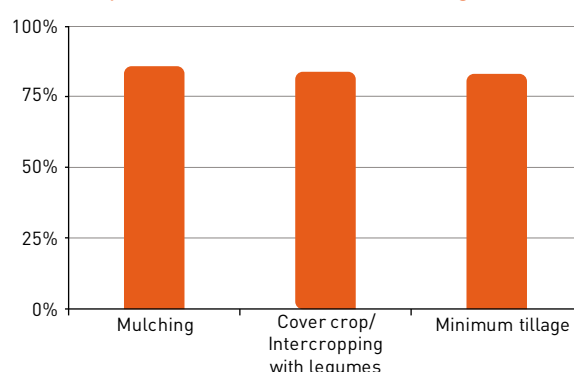
Source: Authors

Conservation agricultural practices

Conservation agriculture was composed of three practices: minimum soil disturbance, permanent soil cover (with mulching) and intercropping. Crop rotation was promoted, but in the area it was considered a traditional practice associated with slash-and-burn agriculture. Double digging was also promoted as a preparatory step before minimum tillage to break the hard pan created from repeated ploughing at same depth.

Almost all farmers (86 percent) adopted mulching (Fig. 61). More female farmers practiced mulching than male farmers. Planting cover crops or intercropping with legumes was adopted by 84 percent of farmers. The level of adoption of cover crops was higher for male farmers than female farmers. Minimum tillage was practiced by 83 percent of farmers and double digging by 77 percent of farmers. The adoption of minimum tillage and double digging was higher for women than men.

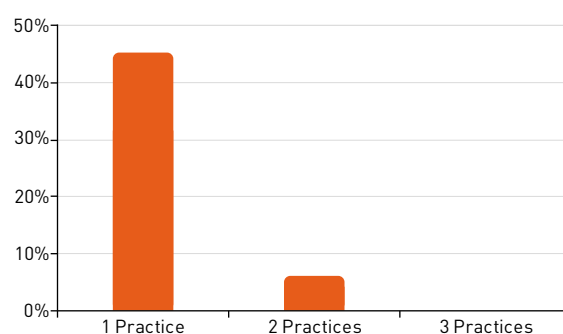
Figure 61. Adoption of individual practices of conservation agriculture.



Source: Authors

The high levels of adoption of conservation agriculture was only associated with individual practices. Most farmers did not apply a combination of these conservation agriculture practices on the same plot simultaneously. The level of adoption of conservation agriculture was low on the farmers' three main plots. Forty-five percent of the farmers stated that they applied only one of the three practices in the conservation agriculture package (Fig. 62). Few farmers (6 percent) adopted two conservation agriculture practices and none of the respondents applied the whole package of conservation agriculture practices on the same plot (Rioux and Gomez San Juan, 2015). This could be explained by the time required for learning and testing individual practices before using them in combination.

Figure 62. Adoption of conservation agriculture practices on the same plot.



Source: Authors

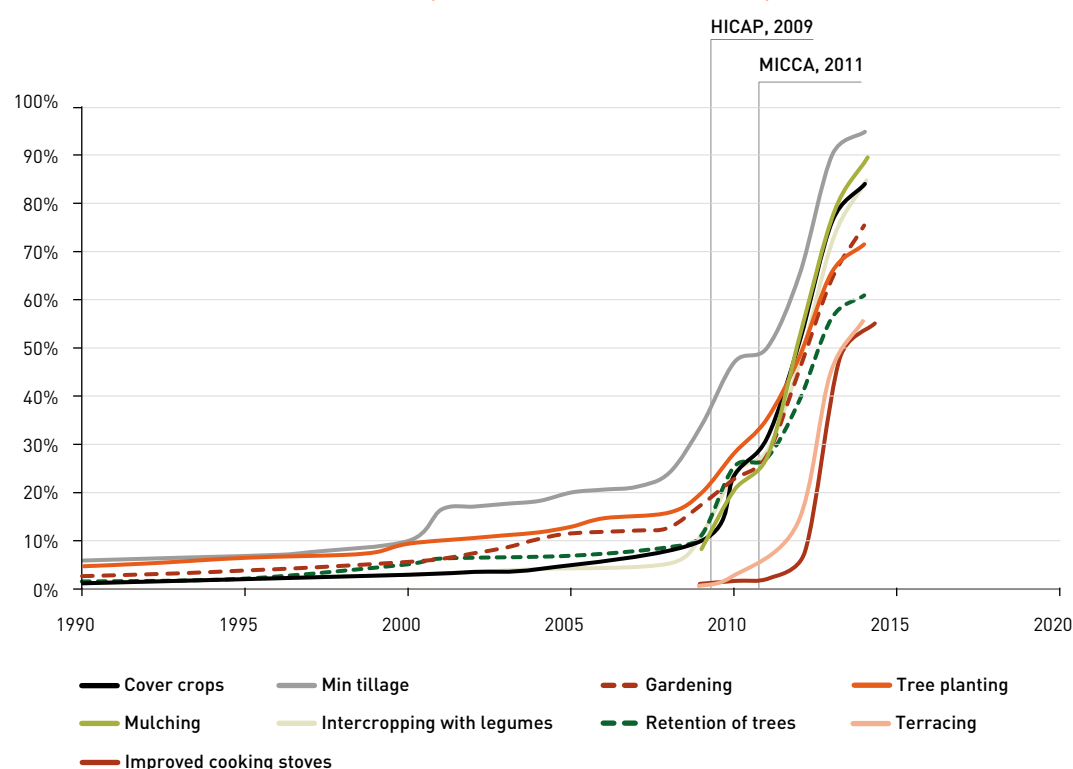
The diffusion rates of CSA practices

Many practices, including cover crops, minimum tillage, intercropping with legumes, gardening and tree planting were introduced to farmers in the 1960s and 1970s. However, the uptake of these practices was much higher in 2009 when the HICAP-CARE project was initiated in the area (Fig. 63).

The practices that were heavily promoted by MICCA, such as improved cooking stoves and terracing, have also seen higher adoption rates since 2012.

This is a clear indication that extension was needed to ensure the adoption and diffusion of CSA practices, and that these practices were not new to the area. They had also been promoted in the past for the benefits they delivered in terms of higher agricultural productivity and better natural resource management.

Figure 63. The diffusion curves of CSA practices in the United Republic of Tanzania.



Source: Authors

4.4.3. Adoption determinants

A binary logistic regressions analysis was also carried out to assess the adoption predictors of CSA practices. The results are presented in Annex 8.6.

Through the focus group discussions, insights were gathered from the community on the enabling environment for the implementation of CSA. Participant farmers provided a variety of reasons for the adoption of CSA practices. The common determinant for higher levels of adoption were training and promotion by change agents and the perception on the part of the farmers that adopting the CSA practices would be advantageous for them.

Determinants for the adoption of conservation agriculture practices

Double digging

The correlation estimated a strong relationship between double digging and hired labour, indicating that as more double digging was undertaken more labour was hired. This suggests that the availability of hired labour and the financial capacity of farmers to hire extra labour would be constraints to the adoption of double digging. Consequently, access to credit would also seem to be an important factor influencing the adoption of double digging. However, if they had enough labor available within the household, poorer farming families could also easily adopt double digging and obtain immediate benefits from increased agricultural productivity.

Minimum tillage

The analysis showed that the likelihood of adopting minimum tillage was higher for farmers who participated in the training, demonstration plots and farmer field schools. In addition, it showed the probability of adopting minimum tillage was significantly higher for farmers who perceived that the practice could increase the agricultural productivity (Table 20 - Annex 8.6). The likelihood of adopting minimum tillage was significantly higher for female farmers compared to male farmers, perhaps because reduced tillage was seen as a less labour-intensive activity by women (Table 19 - Annex 8.6).

Mulching

The logistic regression model estimated that the likelihood of adopting mulching was higher for farmers who received training on mulching (Table 21 - Annex 8.6). By participating in training sessions farmers were able to better understand the technology as well as its benefits and requirements.

The data also showed that wealthier households were more likely to practice mulching. Perhaps this could be linked with the tendency of more affluent households to practice gardening, which requires inputs and tools and access to markets. On the other hand, farmers not owning land seem to adopt mulching as it is temporary, easy and low-cost practice.

Cover crops

The adoption of cover crops had a moderate relationship with the average sale price of crops. This means that as the sale price of a crop increased, it was more likely that farmers would adopt cover crops.

Crop rotation

Crop rotation had a strong relationship with hired labour (Table 18 - Annex 8.6). It was more likely for wealthier households to practice crop rotation as they had more access to credit to hire labour and more land. The probability of practicing crop rotation was significantly lower for poor and food insecure households. This is perhaps because the aim of food insecure households was to increase their food availability, making it difficult for them to try new

crops in a rotational system. The main reasons for the adoption of crop rotation was the promotion by change agents and the benefits that farmers perceived from the practice. Also, the availability of labour and the capacity of a household to hire labour were incentives for the adoption of crop rotation.

According to contact farmers, the main barriers to the adoption of conservation agriculture practices were: lack of cooperation with the village leaders, which was important to formulate and enforce land laws; land use plans and natural resource management by-laws (e.g. addressing the problem of uncontrolled bush fires); and lack of access to land given the cost of renting land.

According to village leaders, the main incentives to the adoption of conservation agriculture were: educating the leaders; making and enforcing by-laws; raising awareness of the farmers; and improving collaboration between the project and village leadership. Land-use and management plans (with certification) were also considered important.

Based on the data collected from the discussion with farmers, insecure land tenure was an important determinant for the adoption of crop rotation. Farmers also mentioned that they did not have access to the necessary tools, such as jab planter, no-till seeder and an improved hand hoe. Only a few farmers (less than 30 percent) had access to these farm tools.

Determinants for the adoption of tree planting

According to the data collected from focus group discussions, the main barriers to the adoption of tree planting was insecure land tenure and the small size of the agricultural fields. Farmers also mentioned that the leaders of the villages were not willing to address the issue of insecure land tenure.

The data collected from the survey showed that tree planting was mostly adopted by older male farmers, rather than female farmers who did not own the land and were not in a position to make long-term land-use decisions.

Access to credit was another determinant for the adoption of tree planting. Farmers needed to have credit to purchase tree seedlings from private tree nurseries. The data from focus group discussions revealed that the majority of farmers felt that there were tree species they could not obtain, such as mkangazi (*Khaya anthotheca*), teak (*Tectona grandis*), mango (*Mangifera indica*) and avocado (*Persea americana*).

According to village leaders, the main incentives for the adoption of tree planting were: the use of schools to produce seedlings; awareness raising among farmers about tree planting; and the enforcement of forestry laws. The very limited availability of seedlings, as well as the threat from bush fires, were cited by village leaders as barriers to the adoption of tree planting.

Determinants for the adoption of terracing

The correlation estimated that training on gardening is positively correlated with the adoption of terracing. However, the adoption of terracing was negatively influenced by the number of male farmers who were not able to work (below 15 years of age and above 65), indicating that terracing requires substantial amount of labour (Table 18 - Annex 8.6).

Despite the cost of constructing terraces, food insecure households adopted terraces. This may reflect the fact that their fields were on slopes where soil was eroded, and they took advantage of the project support.

In general, the likelihood of adopting terraces was higher for farmers who had more assets, as this practice requires inputs and tools for excavating and access to markets where the higher-value crops (e.g. pineapple) can be sold. About half of the farmers indicated that promotion by change agents was the main incentive for them to adopt terracing. The practice of terracing was perceived by farmers as the most beneficial practice in terms of increased yield but the least affordable and the most time-consuming CSA practice.

According to farmers, the main barriers to the adoption of terraces were cost and insecure land tenure. Farmers also said they were unsure whether terraces would lead to higher productivity in the short term. The labour-intensiveness of terracing was addressed through collective action. During focus group discussions, farmers highlighted that terracing allows unusable land on slopes to be turned into a productive land.

Determinants for the adoption of gardening

The adoption of vegetable gardening had a moderately strong relationship with the hired labour needed for planting (Table 18 - Annex 8.6). As the level of adoption increased, it was more likely for extra labour to be hired for planting.

Determinants for the adoption of improved cooking stoves

Based on the results obtained from the regression, the likelihood of adopting improved cooking stoves was positively influenced by the following variables: education, productive assets, frequency of specific training, participation in demonstration plots and farmer field schools, and distance to markets (Tables 19, 20 and 21- Annex 8.6). The likelihood of adopting improved cooking stoves was higher for educated farmers interested in trying new technologies.

Lack of information on the construction of improved cooking stoves and lack of training on how to use them were the main barriers to the adoption. More than half of the farmers (56 percent) stated that they did not receive any training on improved cooking stoves. Lack of credit was the second most important barrier (cited by 23 percent of the respondents), as credit was needed to buy the raw materials and hire labour to help build improved cooking stoves.

Some farmers (16 percent) reported that they did not see any advantages from the improved cooking stoves and that they were not useful. This also stresses the importance of training.

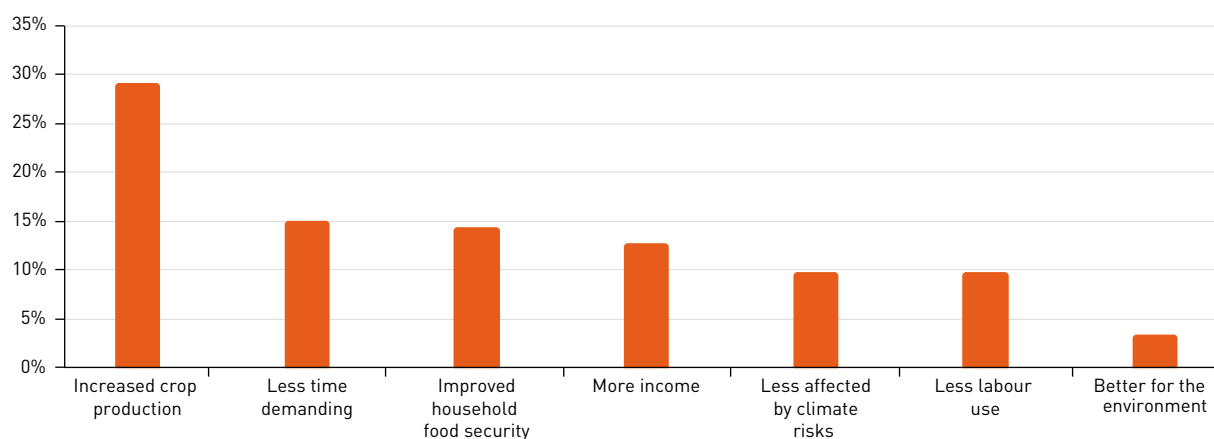
Over half of the households in the middle-income group adopted improved cooking stoves. Construction of improved cooking stoves requires some investment, which may be a limiting factor for poorer households and explain why the adoption rate was relatively low among the poor households. Although the raw materials are affordable, the costs associated with the construction of a kitchen to protect the improved cooking stove from rain can be a barrier.

According to contact farmers, the main challenge was the lack of simple masonry equipment. The incentives to adopt improved cooking stoves were: reduced fuelwood, locally available raw materials and proven benefits. According to village leaders, the main incentives were affordability and its efficacy in reducing the amount of fuelwood needed.

4.4.4. Benefits

Some farmers (29 percent) identified that increased crop productivity was the most important benefit from the adoption of CSA (Fig. 64). The fact that the CSA practices saved time was cited by 15 percent of farmers as the second most important benefit. Other benefits reported by farmers were improved food security (14 percent), increased income (13 percent), increased tolerance to climate risks (10 percent), reduced use of labour (10 percent), other benefits (6 percent) and environmental benefits (3 percent).

Figure 64. Perceived benefits of CSA adoption.

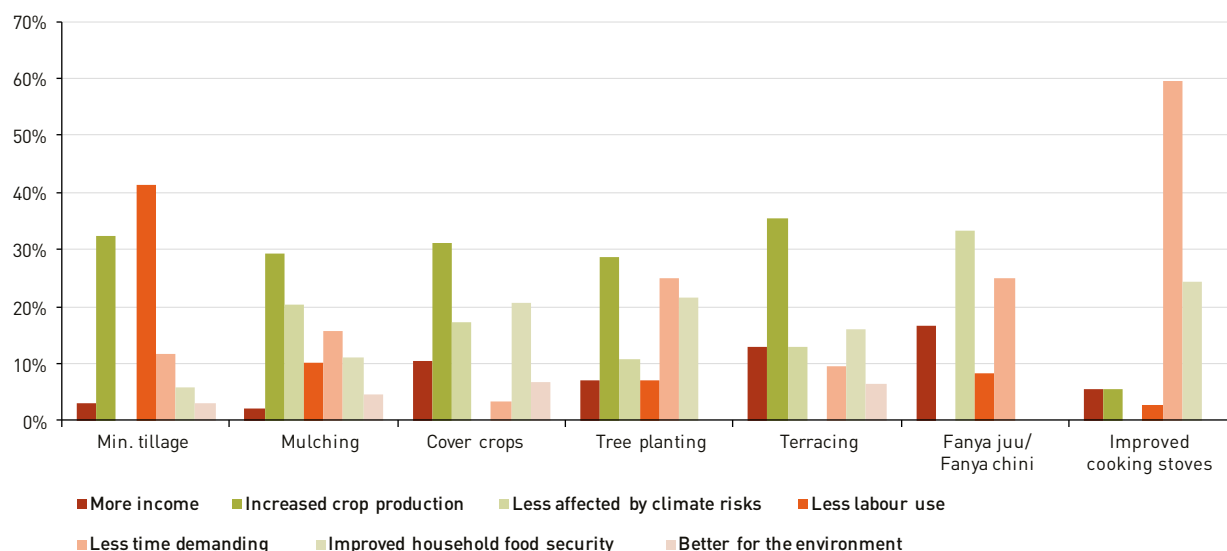


Source: Authors

As shown in figure 65, the two most important benefits identified by farmers were reductions in labour requirements and increased crop production for minimum tillage (41 and 32 percent respectively), as well as increased crop production and higher tolerance to climate risks from mulching (29 and 20 percent respectively), increased crop production and improved food security from cover crops (31 and 20 percent respectively), increased crop production and time saved from tree planting (29 and 25 percent respectively) and increased crop production and improved household food security from terracing (36 and 16 percent respectively). A third of the farmers reported that the most important benefit from "Fanya juu" and "Fanya chini" was

reduced vulnerability to climate risks. Less time spent on fuelwood collection and preparation was identified by 60 percent of farmers as the most significant benefit of improved cooking stoves (Fig. 65)

Figure 65. The relative importance of benefits from the adoption of minimum tillage, mulching, cover crops, tree planting, terracing, Fanya juu and Fanya chini and improved cooking stoves.



Source: Authors

The benefits of conservation agriculture were assessed at plot level where the practices were applied. The maize yield when two conservation agriculture practices were applied was higher compared to the maize yield obtained from the adoption of one conservation agriculture practice or none. Presumably, when implemented correctly as a full package, conservation agriculture could further increase productivity and returns to land.

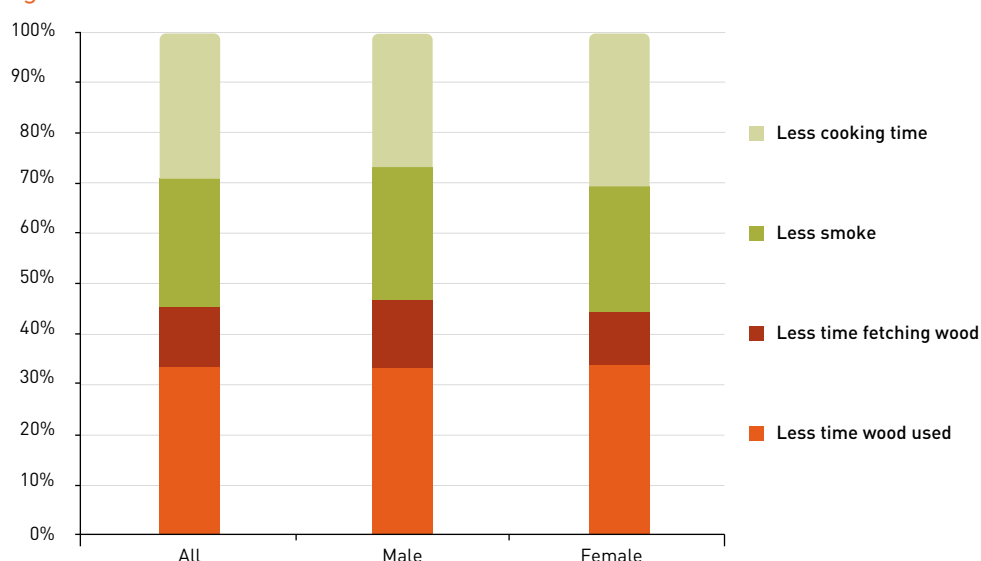
In addition, the results showed that the maize related gross returns to land were also higher when two conservation agriculture practices were adopted compared to when only one conservation agriculture practice was adopted or none.

Also, labour requirements were lower for conservation agriculture practices, which indicates that conservation agriculture can be considered as labour-saving. It was estimated that conventional practices characterized by slash and burn, soil disturbance and random planting may need double the amount of labour compared to conservation agriculture practices. However, the gross returns to labour were not much different when no conservation agriculture was applied or when a conservation practices was adopted.

Farmers who produced high value crops on soil and water conservation structures reported to obtain four times higher yield compared to cultivated slopes. However, in terms of labour requirements, it was estimated that the construction of terraces needed more people during their establishment, and then had similar labour requirements compared to conventional practices. Other benefits identified for soil and water conservation practices were: improved

workability on slopes (easy to stand); the permanence of the terraces; erosion abatement; and rainwater harvesting. According to contact farmers, the adoption of improved cooking stoves could reduce the amount of fuel wood by 30-50 percent. Other benefits identified by contact farmers were: less smoke, climate change mitigation, more pleasant kitchens, less cooking time and cleaner pots. The perceived benefits from the adoption of improved cooking stoves differed slightly between female and male farmers (Fig. 66). The percentage of female farmers who reported less cooking time as a benefit was slightly higher compared to male farmers, and more male farmers perceived the reduced amount of time needed for fuelwood collection as a benefit.

Figure 66. The relative importance of benefits from the adoption of improved cooking stoves by gender.



Source: Authors

Benefits on food security and household income

The people who adopted the CSA practices were separated into two groups: those falling below the median number of CSA practices adopted (six or less) and those above the median level (seven or more) (Fig. 67).

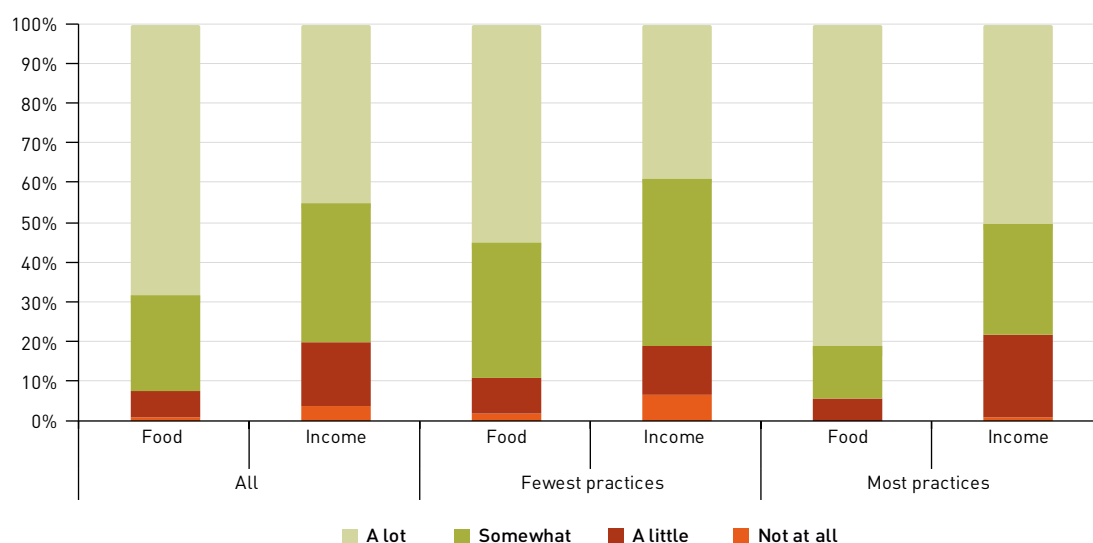
Sixty-seven percent of the farmers reported that the adoption of CSA practices had benefited them by increasing food security, and because of the increase in food production, 45 percent of the farmers identified higher incomes as a benefit of CSA practices. This is an important outcome given that 66 percent of households experienced some degree of food insecurity. The group that adopted the most CSA practices rated the positive impact on their household food availability much higher than the group that adopted fewer CSA practices.

These results are in line with data provided by project participants, which showed that maize yields obtained by CSA practices were two times higher compared to those obtained using conventional practices (3.2 versus 1.5 tonnes per ha). Double digging in combination with cover

crops and mulch showed a positive short-term impact on yield. This was likely due to retention of moisture and nitrogen released by leguminous crops that could be utilized by maize. These productivity gains increased the daily number of meals per family from one to three.

The effect of CSA on income differed between the two groups. Almost all farmers who adopted the most CSA practices perceived a positive impact on household income (Figure 67). Very few (8 percent) of the farmers who adopted fewer CSA practices did not perceive any income benefits. In addition, 50 percent of farmers who adopted the most practices reported to have benefited 'a lot' in terms of income, whereas a lower number of farmers (40 percent) who adopted fewer practices stated that CSA delivered 'a lot' of income benefits.

Figure 67. The impact of CSA adoption on food security and household income.



Source: Authors

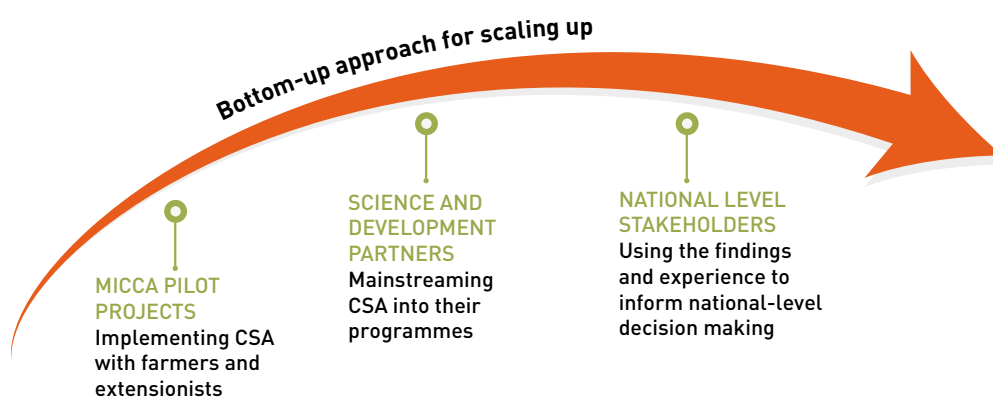
5. Scaling up strategies

5.1 The approach for scaling up

The term ‘scaling up’ is used here to describe the increase in the range of available CSA options and their adoption at the farm and landscape level across a broader geographic area. It includes both the scaling up of practices and the strengthening of enabling environments for CSA through policy development at the local, national, and regional levels.

In the MICCA pilot projects, a bottom-up approach for scaling up was followed (Fig. 68). It started from the pilot projects, extended to large programmes carried out by development and research partners and reached stakeholders at the national level. This strategy was used to increase the impact of the findings and the experience gained in piloting CSA, and integrate the co-benefits of climate change adaptation and mitigation into agricultural development.

Figure 68. Approach for scaling up CSA in the MICCA pilot projects.



Source: Authors

5.2 Working with partners

5.2.1. Building on development projects to mainstream CSA

Building on existing development projects provided key elements for scaling up CSA. The farmers were already engaged in project activities, and capacity development activities and advisory services were already in place. The practices on the ground that were meant to enhance the overall farming systems' productivity could readily fit into a comprehensive package of CSA practices. There was an opportunity to influence or learn along with development actors that were engaged in large-scale efforts both in the region and globally. The MICCA pilot projects also took advantage of the opportunity to have farmer, practitioner and technology exchanges with other NGO initiatives, such as the VI Agroforestry and the Lake Victoria Basin Management in Kenya, and with a FAO land and water management project to support climate change adaptation in Morogoro district in the United Republic of Tanzania.

At the end of the MICCA pilot project in Kenya, farmer trainers from the other 20 EADD producer organizations in Kenya were invited to the Kaptumo hub to learn from the MICCA experience. This workshop created a platform for scaling up the knowledge gained from the MICCA-EADD pilot project in Kaptumo. A key outcome that has contributed to mainstreaming CSA within and beyond the pilot countries was EADD's decision to include a dimension on environmental sustainability and climate change in their Phase II (2014-2018) and integrate CSA into its activities. EADD's Phase II will reach more than 130 000 farmers in Kenya, Uganda and the United Republic of Tanzania. This scaling up will help disseminate the lessons learned about CSA implementation at other EADD sites in Kenya and East Africa.

5.2.2. Research into development to enhance CSA knowledge

Partnering with ICRAF provided the opportunity to develop robust and practical protocols for measuring GHGs fluxes and carbon balances under different farming practices. By combining research with development projects, the research results can be readily applied to the work being done by farmers and development practitioners in the field, which allows the benefits of the research to reach farmers more quickly. It also helped scientists identify research gaps and shape their research programmes so that they are in line with emerging needs from the field.

Through ICRAF, the research methods and lessons learned in the MICCA project were also used to inform the development of parallel and future research projects of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). For example, the photoacoustic spectroscopy that was used in the MICCA project also influenced the CCAFS-led SAMPLES guidelines for estimating GHG balances and the impacts on livelihood in smallholder systems. During its work with MICCA, ICRAF has also started to develop a CSA compendium to assess the outcomes of improved agricultural practices on productivity, climate change adaptation and mitigation (Rosenstock *et al.*, 2016b). FAO is a partner in this compendium and is completing the work by looking at the barriers to adoption of the same potential CSA practices.

5.3 Linking research and practice with policy decision making at the national level

Throughout the implementation of the MICCA pilot activities, the project maintained a close connection with national-level policy processes. In late 2014, as the field activities were ending, FAO joined forces with partners and national government representatives to bring the findings and experiences of the MICCA pilot projects to inform decision making at the national level.

Moreover, with the support of the partners, the lessons learned from the MICCA experience are being integrated into the national-level planning by the country members of the Africa CSA Alliance, which was initiated in 2014. The Africa CSA Alliance, which was convened by NEPAD and builds on the experience of multiple agencies and organizations, has a goal of

helping 6 million farmers in sub-Saharan Africa become food secure and climate resilient by 2025. This work is particularly important for scaling up CSA in sub-Saharan Africa, where a large number of resource-poor farmers need to modify their agricultural practices to adapt to climate change in ways that both enhance their livelihoods and conserve the agricultural ecosystems that support them.

Experience in Kenya

At the time of the CSA national workshop in October 2014, the Government of Kenya had a Climate Change Unit within the Ministry of Agriculture, Livestock and Fisheries and a Climate Change Secretariat within the Ministry of Environment and Natural Resources. The Kenya Climate Change Action Plan has been put in place for 2013-2017 and the Climate Change Policy Framework was being drafted. MICCA and its partners have initiated and implemented:

- a FAO-MICCA scoping study of climate change policies, programmes, projects and activities on CSA in Kenya (Osumba and Rioux, 2015);
- a joint FAO, ICRAF, CCAFS and Government of Kenya workshop that brought together 44 different CSA projects to examine the evidence base for integrated crop-livestock-fish-tree systems in non-arid and semi-arid regions and develop key recommendations for CSA practices in these farming systems (Chesterman and Neely, eds., 2015); and
- policy messaging with the Government of Kenya for its Climate Change Policy Framework and its participation to the twentieth session of the Conference of the Parties of the United Nations Framework Convention on Climate Change in 2014 (FAO, 2014).

These activities, which were instrumental in building a more coherent assessment of CSA in Kenya, mapped CSA activities with climate change policies and programmes, established connections between the ministries of agriculture and environment and shaped the policy messages and instruments for the Government of Kenya. The Kenyan Ministry of Agriculture, Livestock and Fisheries has initiated a process to make the dairy sector more efficient and climate-friendly through a Nationally Appropriate Mitigation Action (NAMA). FAO, UNIQUE and CCAFS are supporting the country's efforts to produce and process more milk with fewer GHG emissions. The MICCA pilot project gathered information to provide concrete evidence that proper management practices can significantly increase milk yields. FAO and ILRI have also developed a method for quantifying the GHG emissions from the dairy value chain. These results are now being used to support the NAMA development in the dairy sector. The NAMA activities include raising awareness and building capacity among dairy sector stakeholders through a designated multi-stakeholder platform and the identification of mitigation options, institutional arrangements and potential financing mechanisms.

Figure 69. Climate change and agriculture workshop in Kenya, October 2014.



Experience in the United Republic of Tanzania

The Government of the United Republic of Tanzania considered its participation in global and regional climate initiatives important for addressing the impacts of climate change and taking advantage of the country's mitigation opportunities. The United Republic of Tanzania was one of the countries that joined the Global CSA Alliance during the UN Climate Summit in September 2014, and is also a member of the Africa CSA Alliance.

The Tanzanian Government has put various policies and plans in place that directly address climate change, including the Development Vision 2025, National Climate Change Strategy 2013, National Agricultural Policy of 2013, National REDD+ Strategy 2013 and National Environmental Policy 1997. The Agriculture Climate Resilience plan (2014-2019) was developed to complement the National Climate Change Strategy (NCCS) for the agriculture sector.

The FAO effort in the United Republic of Tanzania in partnership with the Ministry of Agriculture, Livestock and Fisheries and the University of Dar es Salaam carried out a CSA scoping study (Majule *et al.*, 2015). The MICCA pilot project was reviewed in relation to its alignment to the NCCS and the Agriculture Climate Resilience Plan (ACRP) (Table 16). This comparison showed that the MICCA pilot project activities were adequately aligned to the NCCS and added value to the ACRP coverage.

FAO with the MICCA pilot project's partners, CARE and ICRAF, also held a workshop, in late 2014, on the 'Evidence and Experience of Climate-Smart Agriculture' to present and discuss the agricultural extension and research components of CSA in the country.

Table 10. MICCA pilot project's alignment with key climate change policies.

Sectors	CSA-related strategic adaptation/ mitigation measures	NCCS 2012	ACRP 2014	MICCA
Water resource	Catchment protection and conservation	✓	✓	✓
	Promoting rainwater harvesting	✓	✓	✓
	Increase water use efficiency	✓	✓	
Forestry	Enhanced control of forest fires	✓		✓
	Conservation of forests	✓		
	Support alternative livelihood initiatives for forest dependent communities	✓		✓
	Promoting establishment of woodlots	✓		✓
	Promoting afforestation and reforestation	✓	✓	✓
	Promote energy efficient technologies	✓		✓
	Enhancing and conservation of carbon stock	✓		✓
	Developing Nationally Appropriate Mitigation Actions (NAMAs) in forest management	✓	✓	✓
Agriculture and food security	Addressing soil and land degradation by promoting improved soil and land management practices/techniques	✓	✓	✓
	Strengthen post-harvest processes and promote value addition	✓	✓	
	Promote agroforestry systems	✓	✓	✓
	Promote climate-smart agricultural practices	✓	✓	✓
	Promoting best agronomic practices	✓	✓	✓
	Promote efficient fertilizer utilization	✓	✓	
Livestock	Promoting appropriate technology for animal feed stuff production	✓		
	Promote manure management practices	✓		
	Improving pasture and rangeland productivity	✓		
	Promote development and implementation of land use plans	✓		
	Enhance development of livestock infrastructure and services	✓		
Energy	Promoting development and use of energy efficient technologies	✓		✓
	Promote energy plantations to reduce pressure on catchment natural forests	✓		✓
Land use/ management	Promoting land use planning	✓	✓	✓
	Exploring and promoting sustainable land management technologies	✓	✓	✓

The lessons learnt from the MICCA pilot project have subsequently provided insights on the GHG reduction potential of different agricultural practices, the potential and barriers for adoption of CSA practices, and the drivers of deforestation from agriculture. These results were used to inform the development of the National CSA Program (2015-2025) released through the Vice-President Office. Moreover, the Environmental Management Unit of the Ministry of Agriculture, Livestock and Fisheries with the support of FAO is developing a CSA guideline to inform CSA implementation and up-scaling in the different agro-ecological zones of the country, which was finalized in June 2016.

5.4 Regional and global knowledge exchange

The approach taken by the MICCA pilot projects can contribute to targeting and tailoring future CSA programmes in similar farming systems. Based on the work by Dixon *et al.* (2012) on African farming systems, the pilot sites of Kenya and the United Republic of Tanzania are classified respectively as highland temperate, mixed zone and maize-mixed zone. It is anticipated that the techniques and methodologies, as well as knowledge gained from the MICCA pilot projects can be transferable to other locations in Africa with similar farming systems and socio-economic conditions.

5.4.1. Online community of practice on CSA

To address the CSA knowledge gap, exchange ideas and hasten innovations, the MICCA Programme at FAO created an online community of practice. The approach for participatory technical exchanges through online communities of practice can also be used in different regions. The ongoing facilitation of discussions and sharing of expertise has contributed to enhancing knowledge sharing on CSA at the global level.

The FAO organized an online learning event 'Climate-smart agriculture in the field– planning, implementation and up-scaling' to share results of the MICCA pilot projects with farmers, development partners, researchers and national decision makers. This included two webinars and facilitated discussions through a d-group and a Linkedin group. Moreover, before the event, background materials about the MICCA pilot projects were shared.

The learning event targeted practitioners working on agriculture and climate change projects in the field. The objectives were to:

- support the exchange of experiences between practitioners working on CSA field projects and programmes;
- increase knowledge on CSA planning and implementation at the field and landscape levels; and
- provide guidance on scaling up CSA and linking research, practice and policy for CSA planning and decision making to maximize impact.

Three thousand participants took part in the online learning event between October and November 2015 and three hundred in the two webinars.

6. Conclusions, recommendations and lessons learned

6.1 Main outcomes

Farmers who participated in the MICCA pilot projects considered that the benefits of CSA were higher yields, more income from farming and increased food availability. This indicates that CSA can be an effective approach for improving food security and alleviating poverty in rural areas. The experience and findings from the project demonstrated that smallholder farmers can be part of the solution to climate change by reducing GHG emissions and at the same time improving their food production, resilience and livelihoods. The MICCA pilot projects contributed to refining the measurement and modelling methodologies associated with climate change mitigation and adaptation. The results from the pilot activities have been used to inform decision makers responsible for shaping programming and policies at the local and national levels. The pilot projects provided useful recommendations and lessons learned on CSA that can be applied to planning and implementation processes, the adoption of CSA practices and their scaling up.

6.2 CSA planning and implementation

CSA practices need to be tailored to the specific characteristics of the local farming systems, local socio-economic conditions and farmers' expressed requirements. For this reason, the selection of climate-smart practices needs to be based on an analysis of the agro-ecological and socio-economic context. Farmers need to be engaged in the planning of CSA, and work jointly with technical specialists and extension workers to identify CSA practices that are suitable to local conditions. The implementation of CSA practices should consider: biophysical and socio-economic factors, including gender roles; farming systems and climatic risks; the institutional and policy environment; the availability of, and access to labour, land and credit; and incentives for up-front investment costs.

To ensure sustainable and long-term adoption of CSA practices, farmers need to receive immediate and long-term benefits from these practices in terms of improved food security, food production and income. It is important to plan site-specific assessments of the productivity and the adaptation and mitigation benefits of the selected practices; the barriers and incentives for their adoption; and their effects on food security, income and livelihoods. This type of evidence is needed to support policy decision making at multiple levels. By measuring the impact of climate-smart practices, the MICCA pilot projects provided quantifiable evidence that reducing the intensity of GHG emissions in smallholder farming systems can be achieved in combination with the sustainable increases in food production and resilience.

Because the adoption of CSA is largely determined by training sessions and farmer-to-farmer learning, it is important to support sustainable approaches to delivering extension services. The establishment and promotion of farmer field schools was a successful factor in the adoption of CSA practices. Micro-credit groups can also help farmers, especially women and youth, to adopt new practices. It is crucial to link the promotion of specific climate-smart practices and technologies with sustainable extension services and incentives (e.g. high value crop on terraces, stable markets for milk, income generating activities, access to seeds and loans, group learning).

6.3 CSA adoption

It is essential to gain a better understanding of both the incentives and barriers for the adoption and scaling up of CSA practices in order to design future CSA programmes, extension strategies and investment plans. CSA practices have local and often gender-specific barriers and constraints that need to be addressed. Incentives include: secure land tenure; the availability of credit, farm tools and inputs; the demonstration of proven benefits; targeted training sessions mainly using approaches that are practical and encourage interactions; the formation of farmer groups; and the availability of motivated farmer trainers. It is important to ensure that farmer groups are sustainable and that reward mechanisms are in place for participants and trainers.

The involvement of local decision makers in addressing barriers is important for scaling up CSA. The continuous engagement of local leadership enhances ownership over the new practices and supports the establishment and enforcement of by-laws. In addition, the participation of local level decision makers and farmer groups are important for implementing and scaling up CSA because the adoption of CSA practices often requires collective actions. To overcome some of the financial constraints to the adoption of CSA practices, farmers suggested they need to work collectively to mobilize resources through table banking, cost sharing and gaining access to group credit.

6.4 CSA scaling up

Linking research, practice and policy for effective planning and scaling up of CSA is important for planning long-term programmes that are based on results from the field and aligned with broader policy frameworks. There are still gaps in knowledge regarding the synergies and trade-offs between sustainable production, adaptation and mitigation. More work needs to be done on the different transformational pathways available for smallholder farmers and related policies and incentives.

Key results from the field can inform ongoing national and regional CSA planning processes and make valuable contributions to guiding new investment in agriculture. It is important to

scale up and link climate change response strategies from the field and landscape level to the national level. Climate finance needs to be integrated with traditional sources of agricultural investments. NAPs and NAMAs can be designed to bring a range of co-benefits to farmers that extend beyond climate change adaptation and mitigation.

7. References

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8. Annexes

8.1 Baseline biophysical site characterization

A landscape baseline assessment was carried out at the beginning of the project in both pilot areas. The assessment included a random sampling of 100 square km, divided in 16 clusters with 10 plots sampled in each cluster. Additional analyses were done on farms to better understand the biophysical characteristics of cultivated lands.

The following indicators of key ecosystem functions were assessed: water infiltration rate, pH, carbon/nitrogen ratio and soil texture, vegetable cover, slope and altitude (Table 17). These measurements at landscape and farm level could be repeated in the future for monitoring the degradation rate and the effectiveness of rehabilitation.

The land health surveillance utilized advanced laboratory techniques, including spectroscopy, to analyse soils properties. Biophysical parameters and soil characteristics were measured using the Land Degradation Surveillance Framework (LDSF) methodology (Walsh and Vågen, 2006).

Figure 70. Tea production in the MICCA pilot project in Kenya.



Figure 71. Landscape of the MICCA pilot project in the United Republic of Tanzania.



Table 11. Results of the biophysical baseline assessment.

Site	Soil texture (0-20 cm)	Mean pH (0-20 cm)	Water Infiltration Rate	
			Rate (cm-hour)	Comments
Kenya - Landscape	Clay (69% of the study sites). Clay-loam (31% of the sites)	5.7	0.48 - 6.2	Varied widely throughout the landscape. The higher values were found for soils with shrubs, moderate or low slopes and high clay content.
Kenya - Farms	Sandy-clay-loam.	5.7		The infiltration rate was rapid due to the high sand content of the soils.
United Republic of Tanzania - Landscape	clay (for the majority high clay content, up to 80 %), clay-loam soils (few sites)	5.5	1.2 - 3.64	The higher values of infiltration rates were detected for clay-loam soils.
United Republic of Tanzania – Farms	Sandy-clay-loam (60-80% of the sites)	6.1		Slow rate of infiltration because of compacted soil creating a crust layer.

Figure 72. Clay-loam soils of Kaptumo area, Kenya.



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Figure 73. Clay soils of Kolero area, United Republic of Tanzania.



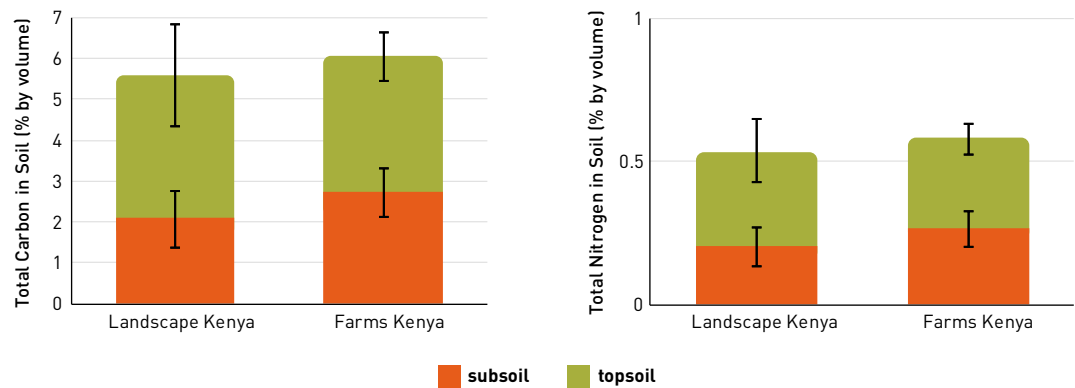
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The carbon/nitrogen ratio was within the range of the fertile soils (10 ± 2) and suitable/normal for soil fertility for all clusters and farms in both sites.

Overall, the carbon/nitrogen ratio in the landscape soils in Kenya were higher than 10 with peak values of 12 and 13, which reduced soil fertility (Fig. 74). At farms, there was less disparity in the carbon/nitrogen ratio than within the landscape clusters.

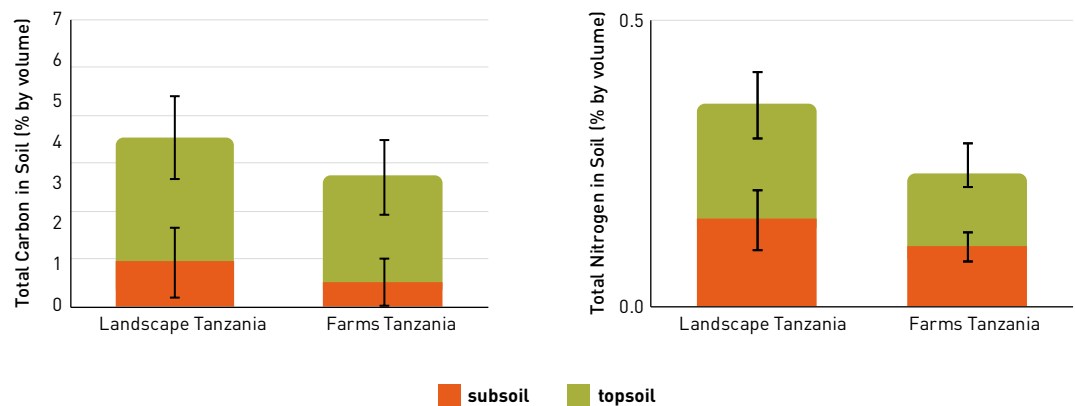
The landscape soils in the United Republic of Tanzania presented slightly higher carbon content at higher altitudes than at lower, as there was less agricultural activity there (Fig. 75). At farms and at the CSL, the average carbon/nitrogen ratio was 10, but the total amount of carbon and nitrogen in the soil was much lower than in the landscape assessment. The lower carbon/nitrogen content in the soil is due to the cultivation of the land with poor management practices.

Figure 74. Total carbon and nitrogen content in the soil of farms and landscape in Kenya.



Source: Authors

Figure 75. Total carbon and nitrogen content in the soil of farms and landscapes in the United Republic of Tanzania.



Source: Authors

8.2 Tree species and uses in Kaptumo, Kenya

Table 12. Tree species and their main uses.

Primary use	Species	Other uses
Soil fertility improvement	<i>Calliandra calothyrsus</i>	Wood for lumber, fuelwood, fodder
	<i>Chamaecytisus palmensis</i> (Tree lucerne), <i>Sesbania sesban</i>	Agroforestry, fuelwood, fodder
	<i>Gliricidia sepium</i>	Agroforestry, soil and water conservation
	<i>Leucaena trichandra</i>	Agroforestry, green manure, charcoal, soil and water conservation, fodder
	<i>Faidherbia albida</i>	Agroforestry, erosion control, bee keeping
Construction materials	<i>Eucalyptus</i> spp.	Agroforestry, fuelwood and shade
	<i>Grevillea robusta</i>	Agroforestry, boundary planting, soil and water conservation, bee keeping, fuelwood and shade
Cash crops	<i>Croton</i> spp.	Medicinal, agroforestry, leaves suitable for mulching, windbreak
	Passion fruit	Fruits
Agroforestry: Trees and shrubs were integrated with crops as live fences, boundary markers, windbreaks and on contours as a soil conservation measure.		

8.3 Tree species and uses in Uluguru Mountains, United Republic of Tanzania

Table 13. Tree species and their main uses.

Primary use	Species	Other uses
Soil Fertility improvement	<i>Tephrosia vogellii</i>	Intercropping with cereals (e.g. maize), fuelwood, bioinsecticide
	<i>Gliricidia sepium</i>	Intercropping with cereals (e.g. maize), soil water conservation, fuelwood, fodder
	<i>Leucaena diversifolia</i>	Intercropping with cereals (e.g. maize), fuelwood
	<i>Faidherbia albida</i> (Mpogoro/Mkababu)	Intercropping with cereals (e.g. maize), erosion control, soil stabilization, bee keeping
Construction materials	<i>Acacia crasscarpa</i>	Fuelwood, boundary planting
	<i>Khaya anthotheca</i> (Mkangazi)	Boundary planting
	<i>Terminalia cattapa</i>	Fuelwood, boundary planting
	<i>Azadirachta indica</i>	Medicinal
	<i>Melea azadirach</i>	Fuelwood, fodder
	<i>Grevillea robusta</i>	Fuelwood and shade
	<i>Senna siamea</i> (Mbiriti/mjohoro)	Fuelwood, shade
	<i>Tectona grandis</i> (Teak)	Boundary planting, fuelwood
Cash crops	<i>Cinnamomum</i> spp., <i>Piper nigrum</i> , <i>Syzigium aromaticum</i> (Mkarafuu/ Cloves)	Spices
	<i>Moringa oleifera</i>	Spices, medicinal
	<i>Carica papaya</i> (Mpapai), <i>Msombalanga</i> spp.	Fruits
Cash crops (continued)	<i>Citrus sinensis</i> (Mchungwa), <i>Citrus limona</i> (Mlimao)	Fruits
	<i>Mangifera indica</i> (Mombasa, Tanga types) - Mango	Shade, improved fallow
	<i>Tamanindus indica</i> (Mkwaju)	Medicinal, shade, fuelwood

8.4 Outcomes of the practices from literature review- Kenya

Table 14. Benefits from the adoption of agroforestry and improved leguminous fodder, improved manure management and soil nutrient, improved livestock managements and biogas.

CSA objectives	Agroforestry and improved leguminous fodder	Improved manure management and soil nutrients	Improved livestock management	Biogas production
Food productivity	<ul style="list-style-type: none"> Improved soil fertility due to biomass transfer, soil moisture retention and nitrogen-fixation Increased farm productivity Increased fodder nutritive value 	<ul style="list-style-type: none"> Improved soil organic matter Increased crop yields 	<ul style="list-style-type: none"> Improved livestock productivity due to improved breeding Higher protein and improved basal feed Restoration of degraded rangelands Higher reproductive efficiency in ruminants 	<ul style="list-style-type: none"> By-product can be used as a fertilizer
Adaptation	<ul style="list-style-type: none"> Crop diversification Increased household income and decreased risk of crop loss Reduced land degradation and soil erosion Increased water infiltration rate Increased biodiversity Increased resilience to climate risks 	<ul style="list-style-type: none"> Increased soil nutrients due to manure composting and crop residues Reduced cost due to the reduced use of synthetic fertilizers 	<ul style="list-style-type: none"> Fodder shrubs and herbaceous legumes are cheap sources of protein for cattle Reduced land degradation due to reduced number of animals per household 	<ul style="list-style-type: none"> Low-cost household energy On-farm produced manure can be used for cooking and lighting and for water pumps
Mitigation	<ul style="list-style-type: none"> Reduced methane emissions due to the reduced number of cattle on farm Increased carbon sequestration above and below ground 	<ul style="list-style-type: none"> Reduced GHG emissions Reduced soil nutrient loss 	<ul style="list-style-type: none"> Reduced GHG emissions due to reduced number of livestock per household Restoration of degraded rangelands Increased soil carbon sequestration Substituting large animals for small ones has large mitigation potential (19 megatonnes of CO₂ equivalent) 	<ul style="list-style-type: none"> Reduced GHG emissions due to improved manure storage (closed digesters)

8.5 Outcomes of the practices from literature review- United Republic of Tanzania

Table 15. Benefits from the adoption of agroforestry, conservation agriculture, soil and water conservation and improved cooking stoves.

CSA objectives	Agroforestry	Conservation agriculture	Soil and water conservation	Improved cooking stoves
Food productivity	<ul style="list-style-type: none"> Improved soil temperature and moisture Increased soil fertility with leguminous species Trees for multi-purposes uses (e.g. food, fodder, construction, fuelwood, medicines) 	<ul style="list-style-type: none"> Increased productivity due to increased soil organic carbon and improved fertility 	<ul style="list-style-type: none"> Improved soil fertility and productivity 	<ul style="list-style-type: none"> Reduced amount of fuelwood used for cooking
Adaptation	<ul style="list-style-type: none"> Increased income diversification Improved soil quality and conservation Reduced soil erosion 	<ul style="list-style-type: none"> Reduced land degradation Improved soil moisture Reduced cost of tilling Improved soil health Increased resilience due to crop diversification Decreased soil erosion Improved pest and weed management Increased biodiversity 	<ul style="list-style-type: none"> Reduced soil erosion and degradation Improved soil quality Increased water infiltration rate Reduced drought Increased biodiversity 	<ul style="list-style-type: none"> Fewer breathing problems due to reduced smoke emitted during cooking Less time needed for collecting fuelwood Less money spent to buy fuelwood or charcoal Forest conservation
Mitigation	<ul style="list-style-type: none"> Reduced emissions due to reduced deforestation Increased carbon sequestration above and below ground 	<ul style="list-style-type: none"> Reduced GHG emissions Increased soil organic matter and carbon 	<ul style="list-style-type: none"> Increased biomass sequestration due to the integration of trees with shrubs 	<ul style="list-style-type: none"> Carbon is sequestered in the biomass due to reduced harvesting of fuelwood Reduced GHG emissions due to the reduced consumption of fuelwood

8.6 Adoption studies - Statistical analysis tables

Kenya

Table 16. Pearson correlations between practices and variables.

CSA Practices	Coefficients and significance	Correlated variables
Agroforestry/fodder trees	0.98 *	Price of milk in dry season
	0.98 **	Price of milk in wet season
Improved fodder production	-0.43 **	Important use of livestock manure
	0.98 *	Price of milk in dry season
Improved manure management	0.60 **	Rhodes grass where cultivated
	0.48 **	Sources of seed for Rhodes grass
	1.0 **	Sources of seed for Desmodium
Tree nursery establishment	0.68 *	Fodder sorghum area cultivated
	0.41 **	December household food situation
	-0.42 **	Period hired labor (months)
	-0.69 *	Maize price - Short rains
**Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level		

Table 17. Cross tabulations with satisfactory Chi-square statistics.

CSA practices	Coefficients and significance	Variables
Agroforestry/Fodder trees	14.10 (p <.05, d.f. = 1)	Agroforestry/Fodder trees
Improved fodder production	8.95 (p <.05, d.f. = 2)	Land tenure: Free hold
	15.71 (p <.05, d.f. = 1)	Participation in EADD-MICCA activities
	7.65 (p <.05, d.f. = 2)	Household head education
Tree nursery establishment	11.02 (p <.05, d.f. = 1)	Participation in EADD-MICCA activities
Chi-square statistics needs to be above 3.84 for d.f.=1 and 5.99 for d.f.=2, p=0.05 before it can be used.		

United Republic of Tanzania

Table 18. Pearson correlations between practices and variables.

CSA Practices	Coefficients & significance	Correlated variable
Double digging	1.0**	Labour hired
Minimum tillage	-	
Mulching	-	
Cover crops	0.472 **	Average sale price crop
Crop rotation	1.0**	Labour hired
Tree planting	-	
Terracing	0.444 **	Specific training in gardening
	0.436 **	Specific training in terracing
	-1.0 **	Number of males 15-65 not working
Gardening	0.553 *	Labour hired for planting
Improved cooking stoves	-	
**Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level, - not correlated		

Table 19. Predictors of adoption: farmer and farm characteristics.


CSA Practices	Significance	Variable
Minimum tillage	+ve (**)	Gender
Crop rotation	-ve (***)	Food insecurity
Mulching	-	
Improved cooking stoves	+ve (**)	Education
	+ve (*)	Productive assets
	-ve (**)	Located in the lowland
+ve and -ve = positive and negative sign of respective coefficients, respectively *, ** and *** = significant at $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively; ns = not significant at $p < 0.1$		

Table 20. Predictors of adoption: technology characteristics.

CSA Practices	Significance	Variable
Minimum tillage	+ve (***)	High productivity payoffs
	-ve (**)	Easiness of observability
Crop rotation	-	
Mulching	-	
Improved cooking stoves	-	
	-	
	-	
+ve and -ve = positive and negative sign of respective coefficients, respectively *, ** and *** = significant at $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively; ns = not significant at $p < 0.1$		

Table 21. Predictors of adoption: social/institutional factors.

CSA Practices	Significance	Variable
Minimum tillage	+ve (**)	Specific training
	+ve (*)	Demonstration plots/farmer field schools
Crop rotation	-	
Mulching	+ve (**)	Specific training
	-ve (**)	Demonstration plots/farmer field schools
Improved cooking stoves	+ve (***)	Specific training frequency
	+ve (***)	Demonstration plots/farmer field schools
	+ve (*)	Distance to the market
+ve and -ve = positive and negative sign of respective coefficients, respectively *, ** and *** = significant at $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively; ns = not significant at $p < 0.1$		



The pilot projects of the Mitigation of Climate Change in Agriculture (MICCA) Programme of FAO in Kenya and the United Republic of Tanzania have promoted climate-smart agriculture (CSA) and have been integrated into ongoing development programmes. The objective of the pilot projects was to show that smallholder farmers can improve their livelihoods and increase their productivity and contribute to climate change mitigation at the same time. The approach was to develop packages of climate-smart agricultural practices based on participatory assessments and expert consultations, implement the selected practices using a variety of extension methods and evaluate their effects on yield, food security and their potential to reduce greenhouse gas (GHG) emissions on farms and throughout the landscape. Farmers who participated in the MICCA pilot projects reported that the main benefits of CSA were higher yields, greater farm income and increased food availability. This is an indication that smallholder farmers can be an effective part of the response to climate change and make a meaningful contribution to reducing GHG emissions. Bringing sound, up-to-date evidence into decision-making processes can help shape policies that support CSA.