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Contents

LIST OF ACRONYMS

ACIAR	Australian Center for International Agricultural Research
AE	Agronomic Efficiency (AE)
AIP	Agricultural Innovation Platform
ARC	Agricultural Research Council (South Africa)
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CA	Conservation Agriculture
CAADP	Comprehensive African Agriculture Development Programme
CASI	Conservation Agriculture-based Sustainable Intensification
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CGS	Competitive Grants Scheme
CORAF	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles / West and Central African Council for Agricultural Research for Development
CIMMYT	Centro International de Mejoramiento de Maiz Y Trigo (International Maize and Wheat Improvement Centre)
CIAT	Centro Internacional Agricultura Tropica (International Centre for Tropical Agriculture)
CSA	Climate-Smart Agriculture
CT	Conservation tillage
DARS	Department of Agricultural Research Services (Malawi)
DTMA	Drought Tolerant Maize for Africa
EIAR	Ethiopian Institute of Agricultural Research
ESA	Eastern and Southern Africa
FAO	Food and Agriculture Organization of the United Nations
GLM	Generalized Linear Model
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ILRI	International Livestock Research Institute
IIAM	Instituto de Investigação Agrária de Moçambique (Mozambique Institute of Agricultural Research)
KCTA	Kenya Coffee Traders Association

KALRO	Kenya Agricultural and Livestock Research Organization
KCEP	Kenya Cereals Enhancement Programme
KCSAP	Kenya Climate Smart Agriculture Project
MAIZE CRP	CGIAR Research Programme on Maize Agrifood Systems
NCATF	National Conservation Agriculture Task Force (Kenya)
NARO	National Agricultural Research Organization (NARO)
NEPAD	New Partnership for African Development
NGO	Non-Governmental Organization
NARI	National Agricultural Research Institute
PCA	Principal Component Analysis
PSC	Project Steering Committee
PMC	Project Management Committee
QAAFI	Queensland Alliance for Agriculture and Food Innovation
RAB	Rwanda Agricultural Board
R4D	Research for Development
SARI	Selian Agricultural Research Institute (Tanzania)
SIMLESA	Sustainable Intensification of Maize–Legume Cropping Systems for Food Security In Eastern And Southern Africa
SSA	Sub-Saharan Africa
SSU	Shamba Shape Up
TARI	Tanzania Agricultural Research Institute

1 Acknowledgments

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2 Executive summary

In response to the well-publicised low agricultural productivity and food insecurity in the Eastern and Southern Africa (ESA) region, the Sustainable Intensification of Maize–Legume Cropping Systems for the Food Security in ESA (SIMLESA) project was conceived in 2010 to support smallholder farmers to adopt conservation farming methods as a way to promote productivity and environmental sustainability in smallholder farming. As shown in Figure 1 of Appendix 1, conservation farming methods include zero or minimum tillage for crop establishment, a maize–legume diversification through rotation or mixed cropping, and the retention of crop residues for mulching. Associated with improved varieties and crop nutrition, conservation methods (CA) provide a path to sustainable intensification (SI). SIMLESA's implementation approach was based on adaptive research at experimental stations and later extended to local communities for further testing and demonstrations. The tested practices came to be called Conservation Agriculture-Based Sustainable Intensification (CASI). The CASI methods tested for broader scaling were those that relied on locally available farm implements such as ox-drawn rippers, jab planters, and dibble sticks.

Partnerships with a range of value chain actors, mainly farmer and community groups, were critical in testing the adoption and scaling of the CASI methods. Sustained CASI demonstrations within reach of farmers became learning centres, providing an opportunity to farmers in local communities to observe and try out new CASI practices. This report describes the results and outcomes of the SIMLESA project and presents the main lessons. With context-appropriate modifications, the lessons from SIMLESA offer a set of guidelines on how to achieve sustainable intensification in ESA and similar regions.

The project was initially implemented in Ethiopia, Kenya, Malawi, Mozambique, and Tanzania. Rwanda and Uganda were later added as spillover countries. At the start of the project, the characterisation of maize–legume production, input and output value chain systems and adoption pathways was carried out. Capacity building and skills strengthening of local extension personnel were done in collaboration with the respective NARIs. The SIMLESA was fully aligned with the 4

CAADP[2] Pillars as described[3]: Pillar 1 identified the role of conservation agriculture in sustainable land management, Pillar 2 dwelt on the need to strengthen agribusiness systems, Pillar 3 looked at strengthening household assets and productivity through markets, while Pillar 4 focused on the need to improve agricultural research systems.

Project impacts

Over the implementation period, the SIMLESA program had large impacts, measured by maize and bean yields in project sites and proximal communities. To provide an overall view of the impacts of the program, a final series of adoption monitoring surveys were carried out in 2018 across the seven countries. The results from these surveys show that the average growth rate of adoption in SIMLESA sites across the region was 3% per year (where adoption is defined as the use of a distinct, contiguous plot of at least two CASI practices). Prospectively, if these adoption growth rates are sustained up to 2030, the economic impacts will be significant. This is because: by the end of 2018, the number of farmers who had adopted at least two practices was 484,000. On average, these farmers had adopted full CA (or at least minimum tillage with maize–legume diversification or mulching) on 0.4 hectares of their farm. The ex-ante analysis shows that by 2023, the number of adopters of two practices involving zero or minimum tillage plus one other recommendation (maize–legume diversification, mulching) would be 562,000 households, while 693,000 households would adopt at least one recommended practice. The financial returns of adopting at least two CASI practices (with minimum tillage as an essential practice) showed that for one dollar invested in CASI, farmers could generate an average of four dollars in return per hectare. Data from across the seven countries show that the average gross margin for implementing full CASI was estimated at $449/ha. In 2018, the total was estimated at 99,587 ha. The aggregate income from implementing CASI was, therefore, imputed at $44.7 million in 2018. On average, farmers' maize returns are less than

[2] The Comprehensive Africa Agriculture Development Program is one of the Africa-wide continental policy frameworks of the New Partnership for African Development (NEPAD), specifically meant to drive agricultural transformation. NEPAD is, in turn, a flagship development program created by the African Union.

[3] *[65]*

$120[4] under conventional farming methods (which would be approximately $12 million) for the total hectare recorded in the SIMLESA report (a 3.8:1 benefit ratio in favor of CASI, consistent with the plot level reported 4:1).

Furthermore, the CASI practices and the processes of extending them have created good prospects for agricultural sustainability[5]. Where CASI practices were implemented, there was a 30%–65% more soil organic carbon compared to soils under conventional tillage. There were also improvements in soil structure with 30% more water retention and a 60–90% increase in water infiltration rates in plots with CASI practices. The Tanzania sites recorded an average increase in soil organic carbon by 23%. Furthermore, the use of crop residue as a permanent soil cover and intercropping reduced soil loss by 34–65%.

Sustainability is a multidimensional concept. SIMLESA's work has demonstrated that these key elements are achievable with an integrated and multidisciplinary approach. The yield and economic superiority of CASI ensure that the *productivity and economic viability* pillar is sound. The implementation of CASI practices improved soil properties (higher soil carbon, moisture retention, and improved soil structure) thereby contributing to the *environmental improvement* aspects. The spread of information and adoption of the practices were enabled by better access to *markets and institutions:* the adoption of CASI required information delivery to farmers through field days, demonstrations and training within their communities. The establishment or encouragement of multi-stakeholder community groups was an important part of the success of the project, contributing to *increased community governance.* Another vital element of sustainability *was improved capacities of individuals* to understand and implement CASI. The extension programmes together with degree and non-degree trainings contributed these *capacity* elements of sustainability. The final element in sustainability was embedding the results of key policy processes to facilitate *local and national ownership.* The SIMLESA project produced large amounts of communications materials and policy briefs suitable for use by non-technical audiences. Many communications materials were widely shared and the results were presented in

[4] See references *[66, 67]* where the net returns of approximately $93 are reported for conventional farming in SIMLESA project sites in Kenya. This is typical of the ESA region.

[5] See summary in Table 7.5

many fora. A key achievement was the signing of a formal joint communique by 14 ministers and permanent secretaries from Eastern, Central, and Southern African regions to support conclusions from the SIMLESA project in their countries' agricultural programs.

3 Background

Food security remains a challenge in the ESA region. According to FAO and UNECA (2018), the prevalence of severe food insecurity was 32% in Eastern Africa and 31% in Southern Africa in 2017, a decade after the 2007–08 food price crisis. While the 2007–8 world food crisis abated somewhat at the international level, it is evident that food insecurity remains high in ESA. Maize and legumes are important elements in food production and supply chains of ESA [1, 2]. Maize is the most critical staple for 300 million people in Sub-Saharan Africa [2]. In Africa, recent estimates show that maize has been grown on about 35 million hectares and is easily the most important staple food crop, feeding more than 200 million people and providing food and income to millions of families. Besides, the region faces many challenges, including low yields and resource degradation, such as soil nutrient mining. Most farmers lack access to improved inputs such as seeds, fertilisers as well as storage equipment. The need for affordable technologies adapted to smallholder farmers' conditions is as critical as ever. Legumes are the key sources of plant proteins and widely used as an intercrop in maize systems. Particularly for women farmers, legumes are often the main "cash crops" [3]. Although these crops are important in ESA, their production is limited by the low adoption of new and more productive varieties and practices.

The focus on conservation agriculture in the context of ESA was appropriate because the vast majority of successful CA adoption has been in the United States, Canada and Latin America (most notably Brazil and Argentina) [4]. At the time of the SIMLESA inception, the evidence base on CA and what makes it work in smallholder systems was still small [5]. SIMLESA is one of the major cross country efforts in Africa to add to the evidence base on CA in smallholder systems.

It is apparent that factors that have always conditioned the adoption of other agricultural technologies may still pose similar hurdles for CA. For example, CA adoption by African smallholders may be influenced by an array of socio-economic factors such as input prices, knowledge, labour scarcity, lack of capital, limited farm sizes or poor infrastructure [6, 7].

The literature [8] has identified four historical milestones in the emergence of CA as a critical tool in sustainable agriculture. The first milestone was the 1996 World Food Summit where the Soil Fertility Initiative was launched. This was followed by the Better Land Husbandry approach and subsequently, a 1998 workshop in Zimbabwe which discussed conservation tillage for sustainable agriculture. In 2000, the African Conservation Tillage network was formed [9]. The core support for the promotion of CA has invariably come from donor funding. For example, in 2003 in Zambia, FAO piloted a piece of ripping equipment and input packs as part of an FAO's emergency agricultural intervention plan. The Monsanto seed company in collaboration with Sasakawa-Global (SG2000) has promoted no-till practices that rely on herbicides and the retention of crop residues in countries such as Burkina Faso, Ghana, Guinea, Mali, Malawi, Nigeria, Senegal, Ethiopia, Kenya, Mozambique, Uganda and Tanzania [8]. In Ethiopia, one of the early efforts to introduce minimum tillage was done by the Sasakawa-Global (SG2000) in the South Achefer district [10]. This project used on-farm demonstrations of minimum tillage improved maize varieties and herbicides. The program was implemented for some years involving field demonstrations.

Conservation agriculture has been formally promoted in Kenya since 1998 under the Kenya Conservation Tillage Initiative (KCTI) and by 2005, KCTI had projects in five districts in the country with plans to scale up the pilot programs through farmer field schools. From these efforts, CA is now emerging in several parts of Kenya among a diverse group of farmers in areas such as the semi-arid Machakos and Laikipia, the high potential Nakuru area and the smallholder sub-humid western Kenya. The 3rd World Congress on Conservation Agriculture was held in Kenya. During this Congress, the government (represented by the vice president of the Republic of Kenya at that time) expressed its commitment to CA in its strategy to revitalise agriculture [11].

Experimental trials on CA in Malawi can be traced back to the 1980s at Bunda College [12]. In recent years, the authorities have shown that they are keen to promote processes and policies to redress land degradation. The promotion of conservation farming is taken seriously enough that there exists a National Conservation Agriculture task force (NCATF). This task force has the mandate of overseeing the proper application of the sustainable use of natural resources/land management practices and the advocacy of CA initiatives throughout Malawi by participating in land resource policy processes especially with regard to CA. The

NCATF brings together researchers, developers, and policy-makers to share information and advance conservation agriculture to new frontiers.

One of the earliest concerted efforts at promoting CA in Tanzania is reported in [13] in which they report that in 2004, a joint program between the German Ministry of Agriculture and FAO supported CA practices in Northern Tanzania. The project used farmer field schools as entry points for extension and farmer education in CA. The project also encouraged the private sector to participate in the fabrication, retailing and developing custom hire services for CA equipment such as jab planters, ripper sub-soilers, and other implements. These projects were pioneered in Arumeru, Karatu, and Bukoba and later expanded to Babati, Hanang and Moshi Districts facilitating the formation of 130 farmer field schools and reaching 3,500 farmers during the 2007–2010 phase [13].

Overall, this review suggests that there have been notable efforts at CA promotion in the study countries. Before SIMLESA, there is scant information on any cross-country program that took a regional approach to the science, agribusiness and institutional innovations approach to CA promotion in a multidisciplinary manner. The SIMLESA program has therefore contributed to answering the question about best bet smallholder-appropriate CA practices. What are the agronomic, economic, institutional and policy factors that can facilitate the widespread diffusion of CA in smallholder farming systems of ESA?

3.1 Eight years of Phase I

The SIMLESA project was conceived in 2010 to support smallholder farmers to adopt conservation farming methods to promote productivity and resilience in maize and legume farming systems of ESA. SIMLESA's implementation approach was based on adaptive research at experimental stations and later extended to local communities for further testing and demonstrations. The CASI methods tested for wider scaling were those that relied on locally available farm implements such as ox-drawn rippers, jab planters and dibble sticks. SIMLESA sought to improve farm-level food security in the context of climate change and its attendant risk of crop failure. To this end, the program identified, analysed and communicated conservation agriculture-based practices to help improve maize and legume yields.

The technological focus was on testing and piloting locally adapted conservation agriculture methods appropriate for smallholder farmers, coupled with the use of good agronomic practices. The social science focus was on characterising the maize–legume cropping systems, undertaking market analysis, and identifying policy and value chain interventions to enable the CA farming practices in ESA. Efforts were also made to strengthen local seed systems for the delivery of appropriate maize and legume varieties. Pilot scaling programs were funded and monitored to document lessons on appropriate strategies. Training and capacity building was done at both non-degree and graduate levels for early to mid-career scientists.

3.2 A ninth year of policy outreach

After eight years of implementation, the ninth year of the project was developed as a policy engagement phase. A total of 13 policy events were held across the seven project countries (one at regional and another at the national level). The guiding theory of change was that by sharing lessons through these forums, key information would be delivered to key decision-makers to help shift perspectives (and priorities) among policy makers. This would provide the basis of increased investments in conservation agriculture-based methods of farming, mixed crop systems and better incentives for CASI such as improvements in extension, microfinance, value chains, infrastructure, and agricultural higher education (see Fig. 3.1). The aim was to eventually catalyse paradigm shifts in smallholder agronomy, rural markets and institutions to support CASI. A milestone event was the participation of SIMLESA in a regional ministerial summit in Kampala Uganda on May 4, 2019 in conjunction with a regional coordinating body, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The forum was attended by 14 ministers and permanent secretaries.

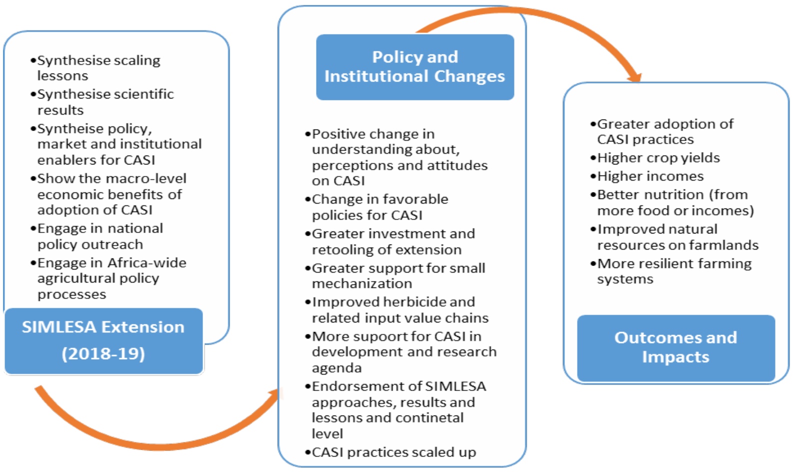

Fig. 3.1 Theory of Change for SIMLESA policy engagement activities

4 Objectives

Phase I of SIMLESA covered July 2010–June 2014 is referred to here as SIMLESA-1. During the third Annual Review and Planning Meeting (ARPM) and the Program Steering Committee (PSC) meeting in Chimoio, Mozambique in 2013, the PSC, ACIAR and partners reviewed and assessed the challenges and the achievements of SIMLESA Phase I and recommended the development of a Phase II proposal. A variation document of Phase I was developed, accepted and approved by ACIAR in April 2014 (SIMLESA-2). The second phase of SIMLESA commenced on 1 July 2014 and ended on 30 June 2018. Phase I findings and lessons underpinned the design and focus of SIMLESA-2:

Finally, a one-year extension variation was also approved (June 2018–July 2019) to focus on policy outreach. The entire project, therefore, covered 9 years (June 2010–July 2019 and a no-costed extension to October 2019), sometimes called SIMLESA-3 in this document. SIMLESA was implemented under the following five themes, called objectives.

4.1 Objective 1:

Phase I (SIMLESA-1): *To characterise maize–legume production and input and output value chain systems and impact pathways, and identify broad systemic constraints and options for field testing*

Phase II (SIMLESA-2): *To enhance the understanding of CA-based sustainable intensification for maize–legume production systems, value chains, and impact pathways.*

The first objective of the project was to identify key policy, institutional and market enablers of conservation agriculture-based farming systems appropriate for small and resource-limited farmers systems in ESA, through economic, policy and market research. The aim was to enhance the understanding of CA-based intensification options for maize–legume production systems, value chains, and impact pathways. The results of SIMLESA-1 generated information that enabled the identification of specific permutations of CA-based intensification options. In SIMLESA-2, the identification and targeting of CA-based intensification options were expanded from the original plot-scale in Phase I to include the farm scale, especially in relation to different household types and community settings, policies, and institutions. Key sub-objectives of Objective 1 were:

Understanding farmers' perception of risks, their attitude towards risk, risk exposure and **sensitivity under different management responses**; and ways to improve on those responses under different biophysical, socioeconomic and institutional innovations.

Understanding CA-based intensification and feed options in selected farming systems: The initial database of technology options developed in Phase I was enriched in Phase II.

Understanding maize, legume and fodder/forage value chains, focusing on institutional constraints and opportunities, costs and pricing patterns (gender-specific). Building on SIMLESA-1, standardised tools were developed for in/output market and value chain analyses.

Functional farm-household typologies matched to CA-based intensification options. Bio-economic modelling was used to identify the mix of interventions from among the maize–legume-fodder/forage systems options that are low-risk and productivity-enhancing, and that best fit the setting, characteristics and endowments of each household typology.

Identified recommendation domains and adoption and impact pathways for maize–legume forage systems. In partnership with the Adoption Pathways Project, adoption and impact assessments were conducted through farm household surveys in selected farming systems to identify impact pathways and facilitate learning, and priority setting processes.

4.2 Objective 2:

Phase I (SIMLESA-1): *To test and adapt productive, CA-based intensification options for sustainable smallholder maize–legume production systems.*

Phase II (SIMLESA-2): *To test and develop productive, resilient and sustainable smallholder maize–legume cropping systems and innovation systems for local scaling out.*

The second objective was adaptive agronomy research to test and refine CA-based farming practices and methods that are suitable for smallholder farming systems of ESA. The aim was to document the adjustments needed for CASI-based intensification options to increase productivity, reduce downside risk and enhance their uptake and impact. It particularly: (1) tests the hypothesis that different CA-based options are needed for different farm typologies (agro-ecology, system, and farm/households) and to examine how these options are adapted by farmers to suit their needs (or context such as risk profile); and (2) tests the hypothesis that to enable CA-based intensification in some crop-livestock systems (i.e., those with high demand for residue), it will be necessary to initiate change in the livestock component (or perhaps other components depending on the context) of the system. While the Phase I on-farm research on CA-based intensification was maintained in the same sites with strengthened multidisciplinary teams, there was a new emphasis on fine-tuning the R4D implications notably in crop-livestock farming systems and feed into out-scaling.

The sub-objectives were:

- **Identified and tested options for systems intensification and diversification that increase productivity and reduce risks in the target farming systems within the whole-farm context:** These evaluations consisted of static and dynamic bio-economic/household modeling as well as field testing. Building on the work done in Phase I (bio-economic model to evaluate ex-ante benefits of CA); in Phase II, the focus shifted to where, how and for whom CASI technologies work in collaboration with the Adoption Pathways project.

- **Functioning local innovation platforms developed in each targeted maize–legume systems to help overcome system limitations and enhance scaling out of technologies:** This was completed in SIMLESA-1.

Innovation Platform-related activities were later moved to Objective 4 with a focus on identifying effective scaling modalities.

- **Evaluated on-farm trials of sequenced CA-based intensification options for different types of farm maize–legume-forage/fodder production systems.** Conservation agriculture-oriented management systems and other production technologies were adapted to the biophysical and socio-economic conditions of innovative farmers in each of the targeted communities.

A key first step in this adaptation was the establishment of a series of exploratory trials, one in each target community. “Best bet” CASI[6]-related options based on past local and regional results were tested on 5–6 farms in each community and compared with the farmers’ current management practices, but with the same variety and fertiliser level as the CASI option(s) to reduce the confounding effects of using different varieties and crop nutrient levels. Trials included more than one option of both CASI and conventional systems based on the results of the ex-ante analysis. On each farm, one replication of the trial was installed with plots large enough for effective farmer evaluation. These trials were combined, as needed, with other outreach and experimental methods (such as mother–baby trials) to gain the fullest participation of target groups, especially women.

[6] We use CASI to refer to what was done in this project and CA as a more specific term as used in the literature to refer to conservation (no tillage), crop diversification such as rotations and mulching. The practices promoted in SIMLESA included these but also improved agronomy broadly, hence CASI.

4.3 Objective 3:

Phase I: *To increase the range of maize and legume varieties available for smallholders through accelerated breeding, regional testing and release, and availability of performance data.*

Phase II: *To increase the range of maize, legume and fodder/forage varieties available to smallholders.*

The third objective was to contribute to the development of functional seed systems for sustainable delivery of high-yielding, drought-tolerant legume and maize varieties compatible with CA. Although it is a continuation of 3 in Phase I, in Phase II, the focus was narrowed to seed systems development (as opposed to variety evaluation). In Phase II, the aim was to diagnose the bottlenecks to maize and legume seed availability. A key approach was to work across multiple projects such as the Drought Tolerant Maize for the Africa (DTMA) project among others to make adequate amounts of seed available for experimentation as well as facilitate the production of early generation seed.

4.4 Objective 4:

Phase I: *To support the development of regional and local innovation systems.*

Phase II: *To support the development of local and regional innovation systems and scaling-out modalities.*

The fourth objective was to identify effective scaling modalities to inform programs that were used to accelerate the uptake of the CA-based farming practices beyond project sites. The objective thereby primarily addressed the third research question: “How can CA-based intensification options best be scaled up (institutionalised) and scaled-out in Eastern and Southern Africa?” The continuation from Phase I was to emphasise the testing of a range of scaling models including on-farm demonstrations, different scaling partnerships (with public and private sector organisations such as local sellers of agricultural inputs, non-governmental organisations (NGOs) and community-based organisations (CBOs, such as farmer cooperatives and savings groups) and multi-stakeholder innovation platforms.

4.5 Objective 5:

***Phase I:** Capacity building to increase the efficiency of agricultural research today and in the future.*

***Phase II:** Capacity building to increase the efficiency of agricultural research today and in the future modalities.*

The program prioritised the capacity building of researchers and extension practitioners as shown by the number of people on the job who were enrolled at different levels in graduate-level training as well as non-degree holders. Training activities were implemented at multiple levels of research and extension. The trainings, therefore, included degree and non-degree practical training and post-graduate degree training for national and regional partners. The emphasis was on building the capacity of early career researchers in social and plant sciences such as agricultural economics and agronomy. These efforts strengthened scientific exchanges between African universities and those in Australia.

4.6 Transition to SIMLESA-3

When SIMLESA-2 was coming to an end, there was the need to consolidate, synthesise and communicate the results from the eight years of SIMLESA. The principal objective was to communicate SIMLESA results to policymakers at the highest levels possible. Designed to flow out of Objective 4 of Phase II, the one-year extension of SIMLESA was intented as a set of four outputs numbered 4.5 to 4.8 in the revised log frame (Phase II outputs ended at 4.4).

Output 4.5: Strengthened, activated and documented principal scaling pathways and modalities for SIMLESA CASI technologies in each of 7 countries (scaling)

- Generate data on scaling modalities/ pathways and outcomes. Inform strategies to guide strategic scaling investments and policy. The goal to ensure SIMLESA's scaling science is documented and applied.

Output 4.6: Consolidated, analysed and synthesised results of SIMLESA effectively disseminated (synthesis)

- Deepen the analysis and the synthesis of SIMLESA results. Complete an adoption monitoring survey across the intervention areas to document robust adoption results and narrative of the various technologies. Identify bottlenecks and opportunities for adoption and associated drivers and learnings.

Output 4.7: SIMLESA results disseminated in each program country and effective policy engagement with stakeholders accomplished through dialogue and outreach (institutionalization)

- Communicate SIMLESA results broadly at country level. Carry out stakeholder dialogue and networking to discuss practical and policy constraints to scaling. Discuss institutional innovations needed for scaling. Hand over to country partners to secure support for SIMLESA-scalable products and innovations beyond the end of the project on 30 June 2019.

Output 4.8: Knowledge gaps and research questions for the next generation climate-smart farming systems identified (climate-smart research agenda)

- Connect SIMLESA 1 and 2 results to the broader climate-smart agriculture (CSA) agenda. Identify the outstanding issues for an ongoing, future and strategic CSA research agenda.

5 Methodology

The SIMLESA research program (Phase I and Phase II) was implemented in five countries of ESA (i.e., Ethiopia, Kenya, Malawi, Mozambique, and Tanzania) and starting in 2014, included Botswana[7], Uganda and Rwanda as spillover countries (**Figure 5.1**), in which maize and legumes are the major sources of food. The farming systems of these countries showed the potential for rapid and sustainable intensification and diversification of farming systems through appropriate germplasm and improved cropping system management technologies.

Figure 5.1. SIMLESA Countries

The SIMLESA implementation approach was based on adaptive research at experimental stations and replicated in local communities and villages. The project funding facilitated and sustained demonstrations of CASI practices in the project communities and beyond. Partnerships with a range of value chain stakeholders in participating countries were a critical implementation mode. To improve its implementation, several adoption surveys have been conducted over the years in project areas of influence in ESA to estimate the adoption of CA. The program was

[7] The involvement of the Botswana team tapered off somewhat in later years. No specific reports are available for Botswana.

built on socio-economic and biophysical diagnoses of production systems and value chains (both input and output) under Objectives 1–4 in both phases. As was outlined in section 4, the objectives were designed to cover socio-economics, agronomy, seed systems, innovation and scaling and finally capacity building.

5.1 Socioeconomics

The main methodology in socio-economics was to develop multi-wave panel datasets building on a 2010 series of baseline surveys conducted in the five project countries. Second, the use of non-experimental micro econometric impact evaluation was widely used. Third, household and dynamic risk modelling was undertaken to understand macro-level drivers (e.g., fertiliser subsidy) on input use and household decision making under climate, biotic, market and idiosyncratic risks. These methods are detailed briefly below.

The generation of Panel Data Sets: The project collected and curated longitudinal data for adoption and impact analyses. The main source of data was farm household surveys designed to achieve representation in terms of natural, socio-economic and farming systems variability across the five countries in which the project was implemented. The sampling design for the surveys was based on the SIMLESA project. The 2010 data collected by national project partners and CIMMYT under the SIMLESA project across 508 villages formed the baseline data on which further data collection and analysis have been undertaken.

Therefore, building on the 2010 baseline data, two more rounds of data collection were implemented in 2013 and 2016. The 2010 villages from which the baseline data were collected were considered the **sentinel sites** in the sense of being used for long-term monitoring purposes in the project. The data collection exercises were based on structured surveys originally designed for the 2010 baseline SIMLESA survey.

In the 2013 and 2016 rounds, the 2010 survey instrument was modified and expanded to collect in-depth panel datasets on gender roles and relations, household vulnerability, and ex-ante and ex-post risk coping strategies. In order to fully address questions on gender that were outlined in the project proposal, the baseline SIMLESA survey instrument was expanded to collect in-depth data on gender roles and relations, household vulnerability, and ex-ante and ex-post risk coping strategies. The data collection efforts were done through collaboration between teams from NARS. Table 5.1 summarises the data and their locations that were collected under the Adoption Pathways and SIMLESA 2010.

Table 5.1: Data Sets Gathered in Adoption Pathways Project

Country	Districts			Villages			Households		
SIMLESA Program	**2010**	**2013**	**2016**	**2010**	**2013**	**2016**	**2010**	**2013**	**2016**
Ethiopia	9	9	9	60	60	60	900	865	833
Kenya	5	5	5	88	88	88	613	535	496
Malawi	6	6	6	230	230	230	896	752	612
Mozambique	4	3	**3**	**70**	61	**61**	510	394	373
Tanzania	4	5	5	60	60	60	701	551	587
Sentinel Sites	**28**	**28**	**28**	**508**	**499**	**499**	**3620**	**3097**	**2901**
Non-SIMLESA									
Ethiopia	30	29	30	133	133	133	1557	1410	Not done in 2015
Malawi	10	10	9	207	207	207	1029	820	585
Sub-total	40	39	39	340	340	340	2586	2230	585
Total	**68**	**67**	**67**	**848**	**839**	**839**	**6206**	**5327**	**3486**

The Adoption Pathways[8] project was closely linked to the SIMLESA program and the data, the information generated was freely available to SIMLESA scientists and national stakeholders. All the data can now be accessed on the SIMLESA website. Some tangible linkages between the Adoption Pathways and SIMLESA projects include the following: The Adoption Pathways project contributed information to SIMLESA with regards to technology adoption and implications for scaling. This information included constraints and drivers of technology adoption and their impacts. Several policy briefs drawing on the lessons from the Adoption Pathways research were shared with the SIMLESA project and are now part of the collection of publications on the SIMLESA website.

Econometric Models for Analysing Technology Adoption and Impact Analysis: Econometric analysis of baseline data collected by SIMLESA in 2010 formed the basis to characterise the adoption of SIMLESA-related technologies, and **identify constraints to adoption** by different groups of households. Using non-experimental approaches, the SIMLESA baselines data were used to perform

[8] *Offically called, "Identifying socioeconomic constraints to, and incentives for, faster technology adoption: Pathways to sustainable intensification in Eastern and Southern Africa", the Adoption Pathways project was an ACIAR-funded project (FSC-2012-024) led by CIMMYT and designed to complement SIMLESA with more in-depth social science analysis.*

impact evaluation methods on relevant outcomes. For the most part, cross-sectional econometric estimation methods were the main analytical approaches used to assess how markets, assets, institutional and infrastructural factors and gender relations promote or hinder technology adoption and dis-adoption. The types of technologies analysed were those promoted by the SIMLESA project such as improved seed varieties, fertiliser, maize–legume intercropping, maize–legume rotations, conservation agriculture practices, organic manure, and the use of different types of modern inputs such as power tillers and drought-tolerant varieties.

The methods used in this area of analysis employed some of the most recent approaches to non-experimental impact evaluation. These methods tackled some of the challenges in impact evaluation related to selection bias and creating non-experimental counterfactuals, a necessity in observational studies. Analysis of gender technology adoption gaps and the underlying causes were undertaken using endogenous (and exogenous) switching regressions as well as gap decomposition methods to understand gender gaps in input use, market access and food security. Some of the potential outcomes that were variously used included yields [14, 15], crop incomes [16, 17], food security, surplus maize sales [18] and risk [17, 19], diet diversity and under-5 child stunding [20, 21].

5.2 Agronomy and scaling:

The general approach was for NARIS to cover two relevant agro-ecologies from each country. The scaled out plan was to reach a minimum of an average of 100,000 farm households in each agro-ecological region. The choice of agro-ecological regions was based on the premise that farming systems in several of these agro-ecologies reached across countries and allowed scale-out of results beyond the country of actual research (as shown by spillover countries) in each country.

In each agro-ecology, three communities were chosen for data collection, characterisation and experimentation. A total of 10 agro-ecology/farming system combinations and 38 communities across the program were selected. With full participation from farmers in the selected communities (making use of existing farmer groups and other social and community groups), program partners identified CASI scaling options. Selection criteria for CASI practices to scale included options that increased yield and reduced labour and other resources.

For the agronomy trials, the first step was the establishment of a series of exploratory trials, one in each target community. “Best bet” CA-related options based on past local and regional results were tested on 5–6 farms in each community and compared with the farmers’ current management practices, but with the same variety and fertiliser level as the CA option(s) to reduce the confounding effects of using different varieties and crop nutrient levels. Trials included more than one option of both CA and conventional systems based on the results of the ex-ante analysis. On each farm, one replication of the trial was installed with plots large enough for effective farmer evaluation. These trials were combined, as needed, with other outreach and experimental methods (such as mother–baby trials) to gain the fullest participation of target groups, especially women.

Thus, in each community, there was one trial with 5–6 replications in different fields to sample the variability of biophysical conditions. Basic soil, topography and cropping history data were obtained for each of the demonstration/validation plots that were established by farmers with program orientation and support. Trials and treatments were run on the same site for the duration of the program, to allow the short-term cumulative benefits of the treatments to be evaluated. Observations of problems on these trials provided inputs into the on-farm research programme and into the management of the same trials in succeeding years. Data on qualitative and quantitative evaluations of demonstration plots were made available by farmers and other members of the innovation platforms.

The use of systems modelling facilitated co-learning between researchers, extension officers, and farmers on “best fit” technologies. This included the identification of potential impacts of new technology packages, improved allocations of limited resources (e.g., nutrients, water, labour, finances, land, and best-fit genotypes for particular management options and environments). The process also aided the quantification of complex interactions and provided ex-ante and ex-post analyses that identified best-bet options for likely future scenarios.

By the end of the program, farmer-selected options had been tested and adapted in more than 190 exploratory trials and 2,000 on-farm research and mother–baby trials. Farmer adaptations were monitored on more than 2,500 farms and scaled out through more than 10 local innovations systems. These were complemented by the licensing of released varieties to seed companies, NGO/extension and farmer promotion of improved maize–legume systems approaches, and recommendations to policy makers, agribusiness, public development programs, and farming communities.

5.3 Partnership:

SIMLESA local partners included the Ethiopia Institute for Agricultural Research (EIAR), the Kenya Agricultural and Livestock Research Organisation (KALRO), the Department of Agricultural Research and Technical Services (DARS) in Malawi, the Instituto de Investigação Agrária de Moçambique (IIAM), the Agricultural Research Services (ARS) of the Ministry of Agriculture in Tanzania, the Queensland Alliance for Agriculture and Food Innovation (QAAFI), and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). International Centres included the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Center for International Tropical Agriculture (CIAT), the International Institute for Tropical Agriculture (IITA), all 3 involved in soil and legume research (the “Tropical Legume 2” program), and the International Livestock Research Institute (ILRI) for livestock research in Kenya and Ethiopia. CIMMYT coordinated and managed the implementation, drawing upon the scientific and coordination capabilities of partner organisations. The program utilised a responsive (adaptive) management approach that considered the diverse systems and needs, strengths of NARIs, changing opportunities, and feedback from the ME&L system on program performance with the full involvement of ACIAR. The overall program planning/progress was reviewed at annual program meetings within the framework of budgets for partners and countries. Continued financial support was dependent on successful implementation and submission of work or activity plans, semi-annual technical and annual financial reports and other progress update narratives. Annual review/planning meetings were held on an annual basis and included leading program partners represented by the national coordinators.

5.4 Management

5.4.1 Program Steering Committee (PSC)

The project had a program steering committee (PSC) that advised the program. This committee was composed of one representative each for ACIAR, CIMMYT, five Director Generals (or their designated representatives) from participating NARIs, and a representative from Australia. The PMC also included two independent co-chairs (recognised agricultural scientists/policy makers, one each from Africa and Australia who provided oversight and strategic guidance to the program.

The PSC through CIMMYT monitored general progress, milestones and partnerships, and reports and recommendations to ACIAR regarding any adjustments in program implementation modalities or budgets that are in the interest of achieving program objectives and impacts. The steering committee met at least annually at the regional planning and review meetings, received semi-annual reports and program impact indicators that served to focus, adjust or reschedule activities (and budget disbursements) as deemed necessary by the steering committee.

5.4.2 Program Management Committee

A program management committee (PMC) was formed within CIMMYT, consisting of the program directors (Socio-Economics and Sustainable Intensification). It provided programmatic leadership to scientists and support to the program leader. The SIMLESA program leader provided active leadership to the implementation of the program as a whole, ensuring coherence across objectives.

5.4.3 Gender Mainstreaming

The program encouraged the participation of both female and male farmers from selected communities. It ensured gender mainstreaming and capacity building for national agricultural research systems (NARIs) of partner countries, the creation of enhanced partnerships and collaboration with established innovation platforms with a gender focus for coordinated scaling out of SIMLESA-generated options and practices.

5.5 Summary of program approaches

SIMLESA was implemented through the following approaches

1) Socioeconomic analyses were done to inform targeting and future institutional and policy enablers for sustaining and domesticating SIMLESA results.
2) SIMLESA established exploratory trials to test the most promising CASI technologies, i.e., reduced soil disturbance, provision of soil cover and the use of crop rotations or associations. Embedded in these was the use of recommended agronomic practices such as inorganic and organic fertilisers, herbicides and improved varieties, timely planting, weed control and proper crop management.
3) Through participatory seed variety selection with farmers and local research institutions, SIMLESA identified maize and legume varieties that were well-adapted to different agro-ecological zones in the region.
4) To increase diffusion and scale-out of CASI practices, SIMLESA formed “innovation platforms” (knowledge exchange and action forums) to increase agricultural information exchange among value chain stakeholders.
5) SIMLESA promoted on-farm demonstrations and field days held at selected farmer fields to provide training in agronomic management practices, such as minimum tillage and weed control.
6) SIMLESA facilitated capacity building for researchers and extension workers through NARS in regions of project activities.

6 Achievements against activities and outputs/milestones

6.1 Summary of SIMLESA achievements:

The implementation of SIMLESA was based on five main principles: **(i)** adaptive agronomy; which included the identification, testing, and recommendation of CASI farming practices suitable for smallholder farmers; **(ii)** socioeconomics and gender research which focused on the identification of the institutional, market and policy enablers of CASI; **(iii)** seed systems involving the strengthening of seed systems to deliver drought-tolerant maize varieties compatible with CA systems; **(iv)** testing scaling modalities which included identifying scaling modalities to support the diffusion of CA methods for true impact and finally and **(v)** capacity building to contribute to upskilling of early-career scientists and cementing the Africa–Australia scientific collaboration.

6.1.1 Provided a compelling business case for CASI

Evidence from SIMLESA showed that investments in CASI lead to higher yields in maize and legume farming systems. In Malawi, the percentage increase in maize yield due to the use of CASI technologies and practices was 17% in the mid-altitude agro-ecology and up to 38% in the lowland agro-ecologies [22]. In Ethiopia, grain maize yields increased by 5–18% on average compared with farmers' practices [23]. Mozambique recorded up to a 20% increase in maize yields using planting basins compared with conventional tilled seedbeds and there was up to a 19% increase in maize yields in Gorongosa under direct seeding [24]. In the drier areas of Tanzania, maize yields increased by 2.5–3 tons/ha while in the high potential areas, the yields increased by 2.5–6.5 tons/ha [25] and farm profits increased by 30% under CASI practices. Economic analyses showed that there was an increase in the net maize income from the adoption of CASI technologies and practices which ranged from 9–35% for CASI practices alone and from 26–137% for CASI practices. Further, there was also an increase in complementary inputs compared to conventional practices [14]. The impact on labour was also substantial. In Tanzania, the use of reduced tillage aided by a two-wheel tractor reduced the amount of time spent on planting one hectare of a maize field from 160 person-hours of intensive tillage using a hand hoe to only 3 machine hours [26]. In Kenya, up to 80% or more of the labour associated with conventional tillage is attributable to land preparation and weed control. Shifting from these conventional methods of tillage to conservation agriculture reduces the costs of labour by 56% [27, 28, 22]. The common message was that CASI practices—including optimal and complementary implementation of crop diversification practices, such as cereal/legume intercropping and rotations, maintaining permanent soil cover and mulches, and practicing minimum tillage—show promise for boosting productivity through both yield increases and cost reductions. In many cases, the adoption of CASI methods can reduce the labour costs[9] for farmers by an average of 50 percent compared to conventional practices, which created large potential cost-saving benefits [27].

6.1.2 Increased adoption rates of CASI

A household survey [29] was carried out at the end of 2018 to provide updated information on the adoption of CASI practices within the project communities in proximal areas (within 17–25 km of demonstration sites)[10]. The results indicate that 484,000 households had adopted at least two recommended CASI practices by 2018 with 14% of them consistently adopted them for 3–5 seasons. The extent of adoption of CASI technologies and practices averaged 0.4 ha per farmer which is equivalent to 43% of the average area allocated by farmers to maize–legume production.

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[9] *The first order goals for adaptive research and scaling of CASI was to raise productivity, conserve soils but do so in an economically feasible way. In the course of implementation, labour savings (especially that of family labour but also hired labour) were recognised in the economic analyses as a powerful economic driver: a driver and incentive for adoption. This should be used as a stepping stone to achieve the long term productivity and soil conservation goals.*

[10] *For more details on the methods and results, see the full report of the adoption monitoring survey in the Appendices to this report.*

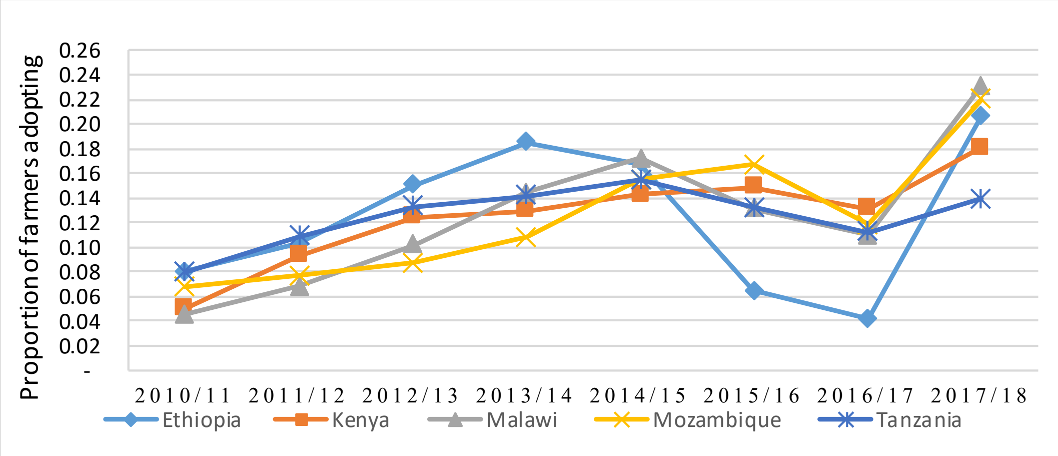

Fig. 6.1: Adoption trends in adoption of CASI in five SIMLESA countries

The adoption monitoring data showed that across the seven countries, the annual adoption growth rates of the three CASI combinations was an average of 3.8% adoption of practices zero or minimum tillage with combination of maize–legume diversification on the same plot (given the moniker partial CASI1 in the adoption report), 1.7% adoption of combination of zero or minimum tillage and use of mulching on the same plot (partial CASI2) and 3.2% for full CA (adoption of all CA practices of minimum tillage, crop rotation or intercropping and surface mulch on the same plot). In terms of country variations, Malawi, Kenya, Mozambique, and Uganda had the highest adoption growth rates with an average of 4.2% compared to the regions: an indication of the concerted efforts by SIMLESA extension networks in these countries. Adoption of partial CASI1 combinations was common among Ugandan smallholder farmers (25%) compared to 1.8% in Ethiopia while Mozambique had the most farmers adopting partial CASI2 combinations. Mozambique, Malawi, and Kenya had the highest proportion of smallholder farmers to adopt full CASI practices [29].

6.1.3 Contributed to institutional development and social innovations

Strengthened transnational collaboration in agricultural research and development. SIMLESA drew 12 institutions together in an international, multi-stakeholder collaboration that helped in building a collaboration where each institution participated based on their unique strengths and local expertise in each country (and district), thereby making the research activities relevant and context-appropriate. Other collaborators included private seed companies, farmers, farmers' groups, agro-dealers and extension departments that contributed.

Better understanding of the socioeconomic, market and policy situation. A key objective of the program was economic, policy and market research to identify key policy, institutional and market enablers of conservation agriculture-based farming systems appropriate for smallholders in ESA. The goal was to enhance the understanding of CASI-based options for maize–legume production systems, value chains, and impact pathways. Lessons for market and institutional innovation and the policy support needed were also generated.

Tested and shared lessons on technology scaling modalities. Toward the end of 2016, the program competitively selected 19 partners to drive out scaling initiatives under a Competitive Grants Scheme (CGS). Lessons from these efforts will be documented and shared widely. A total of 58 agricultural innovation platforms (AIPs) helped to scale out sustainable intensification technologies and market agricultural produce for maximum benefits. Field days, exchange visits and AIPs have continued to improve knowledge transfer, which has increased both maize and legume yields and improved food security in the project sites.

Strengthened maize and legume seed systems as a critical enabler of CASI. In collaboration with national breeding programs, CIMMYT's Drought Tolerant Maize for Africa project, and ICRISAT's Tropical Legume Projects, SIMLESA facilitated the release of 40 maize and 64 legume varieties, which were tested and evaluated by farmers in the study countries.

6.1.4 Contributed to agricultural sustainability and how to achieve it

Productivity and economic viability: The project demonstrated the economic and productivity potential of CASI. In order for farmers to sustainably adopt CASI technologies, these practices have to be economically viable and contribute to incomes more than the increase in the costs. The results outlined in this report show that the economic basis (yield increases or cost reductions) exist to underwrite the sustainable adoption of CASI.

Environmental improvement: The project showed that higher productivity can be achieved while improving the environment. Their adoption can improve soil health, a critical component of sustainability.

Improved markets and institutions: The adoption CASI required information delivery to farmers through field days, demonstrations and undergoing trainings within their communities. The income benefits of CASI can only be sustained if farmers have access to well-organised markets. SIMLESA teams facilitated the formation of community groups to help with market access. The close collaboration between SIMLESA's research teams and government or non-government extension showed the importance of better institutional integration as an important element of sustainability.

Improved community governance: The establishment or encouragement of multi-stakeholder community groups was an important part of the success of the project. These groups were meant to share technical information and identify opportunities for mutually beneficial solutions.

Contributed to improving the capacity of individuals: SIMLESA baseline studies indicated that many farmers were operating in isolation of other value chain actors leading to limited access to knowledge, services and markets with negative consequences on incomes, resilience and food security. Functional agricultural innovation platforms (AIPs) facilitate information exchange, collective action and market participation. In Uganda, for instance, 8 out of 10 farmers had no access to extension services prior to their participation in AIPs [30]. Participation in AIPs increased access to 90% [30]. Collective engagement with markets through AIPs also improved from 1 out of 10 farmers to 90% of the farmers engaging in bulk produce marketing and 50% in bulk input procurement [30]. In Malawi, AIP facilitation increased the number of farmers who adopted CASI from 2% in 2011 to 35% in 2011 [30]. Farmers engaged with AIPs also benefitted from a 44% increase in the prices of their produce due to bulk marketing and a 20% discount on fertiliser prices due to volume purchases through AIPs [30].

Strengthened local and national ownership: A final element in the sustainability project results need to be embedded in the key policy processes. The SIMLESA project produced large amounts of communications and policy briefs suitable for use by non-technical audiences. Efforts were made for a dozen national policy outreach events and a major regional policy forum attended by twelve ministers and permanent secretaries of agriculture. Others attendees included directors of extension, representatives of development organisations, ACIAR, regional bodies for economic cooperation among others. Many communications materials were shared and SIMLESA's results were presented and key lessons articulated. This culminated in the signing of a joint communique by 14 ministers and permanent secretaries to support conclusions from the SIMLESA project.

6.1.5 Contributed information on the role of CASI in Africa's agricultural development

The fact that conservation agriculture-based sustainable intensification (CASI) practices can contribute to large gains in crop productivity and farm incomes was a central message from SIMLESA. Moreover, the CASI practices can play complementary roles in providing food, soil recapitalisation and incomes for farmers (see Section 7). The use of these sustainable intensification practices including combinations of crop diversification practices such as (but not limited to) cereal legume intercropping and rotations, maintaining soil cover and mulches and practicing minimum tillage showed promise in boosting productivity and soil fertility while enhancing the resilience of our farming systems to climate change and related risks.

These are important messages for sustainable development in the ESA region. To disseminate these lessons widely, the SIMLESA project teams across all the seven countries were widely involved in communications, disseminations and policy outreach. The object of these activities was to implement the lessons learnt in SIMLESA into government programming, policy processes as well as community-based and private sector initiatives. During the life of the project, annual project meetings were used as platforms to share lessons with the wider community.

- Early in Phase 2 of the program, an annual program meeting that included more than 100 participants from NARIs, government departments and farmer representatives was held in Harare, Zimbabwe on March 16–19, 2015[11].

[11] https://bit.ly/2wdzMUK

- In October 2015 at Entebbe, Uganda, a regional meeting involving the Directors generals representing the ministries of agriculture who were among 50 participants who gathered to discuss the policy implications of SIMLESA's work and how these can be supported and outline a set of commitments to the principles SIMLESA's work.

- In June 2017, the project organized a large conference in Arusha Tanzania that brought together stakeholders from government, private sector (including financial institutions) and farmers. Major lessons from SIMLESA were discussed for their relevance to sustainable development in the region [31].

- In April 2018, a delegation of SIMLESA made up of the Project Leader, the Deputy Director General of KALRO, ACIAR Consultant for policy engagement in Africa and the coordinator for Socioeconomics objective represented the SIMLESA team at the 14th CAADP partnership platform to in Libreville, Gabon to present key SIMLESA policy findings at a partners' side event.

- During late 2018 and early 2019, all SIMLESA country teams held sub-national (at district level) and national policy. Fifteen different regional and national policy forums were held. Key results were shared and recommendations made for mainstreaming CASI in each country's agricultural programs. In Section 7.5 (Table 7.5) below, readers will find specific summaries of country results and the recommendations from the policy forums.

- In May 2019, the project's policy outreach activities climaxed in a regional forum which was meant to produce a formal communique based on SIMLESA's research. A total of 12 ministers and permanent secretaries signed the communique (Fig. 6.2). This was a major milestone witnessed and signed by the African Union (AU) Commissioner for Rural Economy and Agriculture, Josefa Leonel Correia Sacko. Commissioner Sacko affirmed AU's recognition of SIMLESA's achievements and committed to integrating the findings in future AU programming: *"Looking at SIMLESA's* *evidence, we can say that conservation agriculture works for our farmers,"* Commissioner Sack stated that she would recommend SIMLESA's conclusions during the African Union Specialized Technical Committee in October 2019. She will propose a new initiative, scaling conservation agriculture for sustainable intensification across Africa "to protect our soils and feed our people sustainably."

Figure 6.1: Joint communique on CASI of ASARECA meeting

6.1.6 Provided lessons for future research

A number of remaining research questions also emerged from SIMLESA from recommendations from farmers, researchers and other stakeholders whose suggestions point to the following

More understanding is needed on weed management systems that are not herbicide dependent: In CA systems, weed management is central to proper implementation. The use of herbicides is central to weed management. Yet several governments in the region are hesitant to promote large scale herbicide use due to environmental and human health concerns. Therefore, research on integrated weed management is still needed. An example is to conduct research on exploiting allelopathic approaches to weed management and resolving trade-offs in crop residue use in favor of mulching for maximum soil cover.

Low-cost models of crop-livestock integration: Many smallholder farmers have a mix of some livestock (large or small ruminants) and poultry. There is little information on the context-specific mix of crops and livestock types that resource-limited farmers can afford. To make a positive impact on poverty, nutrition and ecosystem health, smallholder farms need to enhance all three elements simultaneously. This requires a higher productivity and intensification trajectory. Research is needed to identify optimal crop-livestock farm plans, smallholder appropriate resource investments and supportive institutional innovations (e.g., credit and market access) to facilitate meaningful crop-livestock integration. One such element should aim at getting the economics of land allocation to food and feed production right and to resolve trade-offs in crop residue use.

The most effective ways on how to use social learning to facilitate agricultural transformation: The effect of innovation platforms and community groups showed the potential of social groups as avenues for information transfer. Further research is needed to better understand how to foster the use of social insitutions as conduits of learning about new agricultural technologies and associated institutional innovations. The use of social models of learning would be the most effective when combined with investments and with the modernisation of public extension institutions. More specific research on the nature of these investments is needed.

How to effectively engage the private sector: Strong value chains are important for the distribution of inputs and marketing of agricultural produce. The growth of agribusinesses is central to the development of value chains. In those places where farmers had good access to markets, the rate of adoption of purchased inputs and improved agronomic practices were higher than the places where such access was limited. Yet many rural areas have few formal agribusinesses operating there. Research on how to attract formal businesses into rural areas is still needed. The focus of such research could be on farmer organisation or policy incentives for investment into rural areas.

The tables below summarise the achievements of the project covering Phase II (the first set of tables) followed by a second set of tables summarising the activities and outputs/milestones during the one-year extension.

Objective 1: To enhance the understanding of CA-based sustainable intensification for maize–legume production systems, value chains and impact pathways.

	Activity	Outputs/milestones	Completion date	Comments
1.1.1	Create a continuously updated database of productive and risk-reducing CA-based intensification options based on: i) The review of the literature and other projects; ii) Stocktaking of SIMLESA I experiences, including surveys and empirical evidence from on-station and on-farm experimentation, and; iii) Ongoing SIMLESA activities.	A dynamic web-based database of CA-based intensification options (agronomic practices, varieties, crop choices/diversification, fodder/forage) established.	2014–2018, updated annually	**Achievements** A web-based database of CA-based intensification options was compiled. The SIMLESA website (www.simlesa.cimmyt.org) now has all the resources produced in this project Stocktaking of SIMLESA-1 and SIMLESA-2 experiences have influenced the compilation of policy briefs and other communications materials. Socioeconomic and agronomic data from all three rounds can now be found on the SIMLESA data.
1.1.2	A meta-analysis of CA-based intensification options focusing on productivity, yield stability/risk, profitability, sustainability, and adaptability.	One peer-reviewed synthesis of performance of CA-based intensification options. Implications of CA-based intensification options on crop failure analysed and documented	2014, updated 2016	A final adoption report has been produced (see Annex 1 of this report). A SIMLESA synthesis book was completed and sent to ACIAR for editing in late 2019.
1.2.1	Evaluation of crop-livestock interactions, feed demand and supply options in 6 farming systems, through quantitative and participatory data collection and use of analytical tools. (Ethiopia, Kenya, Tanzania)	Synthesis of feed demand, and feed intervention options	2014, updated 2015	**Achievements**: On-farm experiments to identify and adapt selected forage species to supplement livestock feed. http://simlesa.cimmyt.org/download/conservation-agriculture-in-african-mixed-crop-livestock-systemsexpanding-the-niche/

	Activity	Outputs/milestones	Completion date	Comments
1.2.2	Analysis of agricultural input accessibility (fertilisers, herbicides, pesticides) in enhancing CA-based intensification options, including agribusiness opportunities and constraints.	Agricultural input supply options, constraints and (agribusiness) development opportunities identified	June 2015	Policy briefs completed, please visit the resources page of the SIMLESA website. See examples at the following links (among others): Tracing the path: What happens to maize and legumes from research to farm and market in Central Mozambique? Are structured value chains possible or necessary? Some highlights from Ethiopian and Kenyan maize and legume markets Opportunities in agribusiness value chains: Incentives for sustainable intensification Connecting maize farmers with value chains boosts sustainable agricultural intensification in Kenya
1.2.3	Update the analysis of opportunities and constraints for output market and agribusiness development	Report on (gender-specific) output markets constraints and (agribusiness) developmental opportunities for maize, legumes and fodder	June 2015	**Achievements:** An analysis of gender-differentiated market access was done through many studies. Examples include: "Maize market participation among female- and male-headed households in Ethiopia," *The Journal of Development Studies*, vol. 53, no. 4, pp. 481–94, April 2017. *"Fertilizer use on individually and jointly managed crop plots in Mozambique," Journal of Gender, Agriculture and Food Security (Agri-Gender)*, 1.302-2016-4762, pp. 62–83, 2015. *"Agricultural innovations and food security in Malawi: Gender dynamics, institutions and market implications," Technol Forecast Soc.*, vol. 103, pp. 240–248. Does gender matter in the maize and legume value chains or in agricultural innovation platforms in Tanzania? What are the prospects for youth in the agricultural sector of Tanzania? A CIMMYT Report
1.2.4	Determine local, national and regional institutional/agribusiness constraints (incl. policy) in the delivery and uptake of CA-based intensification options (by different farm types and farming systems)	Documentation of institutional/agribusiness constraints to the delivery and uptake of CA-based intensification options	June 2015	A policy brief from Objective 1 was among 6 other policy briefs presented at a regional high-level policy forum October 27–28, 2015, The institutional basis for scaling up summarised in the following brief Sustainable agricultural intensification in eastern and southern Africa: evidence, lessons and imperatives for scaling up and out

	Activity	Outputs/milestones	Completion date	Comments
1.2.5	Testing of alternative value chain interventions for developing a competitive and efficient market system	Alternative input and output delivery options identified and a report produced and shared with program members and other stakeholders	Oct 2015	The value chain interventions needed for CASI are summarised in the following reports. Tracing the path: What happens to maize and legumes from research to farm and market in Central Mozambique? Are structured value chains possible or necessary? Some highlights from Ethiopian and Kenyan maize and legume markets Opportunities in agribusiness value chains: Incentives for sustainable intensification Please refer to the policy briefs page on the SIMLESA website for more articles like this.
1.3.1	Assess farmers' attitude towards risks and perception of risk sources and risk management strategies under different farm household types, resource condition (e.g., farm size) and agro-ecology	Survey instruments to collect data on risk perception and risk management strategies and carry out risk experiment surveys to elicit risk attitude. Country synthesis report on farmers' risk attitude and perception of risk sources and risk management strategies under different risk attitude behaviours produced and shared with stakeholders	Dec 2015	A number of publications touched on risk issues in SIMLESA. These are typified as follows Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics *Clim Risk Manag.*, vol. 16, pp. 208–221, 2017.
1.3.2	Estimate cost of risk and its impact on welfare and the contribution of variability (variance) and downside risk to the cost of risk under different CA-based SI technologies adoption and agro-ecology	Two papers documenting risk implications of CA-based SI investment options and contribution of downside risk and variance produced and discussed with stakeholders	Feb 2016 June 2017	**Achievements** Empirical results published in 2015 (in collaboration with Adoption Pathways Project) showing that by engaging a composite of SI technologies, there is 30–40% risk reduction in production, particularly in Malawi Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics *Clim Risk Manag.*, vol. 16, pp. 208–221, 2017. Production risks and food security under alternative technology choices in malawi: application of a multinomial endogenous switching regression. J. Agric. Econ., vol. 66, no. 3, pp. 640–659, 2015. A report was done on Ethiopia producing results consistent with Malawi ones. Does crop diversification reduce the downside risk of external maize yield-enhancing technology? Evidence from Ethiopia, A CIMMYT Report
1.3.3	Quantify productivity and the risks trade-offs farmers face under different risk attitude, exposure and sensitivity regimes including CA-based SI technologies adoption	Productivity and risk trade-offs farmers face under different risk attitude classes and CA-based SI technologies that adoption estimated	Oct 2017	No analysis was undertaken on trade-off analysis

	Activity	Outputs/milestones	Completion date	Comments
1.3.4	Estimate the relationship between farmers' perception of risk sources and attitude towards risks against farm and farmer's socio-economic characteristics and the cost of risk and risk attitude on technology adoption	Work on factors influencing risk perception and attitude to risk and associated costs	July 2015	**Achievements** Most of this work focused on Malawi as shown under 1.3.4
1.4.1	Exploration and refining of opportunities for investment in maize, legume and forage value chains through a better understanding of climate and market risks i) Two participatory modeling workshops at SIMLESA sites identifying opportunities for the on-farm demonstration of profitability and risk-reducing CA-based intensification opportunities ii) Risk analysis and investment options discussed at farmer group and public-private partnership meetings.	Risk implications of CA-based investment options quantified and discussed with stakeholders	2014–2018, updated annually	**Achievements** Two participatory modeling workshops were done in Malawi and Mozambique **Evidence**: A participatory modelling workshop was also run by John Dimes in Malawi in collaboration with Donwell Kamalongo and the Malawi research and extension team. A participatory modelling workshop was run by John Dimes in Ethiopia's Central Rift Valley in collaboration with Solomon Hassen (QAAFI Ph.D. student) and EIAR extension and research staff.
1.4.2	Adjusting structural typology of SIMLESA I to a functional typology based on adoption constraints of CA-based intensification options for different farm household types (incl risk profiles) and farm systems, building on additional survey data and interviews with identified representative case study households (i.e., the output from SIMLESA I),	A typology of farm households developed and validated Matched CA-based intensification options with identified farm typologies for potential out-scaling	June 2015	**Achievements:** Farm-household typologies were largely completed in SIMLESA Phase I. A book describing these typologies was published as an ACIAR Monograph. https://www.aciar.gov.au/publication/household-diversity
1.4.3	Quantify the benefits and trade-offs of alternative CA-based intensification options for different farm household types (incl. risk profiles) and farm systems	Report on benefits and trade-offs of alternative CA-based intensification options for different farm household types	Dec 2015	**Achievements**: Two papers were submitted to the Farming Systems Design Conference that took place in Montpellier, France, September 2015. A third paper using input from SIMLESA was published in PNAS in 2015. **Evidence** [D. Rodriguez, A. Bekele, P. deVoil, M. Herrero, M. Kassie, B. Power, M. Rufino, and M.T. van Wijk. (2015) "Pathways for the sustainable development of agriculture: Simple rules to inform best-fit interventions," Available: http://fsd5.european-agronomy.org D. Rodriguez, P. deVoil, M. Herrero, M. Kassie, M. Odendos, B. Power, M. Rufino, and M.T. van Wijk. "To mulch or to munch?. Modelling the benefits and trade-offs in the use of crop residues in Kenya," Available: http://fsd5.european-agronomy.org R. Frelat, S. Lopez-Ridaura, K. Giller, M. Herrero, S. Douxchamps, A. Djurfeldt, O. Erenstein, B. Henderson, M. Kassie, B. Paul, C. Rigolot, R. Ritzema, D. Rodriguez, P. van Asten, M.T. van Wijk. (2015). "Drivers of household food availability in sub-Saharan Africa based on big data from small farms," PNAS. Available: www.pnas.org/cgi/doi/10.1073/pnas.1518384112]

	Activity	Outputs/milestones	Completion date	Comments
1.5.1	Identification and refining of recommendation domains (including 15 maize–legume-forage/fodder production systems) for scaling out of CA-based intensification options, through spatially-explicit analyses of similar systems (based on agro-ecological, demographic, economic and institutional conditions). Building on on-farm experiments and soil health research	Recommendation domains for scaling out of CA-based intensification options.	2015, refined annually	**Achievements:** Recommendation domains available for Ethiopia, Kenya and Malawi in collaboration with sister projects and published in *Environmental Management* "Identifying potential recommendation domains for conservation agriculture in Ethiopia, Kenya, and Malawi," *Environ Managet*, vol. 55, pp. 330–346, 2015.
1.5.2	Adoption and impact assessments to refine impact pathways and facilitate learning, priority setting processes for 15 maize–legume forage/fodder production systems in partnership with the Adoption Pathways Project	Report on annual Early Adoption monitoring survey Documented best-fit adoption and impact pathways		**Achievements:** Adoption Monitoring surveys were completed in 2013 and 2016 showing trends in the adoption of technologies *(Appendix 3a in Annual report for 2017).* A final comprehensive adoption monitoring survey was conducted and is now available. It shows that about 484,000 farmers had adopted at least two components of CASI as a result of the project across the 7 project countries. See Appendix 1 in this report

Objective 2: To test and adapt productive, CA-based intensification options for sustainable smallholder maize–legume production systems.

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1.1	Annual on-farm exploratory trials to verify co-identified promising CA-based intensification options in terms of productivity, yield stability/risk, profitability and sustainability (excl. variety evaluation. see 2.1.2) at least 3 sites per SIMLESA country testing at least 3 refined options every year	Validated CA-based intensification options under smallholder farmer conditions.	2011–2018, findings reported annually	**Achievements:** The CA options included minimum soil disturbance, use of herbicide for weed control, water harvesting through ripping under intercropping of maize and common beans and use of fertilisers which has enabled farmers to enjoy labour savings and improved crop yields. **Evidence:** Refer to the embedded PowerPoint Presentation (Objective 2 Project Summary), complimented by this publication addressing yield stability across environments was produced (Nyagumbo et al., 2015).
2.1.2	Annual on-farm participatory evaluation trials of released improved maize, legume and forage/fodder varieties under CA practices to identify the most suitable varieties with male and female farmers with at least 3 sites per SIMLESA country testing at least 3 refined options every year	Improved maize, legume and forage/fodder varieties suitable for CA-based practices identified.	2011–2018, findings reported annually	**Achievements**: SIMLESA-2 ILRI provided a menu of forage options to farmers (integration in cropping niche/species 14 spp) Grasses: Rhodes, Desho, Oats, *Brachiaria*, Napier Legumes: Desmodium, Lab lab, Vicia, Mucuna, Cowpea, Lupines, pigeon pea, Sesbania, leucanea A total of 268 and 378 maize and legume on-farm Participatory Variety Selection (PVS) were assessed where the best performing maize and legume varieties that met famers' preferences were identified for scaling. **Evidence:** The attached PowerPoint Presentation below gives evidence.

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1.3	Annual adaptive on-farm experiments with CA-based intensification options to: (1) smart-sequence options and; (2) integrate options at farm level. This is done for different farm types in different agro-ecological conditions with at least 2 farm types for 5 main farming systems in ESA, and at least one refined set per SIMLESA country every year.	Validated strategies to smart-sequence and integrate CA-based intensification options for different farm types and agro-ecologies	2014–2018 findings reported annually	**Achievement:** Smart sequencing of technologies during SIMLESA 1 was done in 2012. Mechanised CA systems involving ripping techniques enabled timely planting and in some cases translated to improved yields (Nyagumbo, et al., 2017) **Evidence**: Shown in the reports below.
2.2.1	Annual continuation of on-station long-term trials under conditions representative of the agro-ecologies to monitor the medium to long-term productivity, yield stability/risk and soil health dynamics of CA-based intensification practices, including effects on disease, pest and weed dynamics.	Precise data on the effects of CA-based intensification practices focusing on crop productivity, water and soil health dynamics	2014–2018 repeated annually	**Achievements:** Long-term trials continued and were reorganised in some countries. In Mozambique, new long-term experiments addressing challenges with termites on soil cover provision were initiated while new initiatives on weed management were tested. Results from the long-term experiments generally confirm on-farm findings on the improved yields under maize–legume rotation systems. The benefits of CA in terms of moisture conservation and consequently water productivity are apparent in most of the studies conducted in the five countries. **Evidence:** A publication on rotating pigeon pea in maize pigeon intercropping [32] Yield stability analysis for lowlands in Malawi [33]
2.2.2	Annual on-station evaluation of maize/legume varieties for CA-based intensification (released varieties only)	Suitable varieties for CA-base systems identified	2014–2018 repeated annually	**Achievements:** 20 varieties were tested in Chitala in which some were under CA and conventional tillage. More than 22,000 tonnes of suitable varieties of maize and legumes have been identified for CA-based systems for each of the participating countries. These have been channelled through 45 seed companies New varieties of on-station trials were established in Mozambique and Malawi to address diseases and pests in CA during the reporting period. **Evidence**: Refer to embedded document on Activity 2.1.1
2.2.3	Understanding soil responsiveness (incl. micronutrient deficiencies) in SIMLESA sites through annually refined fertiliser trials and participatory mapping of with farmers.	Responsive and non-responsive sites/soils properties characterised and their respective areas in SIMLESA sites assessed. Priorities for responsive vs non-responsive activities determined. Rehabilitation options and phased CA implementation for non-responsive soils identified.	2014–2018 repeated annually	**Achievements**: This activity was pursued in Kilosa trial in Tanzania and was deemed non-responsive. A database on maize response to micronutrients in SSA was assembled by CIAT **Evidence**: Refer to embedded document on Activity 2.1.1

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.2.4	Developing and refining nitrogen application options under CA practices	Nitrogen response and management strategies for CA-based intensification of responsive soils identified	2014–2018 repeated annually	**Achievements**: Work was done in both SIMLESA I &II to obtain an understanding of nitrogen response and CA management strategies, with input from CIAT soils specialists. The focus of this activity was on 6 selected on-station replicated trials in Kenya and Tanzania. Other work was conducted on demand from partners, for example in relay-cropping in Mozambique. Preliminary agronomic efficiency (AE) results showed better response to added N in CA plots compared with CT systems that farmers use at both Kakamega in western Kenya and Kilosa in eastern Tanzania **Evidence**: Refer to embedded document on Activity 2.1.1
2.2.5	Testing and refining the value of existing seasonal climate forecasting (risk) tools for Sub Saharan Africa	A report on the value of existing seasonal climate forecasting tools and native knowledge available across all five SIMLESA countries, and identification of how this information could be used to inform practice change across SIMLESA activities.	2015–2018, adjusted annually	**Achievements:** These activities are aligned with Australian activities 2.2.7 and 2.2.8 for the benefit of both African and Australian farmers. **Evidence:** One publication (Nyagumbo et al., 2017) based on modelling CA in six locations in Southern Africa. Season onset analysis suggested progressive delays in the season start in Malawi of 0.4 days per year over the last 30 years thereby confirming climate change-associated season onset delays. These delays were not evident in Mozambique (Nyagumbo, et al., 2017).
2.2.6	Developing and refining site-specific crop nutrient management tools under conservation practices	Development, calibration and validation of simple site-specific crop nutrient management tools for farmers and extension officers e.g., leaf color charts for maize (as developed by IPNI for rice: Witt et al., 2005), in collaboration with farmers Objective 2 and 3	2015–2018, adjusted annually	**Achievements:** Additional funds have been secured from the MAIZE CRP through a QAAFI-CIMMYT collaboration to develop a modelling approach capable of identifying the crop management and phenotype required to exploit the prolificacy characteristic across a fertility and environment gradient in selected SIMLESA countries. The collaboration was established with IIAM-Mozambique and CMMYT-Harare) for trial sites and data sharing to develop simple N tools for smallholder maize farmers

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.2.7	Developing and refining more sustainable and profitable intensification options in summer rainfall dominated environments of Queensland	A participatory study on the opportunities to reduce Queensland farmers' dependence on the use of nitrogen fertilisers. A communication program in collaboration with Conservation Farmers Inc. (www.cfi.org.au) reaching more than 300 farmers from Northern New South Wales and Queensland.	2015–2018, adjusted annually	**Achievements:** Legume species were evaluated for opportunistic cover or grain crops in summer and winter rotations. Three summer legume trials harvested and sites were planted under cereal. DTMA parental lines imported from CIMMYT by the SIMLESA program have been crossed to produce hybrid seed that will be evaluated in the 2016–17 season in collaboration with seed companies from Queensland. **Evidence**: Refer to embedded document on Activity 2.1.1 on work done in collaboration with QAAFI.
2.3.1	Fine-tuning the implications of the tested options through analyses of trade-offs and synergies at intra-household, farm-scale (in terms of resource allocations and seasonality) and village scale.	Detailed adoption constraints of CA-based intensification options at intra-household, farm and village scale	December 2014 and annually thereafter	**Achievements**: Adoption constraints have been identified. Analysis of yield results across Southern Africa locations in Malawi and Mozambique suggest that good agronomic practices were responsible for the largest proportion of yield increases observed in the trials, despite the significant contributions of CA to yield **Evidence**: http://simlesa.cimmyt.org/download/simlesa-annual-report-july-2016-june-2017/
2.3.2	Aligning and refining on-farm experimentation and soil health dynamics research to recommendation domains	Updated recommendation domains	2014–2018 refined annually	**Achievements**: Recommendations were updated Evidence: https://www.slideshare.net/CIMMYT/casfesa-project-results-lessons-gaps-opportunities-and-challenges-mjaleta?qid=455587a0-aa5d-43f3-8226-84e7e6cf87ba&v=&b=&from_search=3
2.3.3	Development of an interdisciplinary monitoring protocol for on-farm experiments of CA-based intensification options focusing on productivity, stability/risk, profitability and sustainability, and including some farm and household indicators.	An interdisciplinary monitoring protocol for on-farm experiments of CA-based intensification options that can be used beyond the project's lifespan.	Dec 2014, refined 2016	**Achievements**: In-country specific protocols were developed and reviewed for application in SIMLESA countries. Such protocols were reviewed annually and adjusted to accord with desirable data. Out scaling guides were developed in collaboration with objective 4. **Evidence**: http://simlesa.cimmyt.org/simlesa-in-mozambique/

Objective 3: To increase the range of maize, legume and forage varieties available to smallholders

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1.1	Prioritise available stress-tolerant maize varieties for SIMLESA sites annually	Per farming system, revisit 2–3 newly released hybrids and OPVs with potential suitability for the targeted farming system	Dec 2014 and annually until project end	**Achievement**: Completed and periodically revisited. Prioritisation of varieties has been completed for all participating countries, and have been reviewed annually as planned **Evidence**: In Tanzania, 2 hybrids TZH 538 and TAN 600 were released by SATEC and Tanseed International respectively, (SIMLESA partners). VUMILIA K1 released by SARI was recommended for scaling out by partners.
3.1.2	Potential legume species and varieties for the target environment in the program countries analysed with TL II partners annually	Per farming system, 1-2 potential legume species and 2 varieties each for the target communities identified.	Dec 2014 and annually until project end	**Achievements**: Seed plans for legume species and varieties were developed with relevant key stakeholders in 2014. SIMLESA continued to produce seed varieties which suit different environments. **Evidence**: In Tanzania, some legume varieties were bred and released i.e., Pigeon pea variety: Ilonga m 14-2, Ilonga m 14-1, Karatu 1 and Kiboko. Other promising lines in the pipeline are ICEAP series 00056, 00936 and 576-1. Cowpea variety: Raha 1 and Raha Common beans: Jesca and Lyamungu 90 Potential legumes species (cowpeas, pigeon pea, soybean, beans and groundnuts) have been identified for the target environment in each country.
3.1.3	Identify and refine best bet forage/fodder species and varieties suitable for target AEZs for use in maize–legume forage production systems	Per farming system in eastern Africa, 2–3 forage/fodder spp. identified and acquired from available sources	Dec 2014 and annually until project end	**Achievements**: ILRI developed a plan. Few best bet forage/fodder species and utilisation practices were identified in Tanzania and Ethiopia. In Ethiopia, 11 forage species (both perennials and annuals) were screened through on-farm demonstration and participatory evaluation across seven districts of the SIMLESA sites. Adaptability, productivity, multi-functionality and suitability for integration in the cropping system were used as the main criteria for selection by farmers. In Tanzania, using a similar stakeholder-driven process, different forage menus were identified for two districts. The forage options identified were subsequently scaled out to over 4800 smallholder farmers across the two countries. Identification of the best bet forage/fodder species needs to be scaled to other countries **Evidence**: Grasses included (Bracharia mulato II; Rhodes grass; Napier grass: KK1, KK2, ILRI 16837, and ILRI 16835); legumes (Desmodium, Lablab, Vicia, Mucuna, Cowpea) and intercrops (KK1/Vicia vilosa; KK2/Desmodium; Bracharia/Desmodium; ILRI16835/Vivia vilosa; ILRI 16837/Desmodium; Bracharia/ Lablab; KK2/Desmodium).
3.1.4	Increase farmer access to promising but underinvested material (improved maize, grain legume and forage/fodder species and varieties), through seed increase at a relevant stage of seed production pipeline.	Seeds for promising but underinvested maize, grain legume and forage varieties increased annually to meet country demands.	Annual (June 2014–June 2017)	**Achievements:** This milestone was met and continued to be delivered annually. **Evidence**: SIMLESA annual reports http://simlesa.cimmyt.org/?s=Annual+report
3.1.5	Identify, tackle and refine seed availability bottlenecks of improved maize, legume forage/fodder varieties (from sister projects such as DTMA and TL-II), including seed systems and agribusiness support and Improved seed distribution road maps in each of the 5 countries.	Farmer (m/f) access to improved maize, legume and forage/fodder varieties	2014–2017	**Achievements**: Male and female farmer's access to improved maize, legume and forage/fodder varieties improved. **Evidence**: SIMLESA annual reports http://simlesa.cimmyt.org/?s=Annual+report

Objective 4: To support the development of local and regional innovations systems and scaling out modalities

no.	Activity	outputs/ milestones	completion date	Comments
4.1.1	Formulation and advocacy of policy options to address institutional constraints for CA-based intensification options	Policy brief(s) and other advocacy materials on institutional constraints for CA-based intensification. Policy workshops	March 2016 June 2015; Dec 2016	**Achievements**: Policy briefs were used to influence action on CA-based intensification options. A total of 6 policy briefs were produced over the period that SIMLESA was implemented. **Evidence**: http://simlesa.cimmyt.org/?s=policy+brief *i).* M. Misiko, M. Waithaka, and M. Kyotalimwe, (2015). People Power: Harnessing social capital for farmer empowerment. Policy Brief, ASARECA, Entebbe, Uganda. *ii).* M. Waithaka, M. Kyotalimwe, and M. Misiko, (2015). Seeds of Hope: Unlocking legume seed production in Africa. Policy Brief. ASARECA, Entebbe, Uganda. *iii).* M. Misiko, P. Mundy and P. Ericksen. (2013). Innovation platforms to support natural resource management (https://www.g-fras.org/images/globalgoodpractice/note1/Innovation_platfrom_Brief11.pdf) *iv).* "Institutionalizing SIMLESA in ESA: Lessons from on-farm research and scaling in development," in SIMLESA Arusha Conf., 2017. *v).* "Promoting Gender and Youth Inclusiveness through AIPs: Voices from SIMLESA," in SIMLESA Arusha Conf., 2017. *vi).* "Seeding impact by extending CA-based portfolios," in SIMLESA Arusha Conf., 2017.
4.1.2	Evaluation of different organisational models (incl. IPs) for scaling out CA-based intensification options in terms of reach, farmer use and sustainability	Institutional/organisational models (incl. policy options) for scaling out of CA-based intensification options identified and evaluated on potential. Reports on the benefits of SI generated by AIPs, and gender equity are done for Mozambique, Rwanda and Tanzania. The report for the benefits of SI generated by AIPs, and gender equity for Kenya is in progress and will be done before the end of the first quarter of 2018. One article focusing on gender and equitable benefits sharing mechanisms through AIPs in Rwanda has already been submitted to an internationally peer-reviewed journal. Another manuscript of AIPs and gender equity in Mozambique is	Dec 2016	**Achievements**: Organisational models for scaling were developed in consultation with the program partners. The five key approaches were: Agricultural Innovation Platforms; Extension (public, private, business-led); Participatory techniques (including use of demonstrations and trials, field days, exchange visits); Public–Private Partnerships (business models, such as service provision, use of ICT); and through Policy (as mentioned in 4.1.1) Studies of assessment of benefits of SI generated by AIPs were carried out with a focus on gender equity, done in Kenya (2016/2017), Mozambique (2016), Tanzania (2016/2017) and Rwanda (2015/2016). Data were collected from members of the AIPs (farmers), traders within the AIPs, leaders within the AIPs (president, vice president, secretary, treasurer) for four countries. Three reports were generated looking at the benefits of SI generated by AIPs, illustrating gender equity for three countries, Mozambique, Rwanda and Tanzania. An article focusing on Mozambique data was submitted to an internationally peer-reviewed journal at the end of 2017. **Evidence:** journal articles, and more https://www.routledge.com/Innovation-Platforms-for-Agricultural-Development-Evaluating-the-mature/Dror-Cadilhon-Schut-Misiko-Maheshwari/p/book/9781138181717 https://www.tandfonline.com/doi/full/10.1080/15575330.2018.1496465 https://www.researchgate.net/publication/332037380_Agricultural_Innovation_Platforms_Collective_action_catalyzes_sustainable_intensification_transformation_in_Rwanda https://www.cambridge.org/core/services/aop-cambridge-core/content/view/30D620BE7600744D0C175253A73FE05E/S0014479716000752a.pdf/div-class-title-do-mature-innovation-platforms-make-a-difference-in-agricultural-research-for-development-a-meta-analysis-of-case-studies-div.pdf https://www.cimmyt.org/simlesa-embraces-innovation-platforms-and-partnerships-in-mozambique/ See also https://www.cimmyt.org/multimedia/video-how-gender-equity-and-social-inclusion-are-improving-the-lives-of-rural-families-in-africa/

no.	Activity	outputs/ milestones	completion date	Comments
		already at an advanced stage and will be submitted to an internationally peer-reviewed journal before the close of 2017. Also, the two manuscripts for AIPs, SI and gender equity in Tanzania and Kenya, will be completed before the end of the first quarter of 2018.		https://books.google.co.ke/books?hl=en&lr=&id=CfMsDgAAQBAJ&oi=fnd&pg=PR3&ots=vFtSs8lZr5&sig=UogVwMJWL7EjGzXX3VqdHZybzPg&redir_esc=y#v=onepage&q&f=false https://www.g-fras.org/images/globalgoodpractice/note1/Innovation_platfrom_Brief11.pdf M. Misiko, F.U. Ngesa., C.P. Msuya., K.W. Chaula., G. Mburathi., M.M. Kavoi., B.A Beshir., A. Micheni., E. Zerfu., C.J.F. Jorge., J.E. Sariah., G.T. Munthali., D.J.B. Dias. and M. Rukuni. . *Scaling Strategy for Agricultural Sustainable Intensification: African Smallholder Context.* 1st Edition. CIMMYT and ACIAR. El Batan, Mexico, 2019. A Consolidated Report on AIPs in all the SIMLESA countries (including spillovers) was produced. Refer to the attached document below.
4.2.1.	Establish new or strengthen and refine strategic (public-private) partnerships to facilitate the uptake of CA-based intensification options (incl. forward and backward value chain linkages and interventions)	Identified stakeholders for value chain-based scaling-out strategies of CA-based intensification options. At least one new and/or strengthened strategic partnership with public and private institutions.	2015-2018	Different pathways for scaling out were taking a strategic approach to identify service providers and other commercial partners. (see 4.1.2)
4.2.2	Develop, refine and/or upgrade commercially viable (unsubsidised) business models to deliver CA-based intensification options to smallholders (e.g., herbicides)	Strengthened viable service providers of CA-based intensification options.	2017–2018	**Achievements**: Commercially viable business models were explored and tested, taking account of differing constraints in the partner countries. Strategies to build commercially viable business models in Tanzania initiated in May 2015 included rural startups for service provision. Their main service included inputs, including herbicides buying and application. The first steps were to understand capacity constraints, and then carry out targeted training to enhance the orientation of AIP actors, who then took on-board new business-based roles. Non-governmental organisations (NGOs), the private sector and key actors in scaling were involved. This work was based on lessons drawn from three workshops on the mentoring capacity for AIP actors, that were financed through an ACIAR-funded SRA in Rwanda.

no.	Activity	outputs/ milestones	completion date	Comments
4.3.1	Annual competitive and commissioned grants to bring in new partners to scale-out CA-based intensification options in each of the SIMLESA countries (grants protocol includes a commitment to data collection for comparative research into scaling out models)	CA-based intensification options scaled-out by new partners.	2016–2018	**Achievements**: The competitive grants scheme for scaling out was developed in consultation with ACIAR. Twelve partners were competitively selected in 2016, while seven were commissioned in Ethiopia. Ethiopia – 7 zonal extension offices Kenya – a university, seed company. Media and church organisation. Malawi – a farmer organisation. and a radio-focused company Mozambique – a business-focused NGO, farmer organisation an ICT-focused college. Tanzania – an extension services, NGO, a seed company and a farmer org/ network of farmer groups Over 4 million men and women-headed households were verifiably reached by the end of 2018. This was against a target of 2.9 million farmers. **Evidence**: http://www.mari-odu.org/academics/2017s_adaptation/workspace/uploads/food%20security.pdf
4.4.1	Develop SMS-based tools for site-specific decision support to deliver: (1) Simple heuristics for crop management and other information at key times during the year to registered mobile users (service includes information from global seasonal climate forecasts, and in-crop nitrogen management tools). (2) Technical, social networking (e.g., information on field days, trials, farmer to farmer exchanges (m/f), etc.), and market information to farmers, extension	SMS services established in at least three SIMLESA countries	2016	**Achievement**: Tanzania, Kenya, and Mozambique were identified as high potential countries for SMS services. National teams for local management of message content and delivery were formed in conjunction with local CGS partners. System upgrades were facilitated by QAAFI partners based on national team feedback. Subscriber numbers were increased by more than 100% in both Tanzania and Mozambique. 2466 messages were sent in June 2017. Strategic partnerships were entered with CGS partners in Malawi and Ethiopia to share SIMLESA messages through local automated voice and message services. **Evidence**: SIMLESA annual reports https://simlesa.cimmyt.org/wp-content/uploads/SIMLESA-Annual-Report-July-2016-to-June-2017.pdf

no.	Activity	outputs/ milestones	completion date	Comments
	officers and other participants in the maize–legume value chain.			
4.4.2	Development of gender-sensitive, user-friendly leaflets (visuals, local language) on specific CA-based intensification practices, for farmers, agronomists and agribusinesses	Developed simple and attractive leaflets for different stakeholders in the uptake and out-scaling of CA-based intensification.	2017	**Achievements:** Two sets of CASI leaflets developed and tested under other CIMMYT Projects (CCAFS) were used; over 100,000 copies were circulated in Kenya and Tanzania. Project partners were consulted for development to further disseminate information in these leaflets that contained specific information on CA-based intensification practices with a focus on climate change. **Evidence**: SIMLESA annual reports http://simlesa.cimmyt.org/?s=Annual+report https://simlesa.cimmyt.org/wp-content/uploads/SIMLESA-Annual-Report-July-2016-to-June-2017.pdf
4.4.3	Cross-participation in annual research workshops between program members and other programs (other Australian food security initiatives) and effective working relations will be strengthened with 6 other related projects	Shared understanding of regional research challenges and products; sharing of innovative agronomy, breeding and socio-economic research methods and maize–legume system products	Cross participation in all the years	**Achievements**: Communication within SIMLESA was fostered through regular meetings and workshops, including the annual meeting for all program participants (most recently Arusha, June 2017) Full advantage was taken during other events, for instance, the Beating Famine Conference in Malawi (published in https://books.google.co.ke/books?hl=en&lr=&id=CfMsDgAAQBAJ&oi=fnd&pg=PR3&ots=vFtSs8lZr5&sig=UogVwMJWL7EjGzXX3VqdHZybzPg&redir_esc=y#v=onepage&q&f=false), in April 2015, and the DTMAS Project meeting in Ethiopia in 2016. **Evidence**: Shown in the report below.
4.4.4	Annual exchange visits of farmers (m/f) and extension agents between different sites to discuss experiences with CA-based intensification practices	Farmer-to-farmer networking and knowledge exchange facilitated. At least one farmer study visit will take place in each country per year (gender-sensitive selection of participants)	2014-2018 annual activity	**Achievements**: Annual exchange visits were organised in all countries. Vital lessons include the need to strengthen collaboration with other projects in sustaining this approach. In Tanzania, annual exchange visits took place annually, especially through coordination with the government-supported annual *Nane Nane* events. Nane Nane is an annual farmers day that is organised all over Tanzania for a week. SIMLESA has facilitated more than 104 exchange visits in Tanzania. **Evidence**: SIMLESA annual reports http://simlesa.cimmyt.org/?s=Annual+report https://simlesa.cimmyt.org/wp-content/uploads/SIMLESA-Annual-Report-July-2016-to-June-2017.pdf

Objective 5: Capacity building to increase the efficiency of agricultural research today and in future modalities.

No.	Activity	Outputs/ Milestones	Completion date	Comments
5.1.1	Technical training on: (1) CA-based intensification in smallholder agriculture; (2) farm and household typologies and system analysis (incl. risk profile and interdisciplinary farming systems analysis); (3) recommendation domains (including GIS skills); (4) biomass management including fodder/forages in CA-based intensification; (5) soil quality in CA-based intensification; (6) value chain analysis; (7) adoption, risk and impact analysis; and (8) emerging topics. Supported by onsite/on the job training.	Socioeconomic, agronomic research skills of program partners in the national and regional programs enhanced Systems agronomy research skills of program partners in the national and regional programs enhanced. Interdisciplinary research	June 2015, follow-up June 2017	**Achievements**: 65 students have been trained in SIMLESA (Phases I and II); 42 M.Sc. level, and 23 PhDs. Technical training is being provided in socio-economic research and in systems agronomy. Farmer trainings continued to increase efficiency at the farm level. **Evidence**: Shown in the Capacity Building Report.
5.1.2	Free online training courses on: Experimental design, basic statistics and use of R (free statistics software) Soil and weather monitoring	Experimental design and basic statistics using R free course available online Soil and weather monitoring free course available online	July 2015 and follow up support to June 2018	**Achievements**: Online courses in experimental design and statistics are being developed. All SIMLESA Countries were informed about the online training in the first year of SIMLESA 2.
5.2.1	Trainings on gender mainstreaming, supported by onsite/on the job training	Trained relevant NARS and extension staff	2015–2016	**Achievements**: SIMLESA promoted the role of women in the implementation and decision-making structures of SIMLESA. 5th International Gender Summit Africa took place in February 2015. Gender Mainstreaming and Planning Workshop was held in Pretoria, South Africa, in August 2015. **Evidence**: Shown in the reports below.
5.3.1	Seed producers training courses	In-country and regional training course involving at least 10 seed company/producer participants	Dec 2015, repeated every two years per country	**Achievements**: In-country and regional training was done for seed systems, facilitated through Objective 3.
5.4.1	Management training for NARES staff in SIMLESA (incl. 'soft-skills', leadership and team building, M&E, administration and prioritisation).	Trained managers from NARS	Dec 2014	**Achievements**: ARC South Africa participated in this activity to provide management training for SIMLESA country coordinators and CIMMYT management staff. **Evidence**: Shown in the report below.
5.5.1	Annual extension capacity building based on country-specific training needs and short courses	Identified training needs, and provided relevant training	2015-2018	**Achievements**: Country-specific training needs have been identified and short courses were done in 2016/17 at the country level. In Tanzania, ARC conducted short course training on Statistical Guidelines and Statistical Consultation at Moshi Cooperative University (MoCU), on 13–17 February 2017. 18 researchers (10 M and 8 F) were trained. Each participant was able to analyse his/her data from the SIMLESA on-station and on-farm trials

The following which covers the SIMLESA one-year extension, are organised as outputs, with numbering starting from 4.5 following the last output 4.4 that was provided in the tables above.

Output 4.5: Strengthened, activated and documented principal scaling pathways and modalities for SIMLESA CASI technologies in each of 7 countries (scaling)

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Output 4.5	***Strengthened, activated and documented principal scaling pathways and modalities for SIMLESA CASI technologies in each of 7 countries (scaling out)***			
Activity 4.5.1	Complete final year of scaling modalities, through: (1) the Competitive Grant Scheme (CGS) (2) NARS led activities	*Report on scaling progress/achievements incl opportunities & learnings submitted to ACIAR* i) Field monitoring completed for the 2018 season ii) Field documentation of scaling complete	i) Actual scaling ended among 11 out of 12 CGS partners late in 2018 ii) Egerton Uni. Management extended SIMLESA activities one extra season i.e., into 2019 for their own further documentation, and because of success during the main CGS period iii) All documentation for these 12 partners is complete iv) Seven commissioned National Extension Bureau Offices in Ethiopia have in 2019 completed scaling activities v) NARS, and other scaling partners have wrapped up scaling activities in pre-CGS sites. However, certain activities have been handed over to partners	These have been wrapped up. However, scaling research for further lessons is recommended. For instance, a focus on extended ownership of CASI portfolios by CGS partners. Further understanding of long-term institutional benefits from CGS initiative, and SIMLESA scaling, in general, is desirable. Refer to the paper below.
Activity 4.5.2	Document and analyse the results of scaling under the CGS, and in SIMLESA I and II	*Journal paper: Adaptive scaling through competitive grants* i) Writing: abstract submitted in April 2018 ii) Paper submitted: advance format available	i) Scaling through competitive grants: PART submitted to AGSY	Paper has been redone for World Development (2020)

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Activity 4.5.3	Compare various scaling modalities (1) pathways used by partners in the CGS (2) Agr. Innovation Platforms (AIP) (3) SIMLESA scaling pathways since 2010, including mass media, extension, business approaches.	*Journal papers: A comparative analysis of scaling approaches* *Adaptive scaling through competitive grants* *AIP and rural agricultural sustainability* Prioritise and complete pending scaling activities under NARS incl. AIP, backstopping CGS Final data collection for AIP paper complete SIMLESA scaling story / video Full CGS partner reports Synthesis writeshop: Arusha Tz Scaling synthesis writeshop background materials written Paper fully written and submitted	ii) Scaling through competitive grants – PART II to be submitted to AGSY – being edited iii) AIP and agricultural sustainability: being drafted iv) Scaling under NARS completed as explained above v) Final data collection recently done. Being analysed, integrated to complete the paper "Scaling through competitive grants – PART II" above vi) SIMLESA scaling story being completed – key persons interviewed, key SIMLESA statistics utilised, etc. vii) All CGS partner reports completed, except Ethiopia commissioned work viii) Scaling synthesis write-shop held. Report available	A further TV programme on CASI (SIMLESA) ran on the largest Kenyan agricultural TV programme *Shamba* Shape UP (SSU). SSU is developed by The Mediae Ltd., a CGS partner in Kenya. Over 2 million farmers were reached.
4.5.4	Participatory evaluation of institutional benefits of SIMLESA scaling among (1) farmer organisations (2) rural institutions (3) national partners.	*Practice brief*: institutional innovations, needs and benefits of SIMLESA scaling science *Evaluation report on institutionalisation* Participatory workshop among stakeholders, to dialogue and network Statements from high officials, regional organizations and funders - complete	Written as part of "Scaling through competitive grants – PART II", to be submitted to AGSY as stated above The evaluation report on institutionalisation is contextualised under 4.5.5 below. Full ***institutionalisation*** is a highly technical endeavour, requiring meticulous *Research & Innovation* (ReIn) Strategy. Vital lessons are harnessed from the **IISiR** Project (**ACIAR Ref.: CSE/2016/035**). Future CASI investments need to incl. institutional innovation research	**IISiR** – *Institutionalisation of Innovation Systems in Rwanda (CSE-2016-035)*. Funded by **ACIAR**, its aim was to pilot how to embed Agri. Innovation Platform (AIP) through research and innovation (ReIn). IISiR received full support from Rwandan authorities. A key outcome was the change of the legal clause to allow cooperatives to operate based on AIP principle of partnerships. The "game changer" was CIMMYT and RAB meticulous illustration of benefits of CASI through AIP.

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
4.5.5	Hand over to country partners to secure support for SIMLESA scalable products and innovations and further scaling beyond 30 June 2019	*Report to document ongoing scaling up the case in each country, including options to secure resources needed for ongoing scaling out in each country – April 2019* (i) Draft report circulated (ii) Checklist of products/ innovations (iii) Scaling strategy	*i).* Report on scaling corresponding to recent activities of: a) national policy dialogue – minor extent b) spillover activities, esp. recent major national scaling CASI sites, such as KALRO-CIMMYT trials in Embu, Machakos, Zimbabwe sites, etc. c) Major national projects inspired by SIMLESA such as ***KCSAP***, codesigned with CIMMYT (Misiko) significant input, ***KCEP*** that has SIMLESA footprint too. Several other projects in Mozambique and Ethiopia have notable input from CIMMYT Scaling expertise and NARS SIMLESA leadership *ii).* Options to secure resources needed for ongoing scaling out in each country a) Partnerships with FAO being developed for Kenya and Rwanda for major scaling initiatives b) Lessons from SIMLESA being integrated with other projects – FACASI, IISiR – and utilised for advanced scaling concepts on research and innovation for Africa *iii).* "Checklist of products/innovations" to be submitted along with final outputs listed above – under 4.5 Scaling *iv).* ***Scaling strategy*** is complete - Key sections complete with indicative adoption levels from the CGS studies (not overall adoption)	CIMMYT was in March 2019 formally requested by the Kenya government to support ***KCSAP***, a major research investment by the World Bank. Activities by CIMMYT have been modelled around SIMLESA. A funding concept was approved by the Kenyan Ministry of Agriculture and the World Bank, and is awaiting funding. If this initiative succeeds, ACIAR will be fully acknowledged, and outputs and outcomes documented as further spillover benefits of Australia Government investments.

Output 4.6: Consolidated, analysed and synthesised results of SIMLESA effectively disseminated (synthesis)

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Output 4.6	***Consolidated, analysed and synthesised results of SIMLESA effectively disseminated (synthesis)***			
Activity 4.6.1	As per country request, strengthen Data Cleaning Curation and dissemination	1) In addition to current additional data repository made operational in addition to current Dataverse.	**4.6.1 (1):** All the agronomic and socioeconomic data are now readily accessible via SIMLESA website through a user-friendly interface.	
		2) include both household socioeconomic and experimental data	**4.6.1 (2)**: For agronomy data please visit https://simlesa.cimmyt.org/resources/datasets/agronomy/ and for socio-economic data please see https://simlesa.cimmyt.org/resources/datasets/socioeconomics/ Agronomy data was further synthesised to capture seasons that had been missed out for Malawi and Mozambique. Data was uploaded to DATAVERSE in November 2018. A final of agronomic data (Jan 2020 version) was uploaded to update previous versions. The final version contains data on GPS coordinates and drainage characteristics for Southern Africa sites	
		3) Summarised data (e.g., gross margins, cash flows, market and service availability, …) with explanatory notes, ready for decision makers	**4.6.1 (3):** These summarised data for use by general public and to inform practitioners of entry points for CASI scaling are now available in **7** country reports. The numerous recently policy briefs highlight the financial returns to CASI practices • From yields to profit: Conservation farming boosts livelihoods in Malawi • Conservation farming boosts production and resilience in maize agriculture systems • Grow More with Less: Maximising yield through conservation agriculture-based sustainable intensification in Malawi • Conservation Agriculture-based Sustainable Intensification: Minimal tillage saves resources, improves yields on Ethiopian farms • Sustainable Intensification based on conservation agriculture: The business case	Copies available under resources page • Policy briefs • Synthesis Reports • Infographics The following infographic is especially useful for decision makers *Transforming farmers lives through Conservation Agriculture-Based Sustainable Intensification (CASI)* https://simlesa.cimmyt.org/wp-content/uploads/SIMLESA-Results-Summaries-min.pdf

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Activity 4.6.2	4.6.2 Synthesise and document a fine grain but synthetic picture of the results	1). Recommendation domain & targeting report: What can potentially be achieved with each scalable technology/innovation in defined domains building on the existing data and extrapolation across AEZ? (based on geo-referencing/modelling).	**For 4.6.2 (1):** a) Data preparation, PCA, cluster analysis and GLM modelling of food availability outcomes and sensitivity to sustainable intensification practices b) Established target communities with distinct food shortage risk levels based on predictors of food availability c) Identified the technologies that produced the greatest returns for each target community and assessed benefits in terms of reduction in the risk of a food deficit d) A paper entitled *Recommendation domains for conservation agriculture in Ethiopia, Kenya, and Malawi*, was published in *Environmental Management* and can be found here. It covers only Ethiopia, Kenya and Malawi. https://doi.org/10.1007/s00267-014-0386-8	a) Open source stored data and data management using shared R script b) Food shortage risk factors were used the classify households. Risk factors in Mozambique included household size, land under cultivation and rainfall characteristics. Risk factors in Ethiopia also included household size and rainfall characteristics. Five target communities were established for Ethiopia and Mozambique. **c)** The only management practice with evidence of reducing the risk of a calorie and protein deficit for high-risk households was a complex package of residue, herbicide, fertiliser, manure and improved seed.
		2). Synthesis products		
		a. Annotated bibliography of SIMLESA's scientific products and use online reference manager and academic network such as Mendeley (ready by end of September 2018)	**For 4.6.2 (2a):** Instead of reference manager (or annotated bibliography), it was decided that it is better to properly update the SIMLESA website where all the resources are listed under the resources tab. Currently there resources tabs are • Project Reports and Working Papers • Journal Articles • Policy Briefs • Farmer and Extension manuals • Presentations • Infographics and Fact Sheets • Agronomy data • Socioeconomics data • M&E Reports • Videos • Media Reports • News and Events Please visit https://simlesa.cimmyt.org/resources/ The above links are now the primary Knowledge management tool for the project	The website now provides a one-stop-shop to access data, scientific and communications publications from SIMLESA

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
		b. A paper to be led by QAAFI on "Resilience in eastern and southern Africa's farming systems" using the four-wave panel data with crop modelling	**For 4.6.2 (2b):** a) QAAFI produced a working paper titled "The need for agricultural systems approaches to the sustainable intensification of agriculture across eastern and southern Africa", by Rodriguez D, Wilkus E, de Voil P. This is in Chapter 9 in "Understanding Household Diversity In Rural Eastern and Southern Africa" ACIAR Monograph #205, published in 2019. Can be accessed on ACIAR website at https://www.aciar.gov.au/publication/household-diversity b. A manuscript entitled "Risks of household food shortage and inequitable benefits from crop-livestock intensification in eastern Africa" Manuscript can be accessed at https://www.dropbox.com/s/p2tb9ew9ohtfpy1/Wilkus_FA.docx?dl=0	a. The article concludes that: Previous ACIAR investments across the region such as the SIMLESA, Adoption Pathways, ZimCLIFS, and FACASI projects, identified that conservation agriculture-based sustainable intensification can create positive interactions between cropping and livestock activities. Crop production can generate resources that can benefit livestock production, and livestock activities, contribute to cropping activities by cycling nutrients and providing draught power for mechanisation and transport. Synergies and complementarities in integrated crop-livestock systems are also known to increase productivity and whole farm efficiencies, and provide opportunities to diversify sources of livelihoods, and reduce emission intensities.
		c. A paper by CIMMYT agronomy team on "Biophysical and management factors driving yield change in SIMLESA sites: Entry points for intensification" and "CASI impacts on the risk, resilience and sustainability of smallholder farming".	**For 4.6.2 (2c):** • The SIMLESA book chapter on CA and soil fertility entitled "*The role of conservation agriculture as the determinant of sustainable intensification in ESA*" was completed and is part of SIMLESA legacy book with ACIAR for editorial and production processing (as at the time of writing). Monograph tentatively entitled *Sustainable Intensification of Maize Legume Farming Systems for Food and Nutrition Security in Eastern and Southern Africa: The SIMLESA Legacy Book*	

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
		d. A paper led by CIMMYT socioeconomics on "The market, policy and institutional pathways to CASI impact" using mediation aware treatment effects models (ready by end of October 2018).	**For 4.6.2 (2d):** • Ongoing analysis using mediation models to understand mediators of impact based on farmer education, market access and policy support. Draft paper not ready at the time of reporting • Based on SIMLESA, publications variously cited in this report, the summary of the institutional enablers can be found in Sections 7.1.4, 7.1.5 and 9.2 of this report • These factors are also found in the following policy briefs Opportunities in agribusiness value chains: incentives for sustainable intensification. https://simlesa.cimmyt.org/wp-content/uploads/AGRIBUSINESS.pdf Achieving agricultural resilience and sustainability: the role of extension. https://simlesa.cimmyt.org/wp-content/uploads/POLICY.pdf Scale up the scaling methods: towards sustainable agricultural intensification and resilience. https://simlesa.cimmyt.org/wp-content/uploads/SCALING.pdf Research and knowledge management systems for sustainable intensification. https://simlesa.cimmyt.org/wp-content/uploads/RES-AND-KM2-1.pdf Social groups supporting the scaling of conservation agriculture-based sustainable intensification. https://simlesa.cimmyt.org/wp-content/uploads/SOCIAL.pdf	Publications can be accessed via SIMLESA website
		e. A synthesis paper led by CIMMYT gender specialist and consultant on the "The health and economic benefits of CASI adoption for women" and "Gender-sensitive CASI scaling".	**For 4.6.2 (2e):** • A video report on SIMLESA's gender work entitled ***Gender equity & social inclusion*** has been produced by CIMMYT available on the video page on the SIMLESA website.	
		f. (see under 4.5.3, scaling modalities)	**For 4.6.2 (2f)** • Scaling strategy paper completed.	Scaling strategy forwarded to ACIAR for review
		g. A synthesis paper led by ILRI synthesising forage/crop-livestock related research under SIMLESA.	**For 4.6.2 (2g)** Synthesis paper forwarded by ILRI	This will be published on the SIMLESA website once edited

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
		h. A synthesis paper led by CIAT synthesising soil-related research under SIMLESA	**For 4.6.2 (2h)** Synthesis paper, received and posted on SIMLESA website, can be accessed through the following links Conservation or Conventional Agriculture? A Soil's Perspective Several SIMLESA country policy briefs report on the positive impacts of CASI on soil quality e.g., the policy briefs in the links below (as found on SIMLESA website) highlight the beneficial effects of CASI on soil health • Soil Health is Economic Health: Conservation farming improves soil fertility and boosts incomes • Building resilience to climate change: The promise of Conservation Agriculture-based Sustainable Intensification in Tanzania • Conservation Agriculture-Based Sustainable Intensification: Minimal tillage saves resources, improves yields on Ethiopian farms •	
		i. A multidisciplinary cross-cutting synthesis report integrating all workstreams, objectives, geographies and partners (incl CIMMYT, QAAFI, ILRI, CIAT, NARIs partners)	**For 4.6.2 (2i)** • An ACIAR monograph entitled, "Sustainable Intensification of Maize–Legume Farming Systems for Food and Nutrition Security in Eastern and Southern Africa" edited by Erin Wilkus, Mulugetta Mekuria, Daniel Rodriguez and John Dixon was completed and proposed to ACIAR for publication as an ACIAR monograph. • The monograph is composed of 29 Chapters with a total of 95 contributing authors representing all the SIMLESA countries and partners.	a. The manuscript concluded that existing sustainable intensification options provide low returns to high–risk communities relative to other target populations. Development programs need to provide sufficient, feasible options that support the competitiveness of at-risk households in the market, to achieve equitable benefits from sustainable intensification practices under these conditions. b. At the time of this report, the book is with ACIAR for editing and production
		3) Report on risk analysis/trade-offs of sustainable agricultural intensification (SAI)	**For 4.6.2 (3)** • A working analysing how to reduce downside risk in maize yield in Ethiopia is now published on the website. The key finding is the risk-reducing nature if maize legume crop sequences can help crowd in complementary input use. It also minimises the chance of crop failure arising from moisture stress.	The working paper can be accessed at https://simlesa.cimmyt.org/wp-content/uploads/ET-Risk-draft-paper_12April_2019.pdf
Activity 4.6.3	Update and upgrade the adoption results:	1) Consolidated and standardised key adoption indicators	• Adoption monitoring survey completed in all 7 SIMLESA countries involving more than 4,700 households	

No.	Activity	Outputs/ milestones	What has been achieved?	Comments

	Reach, Adoption, Impact	2) Report and data from adoption & benefit monitoring survey 2018: documenting robust adoption results and narrative of the various technologies, identify bottlenecks and opportunities for adoption and associated drivers and learnings	• A new draft adoption report is now completed.
			• Standardised adoption indicators summarised as follows:
			  ○ Exposure to adoption
			  ○ Adoption trends between 2010 and 2018 across project countries
			  ○ Persistence of adoption
			  ○ Adoption of various CASI combinations
			  ○ Proportion of farm area under various CASI combinations
			  ○ Impacts of technology combinations on tillage labour
			  ○ Impacts of CASI technology combinations on yield
				A final draft report is now available as Appendix 1 to this final report

		3) Updated benefits of adoption and SIMLESA: impact assessment results based on new data/assumptions. It will compare its conclusions with the 2018 ex-ante study and discuss the differences.	• Adoption indicators developed as above	Comparative analysis of adoption report and the ex-ante report have not been done. The current adoption report is a straightforward report from a household survey. The ex-ante report was a multidisciplinary exercise by ACIAR commissioned consultants, so a comparative analysis not possible due to differences in methods

Output 4.7: SIMLESA results disseminated in each program country and effective policy engagement with stakeholders accomplished through dialogue and outreach (institutionalisation)

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Output 4.7	***SIMLESA results disseminated in each program country and effective policy engagement with other stakeholders accomplished through dialogue and outreach (institutionalisation)***			
Activity 4.7.1	4.7.1 Communicate results broadly	Communication products for interested public in ESA + Australian Department of Foreign Affairs and Trade + Australian public One publication (book) with extensive illustrations and synthetic statements – not much text - aimed at the general public.	• The SIMLESA team presented 11 papers covering multiple disciplines at the 2nd African Congress on Conservation Agriculture in October 2018 in Johannesburg South Africa. • The highlight was how SIMLESA's work contributes to Continental initiatives, most notably the Pillar 1 on Sustainable Land Management of the Comprehensive Africa Agriculture program of the African Union () and the Malabo declaration #6 on resilient livelihoods (http://www.nepad.org/caadp/overview). • A report of that event can be found in a 9-minute video report on the SIMLESA website entitled "***CA-based Sustainable Intensification builds farm resilience, productivity in Africa".*** You can see the video at https://simlesa.cimmyt.org/resources/videos/. It is a good summary of SIMLESA's scientific work and how it contributes to the CAADP agenda and the Malabo declaration • SIMLESA's work was featured in several international media. Since 2018 to date, the following media houses have reported SIMLESA work. Please find these at https://simlesa.cimmyt.org/media-reports/ ◦ Thomson Reuters Foundation News ◦ All Africa ◦ Africa Business Communities ◦ Addis Standard ◦ Scidev Net ◦ The Citizen in Tanzania	All the materials are variously linked to the SIMLESA website now as a one-stop shop for all Knowledge Management products

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Activity 4.7.2	4.7.2 Stakeholder dialogue and networking and policy engagement at multiple levels (district, country, and (if necessary) regional level), using planned forums when possible including presentations to key stakeholders (e.g., government/Ministry of agriculture, extension, development partners, funders).	Report on stakeholder dialogue and networking, including statements from high officials, regional organisations and funders.	A total of 13 policy forums were completed across the 7 countries. Typically, two forums were held: One at the district level focusing on district-level extension departments and regional agriculture officials such as country governments in Kenya. These forums were extensively covered in the local press. E.g.: • **Ethiopia** Ethiopian Press Agency https://press.et/english/?p=3207# • **Kenya** The East African Standard: https://www.standardmedia.co.ke/article/2001317423/after-nyayo-and-saitoti-now-a-bean-variety-named-raila https://www.standardmedia.co.ke/article/2001317987/raila-bean-to-grace-cereal-dishes-menu The Star: https://www.the-star.co.ke/business/2019-04-03-concern-as-food-production-continues-to-drop https://www.the-star.co.ke/business/kenya/2019-04-08-poor-seeds-affecting-food-production-experts-say/ People Daily: http://www.mediamaxnetwork.co.ke/516288/alarm-over-low-food-production/ Nation TV: https://www.nation.co.ke/video/news/4146788-5034992-ojm0jz/index.html Kenya News Agency: http://www.kenyanews.go.ke/country-faces-a-decline-in-food-production/ Kenya Broadcasting Corporation: https://www.kbc.co.ke/ministry-concerned-over-decline-in-food-production/ • **Malawi** Simlesa.cimmyt.org https://simlesa.cimmyt.org/media-report-malawi-simlesa-policy-forum/ • **Mozambique** Radio Mozambique, please access *"Mozambique Policy Forum"* video (audio from Radio Mozambique Report) at https://simlesa.cimmyt.org/resources/videos/ https://www.cimmyt.org/policy-forum-in-mozambique-recommends-scaling-sustainable-agriculture-practices/ • **Tanzania** Daily News https://www.dailynews.co.tz/news/2019-03-155c8b6dafed5f4.aspx# The Citizen https://www.thecitizen.co.tz/News/Tanzania-loses-Sh222bn-yearly-to-drought/1840340-4986988-5q02q3/index.html IPP Media (Swahili) https://www.ippmedia.com/sw/biashara/naibu-waziri-aagiza-matokeo-ya-utafiti-yaandikwe-kiswahili • **Uganda** Uganda Showbiz https://www.showbizuganda.com/conservation-agriculture-based-sustainable-intensification-casi-in-agriculture-extension-will-increase-agriculture-productivity-naro/	

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Activity 4.7.3	4.7.3 Hand over to country partners to secure support for SIMLESA's scalable products and innovations and further scaling beyond 30 June 2019	Report to document ongoing scaling up the case in each country, including options to secure resources needed for ongoing scaling out in each country.	• In Mozambique, SIMLESA work will continue through a world ban-funded APPSA project • In Ethiopia in March 2018, the Minister of Agriculture confirmed commitment to CASI • In Tanzania, the deputy minister of agriculture committed to including the conclusions of the SIMLESA policy forum (in March 2018) in the national policy documents being drafted. https://www.dailynews.co.tz/news/2019-03-155c8b6dafed5f4.aspx#	Some CIMMYT scientists were requested to participate in the formulation of a new world bank project and it is hoped that some ideas from SIMLESA will be used. A funding concept has been prepared and forwarded to the Kenyan Ministry of Agriculture. Awaiting funding the decisions at the time of this report.

Output 4.8: Knowledge gaps and research questions for the next generation climate-smart farming systems identified (climate-smart research agenda)

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
Output 4.8	***Knowledge gaps and research questions for the next generation climate-smart farming systems identified (climate-smart research agenda)***			
Activity 4.8.1	Identify remaining and emerging research questions, justify the need to address them for future impact, building on SIMLESA achievements and further consultation in partner countries (including governments, development partners, other funders)	Working document and presentation: variously updated	• A Concept Note led by CIMMYT was developed in June 2018 • A report on SIMLESA's relevance to CSA was commissioned and published on the website: https://simlesa.cimmyt.org/wp-content/uploads/Climate-Smart-Agriculture-Assessment-SIMLESA-Gaps-and-Opportunities.pdf •	
Activity 4.8.2	Writing a compelling new research agenda for future investments in CSA in ESA (including Diversification; Intensification; Mechanisation; Adaptation & mitigation; Sustainability)	A compelling research agenda outlining new research questions, knowledge gaps and the case for investment, supported by concept (briefing) notes for potential funding by relevant funders including ACIAR	• A preproposal led by QAAFI was developed and sent to ACIAR for consideration in November 2018 • Pre-proposal was preceded by consultations with SIMLESA teams across the 7 countries	The proposals were not successful in terms of funding. The several key questions identified for further research are: • How to remove risk constraints for crop-livestock integration • The long-term soil effects of CA methods • Pest and disease dynamics in CA production • Economic and policy barriers to the adoption of CASI • Improvements in data and knowledge management systems for CASI

7 Key results and discussion

7.1 Key results from socio-economic, value chains and policy studies

7.1.1 Socioeconomic impacts of CASI under farmer experiences

Surveys show that CASI impacts on farmers' fields are roughly consistent with the results observed on-station or researcher-managed on-farm trials. Economic analysis using statistical methods applied to household data were used to measure the yield and crop income differences between CASI adopters and non-CASI adopters.

The economic analysis showed that the adoption of CASI significantly increased crop yields under farmers' practices by 60–75 percent. In Ethiopia, household surveys showed that the adoption of CASI practices increased the *net maize incomes* by 9–35 percent compared to yields from fields that did not employ these practices. In many cases, higher yield impacts were observed when minimum tillage and crop diversification (839 kg/ha) was applied. This suggests that the benefits from CASI are most apparent when multiple components are applied simultaneously.

7.1.2 Economic complementarities as drivers of CASI adoption

A SIMLESA study in Ethiopia, Kenya, Malawi, and Tanzania examined the evidence and nature of the complementarities between different CASI practices. Overall, the research showed that wherever organic manure was available, farmers reduced the amount of inorganic fertiliser. Fertiliser use decreased among manure users by 20% in Ethiopia, 4% in Malawi and 3% in Tanzania. While the plant nutrition aspects of manure made it a substitute for fertilisers in some cases, the resource improving the effects of minimum tillage, soil and water conservation make it more worthwhile for farmers to use fertilisers. In terms of complementarity, fertiliser use increased from 4% among those who did not implement CASI to 8% among those who implemented CASI practices [34, 14].

Complementarities among seed, fertiliser and sustainable agricultural practices mean that the adoption of single practices will not deliver the desired productivity or environmental outcomes. In principle, farmers can adopt and adapt technologies either as individual substitutes or in a multitude of complementary ways to address their overlapping constraints and opportunities. This perspective has important policy relevance. Given the heterogeneous capabilities of and incentives among farming populations, it is important to make available a wide menu of CASI options to meet the different resource capacities of farmers.

7.1.3 The effects CASI on risk

Yield instability, especially crop failure, resulting in no or lower yield is the most undesirable outcome farmers always strive to avoid. Unless supported by good agronomic practices, expenditures that farmers make on externally purchased inputs (like improved seed and fertiliser) may not guarantee better returns through higher and stable yield. Among the best agronomic practices in maize-based systems, crop diversification, i.e., intercropping of cereals with legumes and/or crop rotation are the most common ones among farmers.

Using plot and household-level survey data collected from a study [19], the contribution of crop diversification in reducing the downside risk of maize yield was assessed. The assessment was made using combinations of crop diversification with improved seed and fertiliser use in maize production. The results show that plots that received improved seed, chemical fertiliser, and any form of diversification generated 3.08t/ha of maize grain yield, on average. However, had the same plots not been treated with diversification but received improved seed and chemical fertiliser, the average yield would have reduced by 0.82t/ha. This amount is roughly attributed to crop diversification [19].

The contribution of diversification showed that farmers using crop diversification practice with these two purchased inputs are less likely to face crop failure (or lower yield) as compared to those using these two purchased inputs on plots with no crop diversification [19, 17]. Numerically, those farmers with crop diversification are willing to pay (forego) only an equivalent of 296kg per ha of maize to avoid any lower yield whereas those using the two purchased inputs on plots not treated with crop diversification are willing to pay an equivalent of 603kg/ha. Thus, on average, the perceived level of the downside risk is lower for farmers combining purchased inputs use with best agronomic practices.

In summary, the impact of CASI practices on yields and risk showed that under conventional practices, most of the yields were distributed below the average observed by the result that more than 50 percent of yields were below observed means. This suggested that a few farmers did well while many were at risk of yields that were below the community average. When CASI practices involving diversification or minimum tillage, whether individually or in combination were adopted, this significantly shifted yield distributions more to the right. This meant that the chance of below-average yields was reduced. The reduction in the chance of crop failure was higher when maize–legume diversification and minimum tillage [19] were adopted together (72 percent) than when the two practices were adopted individually (30–42 percent) [17, 19].

Other studies from SIMLESA [35, 36] on farmers reported their experience of multiple risks such as drought, floods, crop diseases and pests and price or market risks. Others include personal risks such as illness and bereavement (loss of economically active family members). The most common responses were planting drought-tolerant varieties [35] and crop diversification [36, 35, 17]. The main coping mechanism was mainly reliance on family members and relatives [36] [35]. This shows the lack of formal insurance to deal with many production and personal risks. The adoption of CASI and improved resource management can help farmers deal with some of the risks for which there is no formal risk sharing.

7.1.4 Effects of CASI on gender equality and women farmers

Social groups focused on women were important in promoting CASI adoption: The experience of a farmers' group from Liganwa Village in Siaya County, Kenya, offers insights into the benefits of CASI practices for women in particular. In 2010, an all-women's group was formed to help widows acquire micro-business capital. Members belonged to a rotating credit and savings association known as a "merry-go-round". This group was not very successful at first in raising capital. Some members were unable to pay up their contributions. In March 2010, the members joined a larger grouping (an agricultural innovation platform) sponsored by SIMLESA. Earlier, researchers from the Kenya Agricultural and Livestock Research Organisation (KALRO) had contacted local groups to participate in the project. The group's participation in the SIMLESA-sponsored platform was significant. According to the chairwoman, members had been able to earn money selling surplus maize. This enabled them to make contributions to the group. The amount of money the members could borrow rose significantly, from Kshs 1,000 (approximately US$ 10) to 3,000–5,000 (about $30–50), with a 100 percent repayment rate [23].

How to promote equitable access to CASI technologies for women:

A more targeted approach towards improving women's access to agricultural innovations is key to increasing overall agricultural productivity. A work by [15] uses gender-disaggregated household and plot-level data in SIMLESA project locations in 2018 Ethiopia to explore the gender-differentiated impacts of agronomic practices. Gender was defined by the sex of the plot manager. Only a minority of women (9%) operated plots over which they had sole ownership. Using statistical methods that controlled for social factors, local rainfall conditions, and infrastructure, the paper confirms the general conclusions from the SIMLESA project: the CASI practices had positive and significant effects on maize yields and maize income. Yields on plots managed by women were statistically the same as those managed by men and in some were nominally higher (even if the difference was not statistically significant). Additionally, the plots managed by women had yields that were statistically higher by 28–93% [15] than those plots that were jointly managed (by two or more household members such as the two spouses). Where further sub-division of land and individual titling is not feasible, equitable intra-household allocation of agricultural resources and proceeds from joint production is important. This is because joint production is likely to be the norm as agricultural land becomes scarcer. Strengthening women's bargaining power (through education and credit) and strengthening legal regimes may be required.

7.1.5 Effects of CASI on nutrition and diet diversity

In a 2016 paper [21] that looked at the role of crop diversification on household dietary diversity based on the 2010 (SIMLESA) and 2013 (Adoption Pathways) data from Ethiopia, the authors reported a statistically strong correlation between adopting maize–legume diversification (an element of CASI) and the dietary diversity; intake of calories, protein and iron; as well as reduced child stunting. Using seven-day and 24-hour consumption data, the study compared households that implemented maize-legume diversification and those that did not. The study found that maize–legume diversification improved the consumption calories, proteins and iron. Further, it improved dietary diversity and reduced the prevalence of child stunting, compared with non-adoption. As was observed for crop income impacts, the greatest impacts on nutrition were achieved in cases where the practices were jointly adopted. The results confirmed that depending on how many different crops were grown, households that adopted maize–legume diversification consumed 9.6%–13.3% more calories (depending on how many different types of crops were grown). Similarly, with maize–legume diversification (with or without better maize varieties), the consumption of protein increased by 22.4%–26.6% and that of iron by 12.0%– 28.8%. Similarly, another study [20] based on Malawi data that looked at the impact of maize–legume diversification on diet diversity concluded that diet diversity as measured by the Simpson Index (widely used to measure how diverse people's diets are) was improved by 12% for the whole household, by 17% for children under five years and by 11% for mothers.

7.2 Policies for faster adoption based on socio-economic studies

Published research from SIMLESA has indicated that the following are the micro-level drivers of household aspects of adoption which are important and should inform policies to foster adoption.

1) *Role of education:* SIMLESA research has shown that households in which the average cumulative education was higher, there was a statistically significant higher likelihood of using improved varieties and conservation tillage [14, 17, 15]. Therefore, investments in basic schooling, and making agriculture and natural resources studies part of primary and secondary education (and beyond), will have large positive payoffs in promoting sustainable agriculture.

2) *The role of social networks:* The probability of households adopting better farming practices increased as more personal relationships and participation in social networks were observed. This suggests that local

social institutions are important entry points for service providers and extension. Social networks provide opportunities for sharing information, resources, and services [37, 14, 35]. Local institutions that enable farmers to connect with their peers and other actors along value chains should be supported and encouraged by the government whenever needed. This support can take the form of training sessions, exchange visits, and coordination and facilitation of registration and formalisation.

3) *Rebalancing input use:* Promoting legume–maize rotation in conservation tillage systems reduced fertiliser use or at least kept its use constant. Conservation tillage increased pesticide application, most likely to compensate for reduced tillage. Analyses carried out by SIMLESA economists showed that that the adoption of combinations of CASI practices was associated with a number of positive outcomes when all the packages were adopted together. According to the last adoption and benefits survey, the adoption of full CASI would increase incomes from $120/ha to $329/ha compared to conventional systems of farming [29]. The impact analysis model used determined that this was the highest income achieved in any class of farmers [14]. Similar results, showing the best outcomes on combining at least three CASI practices are reported by [15] where yields were more than 70% when three practices were combined than when only two were implemented.

4) *Role of safety nets:* In econometric analyses, farmers who believed they could receive government support in the event of crop failure tended to be more likely to use improved varieties, suggesting that a fallback position afforded by government support is important in enabling farmers to try new technologies [35]. Perceived support from the government provides some assurance to farmers and, hence, an incentive to try new technologies. This means that providing safety nets can help build farmers' confidence to experiment with new equipment, varieties, and practices, especially given the considerable learning and risks (real or perceived) that can act as disincentives. Farmers may be willing to assume the risk if they know they have a reliable safety net.

5) *Importance of mainstreaming holistic CASI agronomy:* The best income-related outcomes were associated with the simultaneous adoption of CASI, the lesson being: better agronomic practices and crop varieties should be promoted as an appropriate package, rather than as single elements, to maximise impact. The portfolio approach should be used in adaptive research, extension messaging, policy support and public investments. In each case, specific packages suitable for particular locations and groups of farmers should be researched, disseminated and supported [15, 14]

7.3 Key results from agronomy and soil studies

Overall mean maize yield from the field experiments across the ESA region was 2 845 kg ha^{-1} (N=4538). Independent samples t-tests comparing CA and conventional tillage in which any system involving reduced soil disturbance and soil cover provision was simply classified as CA and all those involving maximum soil disturbance using ploughs, hoe tillage, etc. classified as conventional till were carried out initially to obtain a general overall impression of the system's performance. The corresponding yield variability reduction through the use of CA was about 11%. The margin of differences between CA and conventional till systems, however, differed from country to country with the agro-ecology, soil type and cropping system employed being key yield factors. From these on-farm experiments carried out across the ESA region, CA gave significantly and statistically higher maize yield compared to conventional till.

Yield improvements under CASI were mostly from maize–legume rotations and ranged between 20 and 50% over conventional tillage, a pattern that featured across the whole ESA region. Rotations generally increased macrofauna diversity, improved nitrogen fixation and had lower incidences of crop diseases. Rotation benefits also depended on the legume crop employed. Short-term yield gains from CASI relative to conventional cropping systems were attributable to improved moisture conservation in seasons with below 600mm rainfall while long term yield improvements were attributable to soil quality improvements over time. The use of improved agronomic practices including planting density, planting configurations, inorganic fertiliser, improved seeds, and timely weed management offered farmers the opportunity for the easiest yield gains. In Malawi and Mozambique, for example, good agronomic practices accounted for more than 60% of the yield increases over the conventional unimproved farmer practices.

Farmers who wish to switch to CASI technologies should, as a starting point, ensure that they take on investments in good agronomic practices as this is a key requirement for any improvements in productivity. Such good agronomic practices include using improved varieties, timely planting, and use of fertility amendments, weed control, and correct planting densities. Yield improvements from CASI technologies, in particular, may only accrue in the long run and would help to ensure that yield variability is minimised particularly in rainfall scarce seasons.

7.4 Key highlights from soil science

One of the major reasons that CASI practices are promising is their positive impact on ecosystem services, for example, mitigating soil loss. Maize–legume intercropping was demonstrated to increase the total nitrogen in the preceding year compared to planting only maize. CASI practices also increased water-use efficiency over time. In Mozambique and Ethiopia, the highest water-use efficiency was achieved when CASI methods were combined with maize–legume intercropping. These options further reduced soil erosion by 34–65 percent. Conservation agriculture, combined with other good agronomic management practices, is important for achieving sustainable intensification. In eastern and southern Africa where SIMLESA project focused on scaling efforts, little evidence of changes in soils due to the practice of conservation agriculture is available. While yield effects of CA are moderately studied mostly in the short-term, a good understanding of other perspectives of CA including ecosystem services such as soil water and greenhouse gases regulations, enhancement of life in soil and issues of nutrient cycling is needed. A report presenting key findings by CIAT [38] provide the following summaries:

Nitrogen conservation: CA presents a good opportunity to reduce the potential chance of nitrogen leaching through temporary nitrogen lock-up in applied residues. At the SIMLESA trials of KALRO Kakamega, mineral-N in soil was higher by 58–72% in CT than in CA all through from planting on time to the late season even though both treatments had a similar nitrogen application rate of 75 kg N ha^{-1}. The nitrogen locked up in CA essentially subverts leaching and the nitrogen is subsequently released to support the crop nutrient demand later on.

Soil temperature moderation: Practicing CA has no effect on average, but moderates fluctuations of minimum and maximum soil temperature relative to CT system. Minimum and maximum temperatures were more extreme under CT (diurnal range higher by 7.3 °C) relative to CA (diurnal range of only 3.8 °C) as observed in the 6-yr trial in Embu. The regulation of soil temperatures increased with the amount of surface residue retention, where diurnal range reduced from 3.2 °C with 3 t/ha of surface residues to 2.1 °C with 5 t/ha of the residues.

Soil biological attributes: Practicing CA enhances the abundance and activities of the soil microbes and meso- and macro-fauna involved in the cycling of nutrients such as the nitrogen and phosphorus needed by crops. Overall, practicing CA led to a 10–50% increment in microbial functional groups whose activities within the soil strata form an important component of soil fertility improvement. Increased abundance of phosphorus solubilising microbes of up to 64% is observed in CA relative to CT pointing to increased phosphorus solubilisation in CA systems. In Kenyan trials, CA practices increased microbial biomass carbon (23.1%), microbial biomass phosphorus (73.1%) and microbial biomass nitrogen (12.1%) over conventional tillage. These increases are attributed to the conducive environments involving minimal disturbance, increased moisture and nutrient availability and microclimate that favour microbial species abundance in CA than CT.

Changes in soil organic carbon: The effects of CA on soil organic carbon are variable and largely dependent on the actual management practice applied, the period/length of time of the practice, climate and the soil type. In Malawi, for example, practicing CA only increased (not significant) SOC in Kasungu (30%) and Ntcheu (11 to 33%) relative to CT, with no observable effect in Mchinji, Lilongwe and Salima. From a long-term perspective (2003–2015), practicing CA (with 2 t/ha/season residue retention) resulted in somewhat elevated SOC levels in the topsoil relative to CT but over time, all the systems were losing carbon. High residue comminution by macrofauna slows carbon sequestration.

Greenhouse gases: Emissions of greenhouse gases such as nitrous oxides are driven by the source and amount of nitrogen application and not by tillage practice. Nitrous oxide emissions were essentially the same in CA and CT systems and overall very low, less than 0.7 kg N2O-N/ha/season. Crop productivity effects: From a long-term perspective, practicing CA results in similar legume and also cereal yields compared to CT systems. Yields of legumes (soybean) are even slightly higher (35 kg/ha) in CA than CT systems. The improvement of yield stability in CA relative to CT varies by the particular CA practice and sites.

7.5 Key results by country and their contribution to sustainability

The SIMLESA project has accumulated multi-country evidence on the benefits of conservation agriculture-based sustainable intensification. These practices demonstrate large potential impacts for improving food security and protecting the environment such as reduced production costs, increased productivity, and reduced soil degradation. Further mainstreaming is needed for these practices to become an integral part of the region's agri-food systems and to achieve impact at scale for positive rural transformation: poverty reduction, responding effectively to climate change and reducing resource degradation. The table below summarises these results as per the sustainability dimensions.

Table 7.5 Key results by country and their contribution to the sustainability themes

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
Ethiopia	1) Production of maize and legumes under CASI resulted in 28% and 40% to 40% and 28% yield advantages, respectively	1) CASI-based practices increased the Stover yields of maize and common beans by 25% and 34% respectively.	1) 26000 tons of improved seed produced to support commercial seed production	Supported degree training: 1) 18 MSc, 8 Ph.D. and 9 undergraduate students supported More than 297 researchers trained in the CASI 2) Between 2011 and 2018, 94 long-term on-station and on-farm experiments were conducted across the country with an estimate of over 37,525 farmers adopting.	Since 2010, with local farmers, participatory variety selections were completed: 1) 170 maize, 172 legume and 53 forage varieties 2) 9 hybrid maize varieties and 21 improved legume varieties were identified for commercialisation through private seed companies	1) Policy outreach meetings were held all the regional offices where SIMLESA was implemented 2) On March 5, 2019, a national forum presided by the State Minister of Agriculture. SIMLESA results were discussed for inclusion into national and regional plans. Various stakeholders (representatives of federal and regional offices, international development organisations among others were present Develop and *incorporate*

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
						alternative soil cover and feeds in CASI programs. A second main message was the enactment of *bylaws to institutionalise controlled grazing*.
Kenya	**1)** In eastern Kenya, CASI adoption led to estimated maize and beans yields increases from 1.6 and 0.6 t/ha to 4.5 and 2.5 t/ha, respectively	1) More than 75% of SIMLESA participants retained crop residue on the soil surface in western Kenya Due to CASI adoption: 2) Soil pH increased from 4.8 at the start of the project (in 2010) to 5.5 in 2014 3) Soil organic carbon and the total soil nitrogen increased from 0.2–0.4% in 2010 to 1.9–2.1% in 2016, respectively, 4) High soil bulk density decreased	1) Since 2013, more than 40 partners (farmers, seed companies and governmental organisations have been members of SIMLESA led AIPs)	1) More than 115,000 farmers had adopted CASI by 2018	1) 11 AIPs were formed to support CASI experimentation, technology evaluation and scaling out	1) Two regional policy meetings were held in Kisumu County on March 15, 2019, and in Meru County on 19 April 2019. County government officials of agriculture and Deputy Director General of KALRO 2) A national forum was held at the Dairy Research Institute in Naivasha on April 2, 2019. Directors of KALRO's research

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
		from 1.5 kg m3 to 1.2 kg m3.				institutes as well as directors of policy and research at the State Department of Agriculture were represented. The main policy message was the need to *increase public investments in the growth and development of collective institutions*. The other was the need for *investments in long-term research and knowledge systems* to gather, curate, analyse and communicate CASI information.
Malawi	1) CASI-based cropping systems increased maize yields by 37% in the low-altitude areas	1) In Balaka district, 175 women farmers adopted mulching without using herbicides.	1) 10 improved maize varieties released 2) 11 improved legume identified	**1)** 36 on-farm exploratory trials have been established. **2)** Over 50,200 farmers have	1) Six innovation platforms involving 538 farmers established	1) A regional policy forum in Lilongwe on March 1, 2019 with representatives from research,

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
	2) CA-based practices led to a 16% decrease in agricultural production risk 3) CASI practices increased maize yields by 19% in mid-altitude areas		and released for commercialisation	adopted CASI practices by 2016. **3)** Over 2,500 farmers (1017 women) attended CASI demonstrations. **4)** 354 farmers participated and graduated from 12 farmers' field schools established by SIMLESA.		extension, seed companies, NGO's, scaling partners, Civil Society and farmer organisations. 2) A national policy forum was held in Lilongwe on March 26, 2019; the meeting was presided over by the permanent secretary in the ministry of agriculture. Representatives from the CGIAR, World Bank, & USAID were present. The main message from Malawi policy forums was the need for *increased funding in long term soil research sites* to provide evidence for upscaling CASI.

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
						Additionally, the need for *increased national and regional agricultural budgets budget allocation for community-based demonstrations* on CASI for farmer capacity building was emphasised.
Mozambique	In SIMLESA, communities where CASI was implemented: 1) Maize yields increased from 1.2 t/ha to 4.5 t/ha in low and to 6.5 t/ha in high potential environments 2) Yields of pigeon pea increased from 0.38 t/ha to 1.15 t/ha in the low and to 1.4 t/ha in the high potential areas. 3) On average, the CASI practices	**1)** Project surveys recorded a 67% rise in crop residue retention on the filed	**5)** 871 participatory seed variety selection trials were carried out. 22 legume and 12 improved maize varieties released for commercialisation	1) The project reached 38,057 households with CASI technologies by the end of Phase 1.	1) By 2017, more than 191,700 farmers reached using partnerships with the private sector, NGOs, AIPs, on-farm demonstrations, training, field days, exchange visits, multi-media, extension meetings, and training	A regional forum was held in Chimoio on February 7, 2019 and presided over by the Director General of IIAM. A national-level forum was held and a national forum in Maputo was presided over by the deputy minister of agriculture and the director general IIAM. IIAM scientists, technicians, representatives of the ministry of agriculture technical directorates, directors of regional zonal research

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	**2. Environmental improvement**	**3. Improved markets and value chains**	**4. Improved technical capacity of individuals**	**5. Improved community governance**	**6. Local & country ownership**
	increased maize yields by 37%, cowpea yields by 33% and soybean yields by 50% based on data from Sussundenga and Manica districts.					centers, representatives from CGIAR and academic institutions. The main message from Mozambique policy forums was that the national policy focus should be on *increased investments in rural business incubation.* *Strengthening CASI knowledge systems* by investing in long-term farm-based research, data collection, analysis and dissemination was emphasised.
Rwanda	1) After two seasons, bean yields under conservation agriculture were10–30% higher in CASI plots and CASI was able to suppress the need for seasonal	1) In this short period, in many maize plots, yields under conventional and conservation tillage was statistically the same. However many environmental benefits were	1) Successful SIMLESA-sponsored AIPs achieved 50-50 gender parity. 2) The AIPs embraced collective business models and focused on	1) The project supported one M.Sc. student who since then published papers on conservation agriculture. Farmers in the project area were trained on how to practice CA. Farmers in	1) AIPs facilitated information flow, value chain upgrading and access to markets 2) The two main AIPs reached 7,500 households within 2 years of	The Rwanda national forum was held in Kigali on March 21, 2019 presided by the Ministry of Agriculture (MINAGRI), Rwanda Agriculture Board (RAB) and civil society. Others were the deputy director

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
	application of manure and fertilisers.	seen such as the presence of many micro-organisms and the efficient use of rainwater was observed which resulted in good infiltration and absence of erosion. **Meaning**: The environmental benefits of CASI can be achieved without sacrificing yield	financial services as entry points.	Bugesera obtained a small grant from SOS Children Villages sponsored by Germany to continue the CA practices in the framework of climate change mitigation.	project implementation 3)	general of RAB and the representative of the permanent secretary of the ministry of agriculture. The importance of *institutionalisation of the AIP innovation approach* in national agriculture policy. A second lesson was to emphasise *long-term CASI based soil systems research*.
Tanzania	1) When combined, CA-based technologies reduced women's labor in weeding and land preparation by 50% 2) Yields increased from 0.38 tons/ha to 1.5 tons/ha for pigeon pea and from 1.2 to 4.5	1) Improvements of up to 65% were observed in CASI plots	1) Through 172 PVS trials for improved maize varieties, farmers selected 91 varieties for out-scaling. 2) 124 PVS trials for improved pigeon pea varieties, farmers selected 13 varieties for out-scaling.	1) Between 2010 and 2018, it is estimated that about 43,000 households benefited from the adoption of the CASI practices 2) SIMLESA-Tanzania has trained 1 Ph.D. and 9 M.Sc. students; 109 others have received short	1) AIPs provided opportunities to fuel innovation resulting in a 35% increase in the adoption of CASI practices.	Two sub-national forums were held in Arusha on February 12, 2019. There were 60 participants from regional and local government authorities; development partners, farmers, extensionists, researchers, policy makers and media people.

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	**2. Environmental improvement**	**3. Improved markets and value chains**	**4. Improved technical capacity of individuals**	**5. Improved community governance**	**6. Local & country ownership**
	tons/ha for maize when farmers implemented CASI practices			courses in the SIMLESA trainings.		The national forum was held in Arusha on March 13, 2019. Among those present were the deputy Minister of Agriculture, the board chair of TARI, Director general of TARI and other senior agriculture sector officials and scientists from TARI. Key messages from Tanzania policy forums focused on *leveraging the efficiencies of the private sector to lower the costs of dissemination of CASI.* Additionally, *investment in short- and long-term training was carried out to build a critical mass of researchers* and trainers in CASI.
Uganda	1) CASI implements (rippers, seeders and jab planters)	The use of ripline technology improved soil structure	**Before the establishment of SIMLESA-led AIPs**	**Before the establishment of SIMLESA-led AIPs**	As shown in the previous two columns: Functional AIPS facilitated information	The sub-national forum was held at Nakasongola Town Council, Nakasongola District

Country	Sustainability Dimensions					
	1. Increased productivity and incomes	2. Environmental improvement	3. Improved markets and value chains	4. Improved technical capacity of individuals	5. Improved community governance	6. Local & country ownership
	enabled timely operations leading to: • 62% reduction in labor using oxen rippers • 44% increase in bean yields • 50% increase in maize yields		1 out of 10 farmers engaged in cost-reducing collective marketing **After the establishment of the AIPs** 9 out if 10 AIP members engaged in collective produce marketing 5 out of 10 farmers engaged in bulk input procurement	Only 2 out of 10 farmers had access to extension services **After the establishment of the AIPs** 8 out of 10 had access to extension services	exchange, collective action and market participation	on February 16, 2019 The national policy forum was held on March 28, 2019. High ranking ministry of agriculture officials were represented by the Chair of the board of NARO. *Private sector-led business in CASI promotion* is the most successful. *Update extension field guides* and relevant communication tools on the optimal patterns of intercropping

8 Impacts

8.1 Scientific impacts – now and in 5 years

The scientific research impacts of SIMLESA flow from the large amounts of peer-reviewed publications and data associated with the project which have been presented in this report. SIMLESA scientists variously participated in international learned conferences. An example of such was on October 9–12, 2018 at the second Africa congress on conservation agriculture at which eleven SIMLESA researchers presented SIMLESA results. Other scientific conferences at which SIMLESA scientists were present included the International Association of Agricultural Economists 2012 Conference, August 18–24, 2012, Foz do Iguacu, Brazil and the World Congress of Conservation Agriculture in Winnipeg Canada, June 22–25, 2014. In total, more than 100 peer-reviewed articles and drawing from this body of research, more than 60 policy briefs were published during the life of the project. The following can be summarised as SIMLESA's broad scientific impacts.

Strengthened trans-national collaboration in agricultural research: At least 12 institutions in an international collaboration emphasised working in a multi-stakeholder process across the value chain to facilitate the division of labour. Private seed companies, farmers, farmers' groups, agro dealers and extension departments have been involved in the activities of the SIMLESA program. The networks created in this process will provide an enduring resource for future collaboration in the areas of CASI research and development. The maintenance of these networks will be critical for the long-term scaling of CASI in research, policy and practice.

Provided data and publishing scientific information on CASI: Large amounts of socio-economic datasets are now freely and publicly available on an Open Access basis through a link on the SIMLESA website[12]. That link takes visitors to the CIMMYT

[12] *Please visit* https://simlesa.cimmyt.org/resources/datasets/agronomy/ and https://simlesa.cimmyt.org/resources/datasets/socioeconomics/

dataverse repository. In that repository, multi-panel socio-economic datasets from 2010/11, 2013 and 2015/16 cropping seasons from more than 5000 households in 500 villages located across eastern and southern Africa can be freely accessed by any interested researcher or analyst. Also freely available are agronomic farm trials data from 40 sites covering seven seasons across the 10 agro-ecologies in the five project countries in eastern and southern Africa. The data covers 150 trials from on-farm experimentation over the last seven to eight years across the five SIMLESA countries. Also through the website, a wide variety of scientific publications, farmer and extension manuals, policy briefs, and project reports and media articles are accessible to a global audience. Therefore, SIMLESA's work has been impactful in making available updated information that can be used by a broad audience to gather information on CASI.

Generated lessons on scaling modalities for CASI: Toward the end of 2016, the program managed to competitively select 19 partners to drive the scaling out initiatives under a competitive grants scheme. A total of 58 innovation platforms were operational at the end of 2018. Future tracking will confirm the success of these efforts in helping drive the scaling out of sustainable intensification technologies. Field days, exchange visits and innovation platforms have continued to improve knowledge transfer, which has increased the yield of both maize and legumes, and improved food security in project sites.

Provided lessons on the institutional enablers of CASI: SIMLESA social science research has strengthened the evidence for the kinds of institutional innovations needed to scale up CASI. One of the key lessons was that collective institutions can help improve value chain functioning by integrating farmers into markets. Proximity to markets provide access to farm inputs and improve the chances of CASI methods to be implemented. These lessons on institutional development were drawn from the social science publications that were produced in SIMLESA. Policies that help develop inclusive rural markets stand a better chance to advance the spread of CASI.

Strengthened maize and legume seed systems as a critical enabler of CASI: In collaboration with national breeding programs, CIMMYT's Drought Tolerant Maize for Africa project and ICRISAT's Tropical Legume Projects, SIMLESA facilitated the release of 40 maize and 64 legume varieties which were tested and evaluated by farmers in the study countries. Partner seed companies selected and scaled up seeds that performed the best and met farmers' preferences.

8.2 Capacity impacts – now and in 5 years

SIMLESA implementation generated a lot of training opportunities and capacity building in several areas. Arguably, these will likely be the most impactful aspects. The capacity and knowledge acquired through various forums such as degree and non-degree training for early-career scientists and other opportunities arose as the project worked with governments, maize legume value chain actors and community groups to provide an enabling environment for scaling of CASI technologies. These skills will live with the beneficiaries for years to come and provide a strong basis (together with better policy and programs) for a sustainable spread of CASI.

Degree and non-degree training: To provide the basis for future research in and development of CASI practices in hither traditional and conventional farming systems, SIMLESA facilitated technical training in system's agronomy and socioeconomic research. The project and Australia Awards Scholarships (formerly Australian Development Scholarships), ACIAR and the ARC South Africa supported 65 masters and doctorate students who studied in Australia, and African universities. This was in addition to non-degree training for 297 researchers and partners-received training in CASI practices during its implementation period.

Policy outreach workshops: A series of learning workshops during the country policy forums were a good learning experience in policy engagement and networking. More than 40 scientists affiliated with the SIMLESA project attended these sessions. Several topics were covered including communications, writing policy briefs, media engagement and outreach to senior government officials. These skills are important to all scientists working in applied agricultural research in the region. We believe that SIMLESA has contributed to capacity building in this critical area. In fact, policy outreach in itself needs to be institutionalised. SIMLESA set a good example of building capacity in this area. SIMLESA was, therefore, trend setting in this regard and provided a good example for future projects.

Farmer training: To achieve the required adoption rates, SIMLESA provided farmers with an opportunity to experiment with the practices in incremental steps. This led to the emergence of innovative and intensive extension approaches not limited to experiential learning, whereby small amounts of inputs and equipment were subsidised for trial and learning, then supply chains were developed to deliver these inputs cost-effectively. The project sponsored and participated in information campaigns using the most accessible forums, such as local language radio stations. Farmer-managed on-farm trials provided an opportunity for farmers to test and choose the best practices. Demonstrations, field days, exchange visits and farmer field schools provided avenues to popularise and promote the new approaches among farmers.

8.3 Community impacts – now and in 5 years

The impacts of the SIMLESA are apparent in the economic and social outcomes that happened in the project areas and their vicinity. The productivity benefits translated into more food and income for farmers. The networking in AIPs and other forums created community cohesion. The participation of women would create social progress for them. The overall reduction in labour demands is likely to reduce women's labour burdens opening up opportunities for economic diversification.

8.3.1 Economic impacts

The final adoption and benefit surveys conducted at the end of 2018 provide evidence of the economic impacts of SIMLESA, based on data from farmers' fields. The economic impacts of SIMLESA derive from the number of farmers adopting CASI practices. By 2018, the results showed that the average rate of adoption in SIMLESA sites across the seven project countries was 3% per year (for the adoption of at least 2 practices or full CASI or adoption). In the 2010/11 season, the adoption rate of full CASI practices was approximately 1% (on average) and in 2018, it was averagely 24% [29]. The context of this adoption increase was the intensive activities in the project communities. Broadly, a system that would implement these activities as a program or policy framework is summarised in Section 9 below. If these adoption growth rates are sustained till 2030, the economic impacts of SIMLESA would be large. Based on the adoption rates in 2018, 484,000 farmers had adopted two CA or full CA practices (or at least minimum tillage with maize–legume diversification or mulching) on 0.4 hectares of their farm. According to the estimated adoption increase per year, by 2023 the number of adopters of zero or minimum tillage (a critical element of CA) in combination with at least one other recommendation (maize–legume diversification, mulching) would be 562,000 households, and 693,000 households would be adopting at least one recommended practice [29].

The estimated financial returns to adopting at least two CASI practices (with minimum tillage as a basic practice) showed that for every dollar invested, CASI farmers can generate an average of four dollars in return per hectare. For example, a smallholder farmer in Ethiopia would generate $732 per hectare per season under full CASI with an average production cost of $91. The adoption of CASI practices had more returns per unit cost as shown by the benefit–cost ratio (BCR) analysis. A farmer adopting full CASI in Ethiopia earns $8 for every $1 spend on production per hectare (BCR of 8), similar to Mozambique where the BCR was 6.7 for every dollar invested in CASI, Kenya (4.3), Malawi (3.7), Rwanda (3.4), Tanzania (2.7) and Uganda (1.2).

The average gross margin for implementing full CASI was estimated at $449/ha. The enumerated total area under full was estimated at 99, 587 ha. The aggregate income from implementing CASI was therefore estimated at $44.7 million in 2018. On average, farmers' maize returns are less than $120 under conventional farming methods (which would be approximately $12 million) for the total hectare recorded in the SIMLESA report. Given the adoption growth rate of 3% per annum, it can be estimated that between 2012 and 2018, the financial benefits of adopting at least two CASI practices was more than $220 million across the project sites.

8.3.2 Social impacts

SIMLESA succeeded in increasing the adoption of CASI technologies and this resulted in increased food security and economic opportunities among female-headed households, as well as enhanced women's empowerment. The new approaches also make farming more viable for women because they offer options that reduce the time, labor and financial requirements associated with farm activities. Diversification of crop production into legumes, such as groundnuts, soybeans and pigeon peas, has also improved nutritional status among households in Ethiopia [21] and Malawi [20] for example. Increased adoption of hybrid maize and improved legume varieties has enabled female-headed households to substantially increase their crop yields and sell their maize surpluses [39].

Reduced labor burden: Studies on gender and climate-smart agriculture in Kasungu and Lilongwe indicate that women typically spend 8 to 10 hours per day on agricultural tasks and an additional 5 to 6 hours per day on household and other nonagricultural tasks [22]. CASI technologies promoted by SIMLESA have proven to reduce the time and labour associated with preparing land for planting and controlling weeds, easing the time and burden, especially for women. Smallholder farmers in Mozambique primarily rely on their family members to provide farm labor. Female-headed households often have less family labour available, increasing the need for hired labour. As a result, the labour-saving benefits of conservation agriculture are potentially even higher for these women-headed households then for the other households. In the high-potential areas of Mozambique, the use of conservation agriculture practices reduced the labor requirement by 15–27 person-days per hectare across seasons compared with conventional methods. In the low-potential areas, the equivalent labour reduction was 16–28 person-days per hectare [28].

The primary obstacle to timely planting is the need for labour to prepare the land, which greatly limits the production area because most farmers use a hand hoe as opposed to mechanisation. In choosing between the two newly introduced technologies, many farmers opt for oxen-drawn rippers as opposed to permanent planting basins because the rippers increase production area with less labor. In addition, by reducing drudgery and increasing farm profitability, the rip line technology has attracted the younger generation to farming. In addition, the reduced requirement for labour has given women more time to attend to other family responsibilities and personal needs, while also providing them with opportunities to engage in vertical diversification, such as rearing poultry [40].

8.3.3 Environmental impacts

While the broader aspects of environmental impacts are yet to be assessed, the implementation of SIMLESA has re-emphasised the need to prioritise natural resource conservation after many decades of relying on nutrient-depleted soils for production. Widespread application of CASI practices will have positive effects on soils as evidenced by the results summarised in this report.

The CASI practices when implemented had important soil health benefits. Shifting from conventional tillage-based cropping systems to conservation agriculture improved soil stability and fertility helped reduce the high runoff and soil loss responsible for soil degradation. For example, in Malawi, results on the impact of CASI on soil health showed 30% more soil organic carbon under CA-based rotations compared to soils under conventional tillage, 30% more water retention for soils under CA systems and 60–90% increase in water infiltration rates in CA systems in relation with the conventional furrow and ridge system [41]. The Tanzania sites recorded an average increase in soil organic carbon by 23% [42]). Furthermore, the use of crop residue as a permanent soil cover and intercropping reduced soil loss by 34–65% in the Central Rift Valley (CRV) of Ethiopia [43].

The emphasis on mainstreaming these practices remains the best conduit to achieving these results in the aggregate. As an example, the Ethiopian government, for instance, established a national-level conservation agriculture task force to coordinate different government and civil society initiatives to promote the application of both climate-smart and conservation agriculture practices. The continued implementation of CASI methods among many farmers will produce positive environmental dividends. If the extension systems continue to improve farmers' knowledge of sustainable cultivation, then the goals of reclaiming degraded land through improved soil carbon, soil loss mitigation, and overall soil fertility improvement will happen on a wider scale. The evidence generated through SIMLESA on the improvements in soil health support the environmental impacts that have accrued on a small scale, but it will be widespread in the future, so long as the adoption of CASI practices among current adopters continues and more farmers adopt them. SIMLESA has contributed to the advancement of environmentally sustainable and climate-smart agriculture by laying down the foundations for future scaling through its research and scaling work. The nearly half a million farmers who have adopted the CASI practices strengthen these prospects. The program has also succeeded in elevating the discussions on CASI and providing evidence on how CASI works in smallholder settings. This is critical for future impacts.

8.4 Communication, dissemination and policy outreach

SIMLESA's activities were widely reported in mass media including radio, newspapers and national television (see SIMLESA website under media reports). The publicity value of these reports has been immense as they have conveyed SIMLESA's message to a broad audience. At various points in the life of the program, the results have been disseminated at scientific conferences (bringing the results from the program to wider audiences beyond the project). A major policy outreach event was conducted in 2015 at the mid-point to share the results with the top leadership of the NARS in the SIMLESA countries.

8.4.1 A major regional milestone in policy outreach

As described in Section 6.1.5 and 7.5 during 2019, more than twelve policy events were conducted in each country. These were attended by the senior leadership (Table 7.5). SIMLESA's communication efforts culminated in a joint communique signed by 12 ministers and permanent secretaries from eastern and southern African countries. A joint communique highlighting the lessons from SIMLESA was signed by the ministers and permanent secretaries, as described in Section 6.1.5 above.. The key lessons that were contained in the communique are summarised in the concluding section.

9 Conclusions and recommendations

After nine years of operation, SIMLESA closed in October 2019. As outlined in previous sections, the program was implemented in three phases (July 2010–June 2014, July 2014–June 2018 and June 2018–October 2019). The broad aim was to find resource-conserving methods that can help in the sustainable intensification of smallholder maize–legume farming systems in ESA. The agronomic trials identified smallholder-appropriate CA-based agronomic practices to implement minimum tillage with maize–legume intercropping and rotations as well as mulching in efforts to educate farmers in conservation farming. The social science, scaling, training components were designed to support the adoption of CASI practices. Overall, the project was meant to catalyse paradigm shifts in smallholder agronomy, rural value chains and institutions to make CASI the new normal in ESA smallholder farming systems.

9.1 Conclusions

Based on the evidence presented in this report, SIMLESA work has shown that CA farming methods are economically, environmentally and socially appropriate for smallholder farmers [16, 44, 14, 45, 46, 19]. When applied correctly (as a complete set of practices), the yield and income benefits are on average 37–50% better than conventional methods [14, 15]. This conclusion is supported by the data showing that close to half a million (484,000) farmers had adopted at least two components of the CASI practices on an average of 0.4ha of their farm [29]. At the adoption rates observed during the program implementation, around 0.7 million farmers (693,000) would have adopted at least one CASI recommendation and 562,000 households at least two recommendations [29]. SIMLESA's unique research and development contributions are highly recognised by the program's national agricultural research systems partners. Based on its resource allocation and impact orientation, SIMLESA has contributed to building important transnational research networks and capacity, generating scientific data and information on the potential for smallholder-appropriate CASI and engagement in policy processes.

9.2 Recommendations

The final policy summit put forward the key recommendations to take CASI to scale and institutionalise it in mainstream agricultural research and development. These recommendations fall into two broad areas under which several specific recommendations were made. The first area was on the institutionalisation process and the second was on improving market systems.

9.2.1 Mainstream and institutionalise CASI in the national farming systems

In order to institutionalise CASI, a number of key investment priorities may be needed to be made. The take-home message from SIMLESA work suggests the following areas for investment:

Include CASI in annual agricultural work plans, programmes and budgets

Given its potential to address economy-wide challenges, policy discussions arising from SIMLESA results proposed [47] that CASI be institutionalised by being integrated into the regular program of work of national extension systems, the ministry of agriculture and other institutions in the agricultural development space. The rationale for this suggestion was based on the need to concretise the recommendations through budgetary allocations to annual work programmes thereby bridging the gap between research and action.

Update extension training curricula and field manuals to include CASI: This recommendation frequently made by country teams during the policy forums [25, 47] may encompass easily accessible CASI guides and manuals suitable for extensionists, development practitioners and farmers. This is necessary to create a critical mass of actors familiar with CASI. A critical mass of farmers is also needed to ensure sufficient momentum for diffusion. These need well-trained teams of frontline extension staff as shown by various studies on this subject [35, 37].

9.2.2 Build up extension systems to support farmers

Through enhanced investments in extension modalities including innovation platforms focused on CASI: Investing in agricultural extension systems is a crucial element in the success of CASI. In countries such as Mozambique, it was reported [48, 49] that the diffusion of CASI practices was enabled by the involvement of local agricultural extension. Socioeconomic studies invariably found that in the cases where farmers had multiple contacts with agricultural extension agents or other scaling activities, there were high chances of CASI adoption [48, 49, 50]. In many cases, the AIPS actually acted as platforms for the extension. Almost all SIMLESA country teams emphasised the need for re-skilling extension personnel in CASI [49, 48, 51, 52]. They also suggested that extension departments can be trained in the operations of farmer innovation platforms and collective institutions [49, 53]. Finally, many of the recommendations focused on investments in farmer learning sites [48, 50]. Since long-term learning sites would need resources, mobilising public–private partnerships to fund such systemwide networks of long term CASI learning sites will be critical. Finally, CASI entails intensive farmer learning [46, 35, 54]. Strengthening farmer capacity will require extensive education and training. The evidence also showed that innovations that enable low-cost farmer learning and experimentation will facilitate faster CASI adoption [50].

9.2.3 Support community and social groups as platforms for scaling CASI

By formalising social network formation in farming communities: SIMLESA research findings were consistent with published literature: farmers operate in a complex and difficult environment. This is compounded by spatial isolation due to poor infrastructure [55, 56]. Some of these difficulties can be reduced if farmers participated in networks that provide support to access information, transport services, machinery and finance [57]. Collective institutions strengthen the social capital of communities: by contributing to increased trust, reciprocity and cooperation. They create networks for information exchange, market access and resource mobilisation. They support the creation of collective arrangements for demand articulation and technology transfer. The reported low capacity in the management of farmers groups [57] lends weight to the conclusion for providing material and capacity building support to improve their operations and viability of farmer groups. The strengthening activities could include group formation, managing group dynamics (such as conflict resolution), financial and business management and the like.

9.2.4 Invest in networks of community-based farmer learning centers

By installing community-embeded learning sites: Bringing validated agricultural technologies to scale is often recognized as a critical adjunct in the research-to-farmer uptake path. Investing in scaling modalities such as readily accessible demonstration sites can accelerate the diffusion of the given technology. The most recently collected data from SIMLESA [50] show that the area under CASI technologies was strongly associated with farmers' attendance at farmer outreach events organised by SIMLESA teams. The study [58] found that in general, all the SIMLESA outreach programs and in-community attending training sessions organised around demonstration sites were consistently associated with higher odds of adopting conservation farming practices. Compared to those who did not attend such training or field days, those who did were 10–14 times more likely to adopt complex combinations of CASI practices [58]. The conclusions from the SIMLESA research [58, 50] confirm the need for more formal and institutional approaches in sustained funding of agricultural extension activities to support CASI. Well-resourced community demonstration sites across multiple sites are crucial in lowering the costs of access to information about CASI. Community-embedded programs that last several seasons and take a multi-year approach to institutionalised extension efforts appear warranted.

9.2.5 Support agribusinesses willing to invest rural value chains

The search for value chain solutions to support sustainable agricultural intensification informed a lot of SIMLESA's work [49, 56]. Four important principles for value chain development were identified in SIMLESA research [59]: formal price information systems based on broadly accepted quality definitions; improvements in the infrastructure for post-harvest services such as sorting, cleaning, grading and packaging; vertical integration of value chains actors to support rural households capture greater benefits of value addition and publicly available research-based information for agribusiness opportunities in rural agri-value chains.

There was consistent evidence that farmers closer to markets were more likely to also be CASI adopters [35, 18]. The use of machinery, a critical enabler of CASI requires the development of sustainable businesses supplying and servicing the machines. Based on SIMLESA research, the following actions can be recommended:

Through targeted investments in rural value chains: Many businesses avoid rural areas due to the high costs of doing business there. They have to deal with thousands of farmers dispersed over large areas selling or demanding small quantities and often connected only by rudimentary road networks [56, 55, 59]. These facts increase the costs of doing business. Given these high costs of operating in rural areas, incentives for agribusinesses willing to invest in rural markets are important. Few things can replace the need for improving rural infrastructure to reduce the time and distances to agricultural markets. SIMLESA research showed that in many parts of ESA farmers are sometimes two or more hours from markets [55, 56]. Continued focus on rural infrastructure upgrading is paramount.

9.2.6 Support collective action in seed value chains

By implementing industry-wide demand creation: Extensive community demonstrations as part of the SIMLESA project were key to success in increasing seed demand among farmers. The project demonstrated that eight in ten farmers, who participated in field days around the demonstrations, chose to plant drought-tolerant maize seed. The lesson from this was that good and extensive demonstrations create market demand. While the project tested this in a research setting, individual agribusinesses do not have the incentives to invest in these kinds of activities that benefit the whole industry. This is because they cannot exclusively recoup the benefits of their efforts, a requisite for private investment. Therefore, demand creation for seed and other inputs could be done collectively for the benefit of the industry. As markets begin to grow, there will be a strong business case to invest in distribution channels.

9.2.7 Support businesses specialised in CASI-appropriate machinery services

By investing in sector-wide efforts to improve mechanisation: Ownership of machinery is beyond the reach of most farmers [48, 60]. The most feasible option is access to hiring services. These are still absent in many rural markets. Policy support to develop markets of machinery hire is crucial for the success of CASI [61, 60]. The low development of private markets in smallholder appropriate machinery suggests a need to invest in sector-wide efforts to improve mechanisation. Similar to seed value chains, expert consultations in SIMLESA and related research have concluded that individual businesses may not have the capacity or incentive to carry out these industry-wide activities. Collective approaches from government and private agribusiness are needed to develop machinery markets. Moreover, research has shown that custom hire services can help overcome the high costs of equipment purchases. Even small machines are likely to be expensive for many smallholders. For many farmers, it will be more cost effective to hire machinery instead. A framework involving different players in the machinery sector for market demand creation and service provision is warranted.

9.2.8 Leverage the private sector to support farmer education in CASI

By linking innovative agri-businesses with extension services: Some agribusinesses may be willing to invest in rural innovation, market development and technology adoption as part of their business model. These should be given full policy support. In SIMLESA, there were good examples of public–private partnerships through a competitive grants scheme. One way to scale up these kinds of efforts would be to link innovative agri-businesses with extension services to run demonstrations and the promotion of agro-inputs. If appropriate, participating businesses will need to qualify by demonstrating co-investment in the development of the relevant value chains. Another important opportunity for action may revolve around creating funds that small and medium agribusinesses can access, to buy machinery for hire, for example. When this approach is combined with demand creation opportunities, the impacts are likely to be considerable.

9.2.9 Strengthen regional CASI knowledge management systems

By building regional CASI networks of research and knowledge systems: Although there is a strong evidence base on potential multi-criteria benefits (economic, social and environmental) from conservation agriculture-based sustainable intensification (CASI), there is still need to nurture the system transformations needed for CASI to take root which is still lacking. To achieve the necessary system changes, this evidence base needs to be regularly updated and communicated to farmers and all stakeholders. Yet, there is a general lack of mechanisms to facilitate access to data, findings and publications to a wider audience. The wider availability of up-to-date information is important for CASI institutionalisation. With time, even the existing evidence may become outdated if consistent investments in research are not made. It will also be difficult to scale the practices if persistent scaling efforts are not made in many communities across different agro-ecologies. Knowledge management systems are needed to gather, curate, analyse, synthesise, update and communicate scientific findings from continuous research.

Building on existing programs and networks to create multi-stakeholder coalitions (involving international and national researchers, extension departments, farmer groups and seed companies) can have significant results and hasten research institutions of all kinds which have a pivotal role to play in making available the knowledge and solutions for connecting sustainable agricultural intensification to these grand challenges [62] by moving CASI innovations through the research and development pipeline.

9.2.10 Strengthen regional CASI knowledge management systems

By establishing national and regional databases and information repositories: There will be the need to coordinate these knowledge management systems. Such systems will help in the standardisation of messages for farmers, dissemination of most up-to-date findings to the larger community and faster validation of research results. Without these and similar actions, there will be missed opportunities to benefit from the free flow of new ideas and research and create much-needed spillovers across institutions and countries. Establishing a regional network of research and knowledge management, hosted by a regional institution and funded by the member countries, can help make CASI the new normal in Africa's farming systems.

As was described under the section on scientific impacts, SIMLESA has set the pace in sharing large amounts of socio-economic and agronomic data [62] that are now freely and publicly available on an open-access basis SIMLESA website (https://bit.ly/2ISEsCe and https://bit.ly/2TXiNzn). Through the website, interested parties can access a variety of journal articles, practical guides for framers on how to implement CASI practices, policy briefs summarising key actionable messages by development and public sectors and media articles highlighting major milestones in the project. All these are accessible to a global audience.

This approach provides an example of how to institutionalise CASI in the ESA region. The SIMLESA experience suggests that a coordinating mechanism would be a good institutional innovation. These coordinating mechanisms could use already existing regional institutions such as ASARECA, CCARDESA and CORAF. The recommended knowledge and research systems will help in the standardisation of messages for farmers, maintaining research momentum, dissemination of most up-to-date findings and faster validation of research results. Moreover, these will facilitate needed cross border spillovers across institutions and countries.

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11 Appendices

11.1 Appendix 1: Adoption Monitoring Report

Adoption and Impacts of SIMLESA Program

Pathways to sustainable intensification

Content of the Appendix

EXECUTIVE SUMMARY

The Sustainable Intensification of Maize–Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) project was conceived in 2010 to support smallholder farmers to adopt productive, resilient and sustainable maize–legume cropping systems through adaptive research, community demonstrations, and social innovations to facilitate local learning and scaling of new farming practices. The project was initially implemented in Ethiopia, Kenya, Malawi, Mozambique, and Tanzania. Rwanda and Uganda were later added as spillover countries. At the start of the project, the characterisation of maize–legume production, input and output value chain systems and adoption pathways was carried out. Capacity building and skills strengthening of local extension personnel were done in collaboration with the respective national agricultural research centers (NARs).

SIMLESA implementation approach was based on adaptive research at experimental stations and replicated in local communities and villages. The project funding facilitated and sustained demonstrations of conservation agriculture for sustainable intensification (CASI) practices in the project communities and beyond. Partnerships with a range of value chain stakeholders in participating countries were a critical implementation mode including scaling efforts for effective diffusion of CASI practices among smallholder farmers. The selection and recruitment of lead farmers who hosted CASI demonstrations and their inclusion as trainers were critical. Sustained CASI demonstrations within the reach of smallholder farmers became learning centres providing the opportunity to both women and youthful farmers to try and embrace the technologies and climate-smart practices.

Through established monitoring and evaluation systems, the project utilised local resources to reach more farmers. To improve its implementation, a number of adoption surveys have been done over the years in project areas of influence in Eastern and Southern Africa (ESA) to deduce project successes, document the opportunities and challenges and provide meaningful feedback to the team. To provide a unifying framework for understanding, the adoption and benefits from SIMLESA, the latest

adoption survey was conducted between October and December 2018 in the seven countries. The survey was meant to provide a parsimonious overview of the adoption, impacts and benefits (AIB) of the SIMLESA program. The survey adopted a simple random sampling procedure of farmers who were within a 25 km radius of SIMLESA on-farm demonstration sites.

In summary, the Adoption Impact and Benefits survey shows increased adoption of CASI practices in project communities compared to the baseline year (2010). The major impacts of these practices were the reduction in production costs (i.e., labour savings), and increased crop productivity per unit area (hectare). The adoption of combinations of CASI practices and crop diversification was evident. In all seven countries, Conservation Tillage (CT) was adopted at a rate of at least 7% in Kenya and up to 43% in Uganda in combinations involving at least two CASI practices. The highest incidences of CT only were as follows: Malawi: 41% followed by Uganda (31%), Rwanda and Mozambique were both at 24%. The adoption of CT with mulching and Maize–Legume Diversification (what we refer to as “complete CA”) was 19% in Kenya and 6% in Tanzania.

Areas allocated for maize–legume diversification (MLD) at household level rose across ESA during the project period with Tanzania leading at 5.28 ha of which 15% was under complete CASI practices followed by Mozambique 4.94 ha (28% CASI), Uganda 3.49 ha (29% CASI), Malawi 3.35 ha (23% CASI), Kenya 2.43 ha (21% CASI), and Rwanda at the end at 1.3 ha (31% CASI). Further, adoption trends show that an average of 6.5% of adopters had been adopting since 2011 and about 14% adopting for about 3–5 years. These results suggest continued and long-term efforts and investments in demonstrations, institutionalising CASI practices in the partner NARS, good links to crop and input markets including machinery are effective to achieve sustained adoption.

1 INTRODUCTION

1.1 About SIMLESA

Between 2010 and 2019, the Sustainable Intensification of Maize–Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) was a multi-stakeholder collaborative research program funded by the Australian Centre for International Agricultural Research (ACIAR). It was managed by the International Maize and Wheat Improvement Centre (CIMMYT) and collaboratively implemented by National Agricultural Research Systems (NARS) in Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania and Uganda. Other regional and international partners included the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Agriculture Research Council (ARC)-South Africa, Queensland Alliance for Agriculture and Food Innovation (QAAFI), and international centres CIAT, IITA and ILRI. During 2019, the program shifted towards synthesis and policy engagement to share results and information with the wider research, development and policy communities.

SIMLESA focused on leveraging science and technology to develop and deliver technological and institutional innovations in relation to maize–legume production systems. In turn, it was envisaged that these will make significant, measurable and positive changes in the livelihoods of smallholder farmers. SIMLESA also aimed to improve the adoption of risk-reducing practices. The program was envisaged to reach 650,000 small farming households in the five countries over a period of eight years. The technology focus was on testing and piloting locally-adapted and smallholder appropriate conservation farming methods. The social science focus was on the analysis of the market, policy and value chain enablers of conservation agriculture-based sustainable intensification (CASI) in eastern and southern Africa. Efforts were made to strengthen local seed systems for the delivery of appropriate maize and legume varieties. Pilot scaling programs were funded and monitored for documenting lessons on appropriate scaling strategies for CASI. Capacity building involving graduate and non-degree training was done. A total of 65 African post-graduates (23 of them being PhDs) were sponsored and trained under SIMLESA capacity building initiatives.

1.2 Objectives of the report

The purpose of this report is to provide an overview of the status of adoption and diffusion of SIMLESA technologies. By SIMLESA technologies, we mean conservation agriculture-based sustainable intensification practices (CASI) that were researched and piloted within the activities of the program. It is the contribution of the CA practices towards sustainable intensification that has led to the designation of CASI. By utilising these technologies, SIMLESA sought the dual outcomes of sustainably raising yields by 30 percent, while decreasing the risk of crop failure by 30 percent. In short, SIMLESA focused on, and promoted, maize and legume cropping systems to improve food and income security and resilience to climate change on African farms.

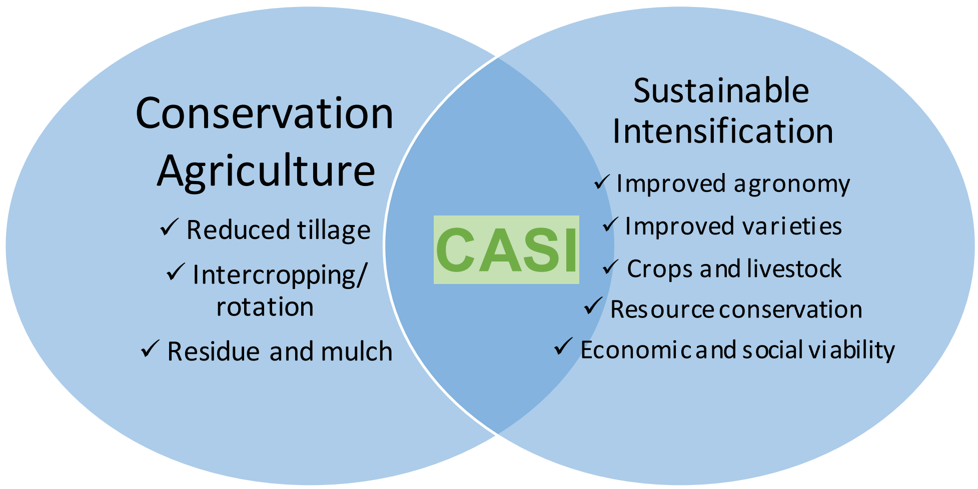

Figure 1. Conservation agriculture-based on sustainable intensification

In this report, we present a summary of key adoption metrics followed by crop yield and labour impact measurements. This is important for the following reasons. The aim of SIMLESA's adaptive and community-embedded research was to ensure that this research is not isolated from the real farming conditions, knowledge and perspectives and unique problems. This report is also meant to help identify the potential impacts the project has had or will likely have if the research, demonstration and scaling efforts are sustained. The objective is to measure the degree to which the CASI practices are being used in the SIMLESA communities and their potential for diffusion and wider macro-economic impact beyond the communities involved in the research.

2 METHODOLOGY

2.1 Defining adoption

Through national partners, project activities were embedded in national extension networks. Awareness campaigns designed to reach smallholder farmers were rolled out through various communication channels such as radio, TV, public gatherings and farmers' schools. In the initial years, a small group of farmers was trained on a set of CASI practices and their benefits in natural resource conservation for food security. A number of on-farm demonstrations were set up close to various research stations and managed by CIMMYT researchers together with their counterparts from NARs to act as learning centres for farmers as listed in table 1 below. In each country, the research activities were implemented in two contrasting agro-ecological zones in participating countries.

Table 1. SIMLESA project sites

Ethiopia	Kenya	Malawi	Mozambique	Rwanda	Tanzania	Uganda
Bako	Embu	Salima	Sussundenga	Bugesera	Gairo	Lira
Pawe	Meru	Balaka	Manica	Kamonyi	Kilosa	Nakasongola
West Gojjam	Tharaka Nithi	Ntcheu	Gorongosa	Musanze	Mvomero	
Jigjiga	Bungoma	Lilongwe	Angonia		Mbulu	
Central Rift Valley	Siaya	Kasungu	Gondola		Karatu	
		Mchinji	Makate			

Over time, a number of farmers acquired knowledge on CASI either through training or on-farm demonstrations, tried on their farms, embraced the practices, and gradually adopted them either individually or in combinations as a form of production method. **The farmers who learned, tried and implemented CASI on their farm plots (designated area of land for arable production by a farmer for a particular crop enterprise) are referred to as CASI adopters.**

It is important to note that neither continuous exposure to nor investments in CASI practices in a single season automatically led to persistent adoption. Different farmers adopted at different times and seasons based on their resource endowments, knowledge and skills. Given the inherent benefits of CASI to smallholder farmers, adopters varied their plot sizes under CASI over seasons. At the conclusion of the project, the number of adopters and areas under CASI had risen significantly compared to 2011 (baseline year). In Mozambique, a study by Khainga et al. (reference 50 in the main report) shows that adoption observed was due to the multi-year extension efforts. A dose-response model for the impact of extension suggests that community-based extension efforts should continue consistently for 6 growing seasons.

The actual demonstration plots were identified and set up by researchers in specific village communities (lowest administrative level) so that they are as close as possible to the farmers. Access to these demonstration farms provided sustained exposure to the CASI practices for many farmers, through repeated visits, training and funding for these field activities that were meant to catalyse the diffusion of CASI in the project communities and beyond. From researcher managed demonstration plots to fellow farmer hosted trial plots, the spread of CASI was meant to reach more farmers with the minimum cost possible.

2.2 Sampling Procedures

On the basis of the spread of CASI demonstration plots in the communities, a sampling procedure was designed to yield a sample that is representative of the population of smallholder farmers in SIMLESA areas of influence capturing randomly those within a 17–25 km radius from the demonstration plot as expounded in the following section. We adopted a continuous random sampling methodology for impact evaluation in each of the seven countries.

This was a two-stage approach, the first of which was the selection of primary sampling units (PSUs) within the countries. These were areas that were deemed to be the lowest administrative units within which SIMLESA activities were implemented. Within the PSUs, households were randomly selected as units of analysis. Note that during the project implementation, the activities were spread in different regions with different farmers hosting demonstration plots. The study, therefore, limited itself to PSUs that were found to be within a 17–25 km radius of these demonstration sites. Households were randomly selected from villages within the PSUs.

During the household sampling, care was taken to exclude farmers who hosted SIMLESA activities/ demonstration plots. However, these farmers were interviewed independently from the main survey across the countries. The study enlisted the help of extension officers from partnering NARS and local authorities at the PSU level. Actual data collection was done by trained graduate Research Assistants using computer-assisted personal interviews.

Sample size

Sample size computation was based on a continuous random sampling as explained in the practical sampling for impact evaluations by Kirstein (2012) using the following formula;

$$n = \left[\frac{4\sigma^2 (z_{1-\alpha/2} + z_{1-\beta})^2}{D^2} \right] [1 + \rho(m-1)]$$

where

n = sample size

σ = variance in population outcome metric

D = the effect size or how much of an impact the project will have

$Z_{1-\alpha}$ =Z value at 5% significance level/ Probability of Type 1 error

$Z_{1-\beta}$ = Z value at 80% statistical power/ Probability of Type 2 error

ρ = the intra-cluster correlation effect.

m = the number of observations in each cluster (village)

The project had a target of improving the production of maize legume output by 30% from the baseline yield (SIMLESA baseline survey report). This was the basis of computing the project effect size for 8 years with a meaningful success rate of 85% from 2010 yields in each country. The intra-cluster correlation effect tells us how strongly the outcomes are correlated for units within the same cluster. This is computed from the baseline data from 2010 on the basis of districts and our clusters and maize yield per ha in metric tons. In each cluster, a random sample of 20 households was selected.

Table 2 below presents random samples of households that participated in the SIMLESA adoption survey. Among the households selected were adopters, dis-adopters and non-adopters, randomly selected within SIMLESA areas of influence.

Table 2. Adoption survey random samples in participating countries

Country	Computed Random sample
Kenya	807
Ethiopia	873
Tanzania	958
Malawi	624
Mozambique	851
Uganda	300
Rwanda	289

2.3. Basic assumptions on adoption

A number of assumptions were made in computing the sample size for the survey:

- ❖ We assumed that the cluster/ village was homogeneous so a random sub-sample of 20 households was representative of its farming population. A homogeneous cluster is composed of a target population with a common ethnic, religious, socio-economic or cultural heritage that has not been influenced by external factors and whose members practice a similar livelihood. Random sampling enables a representative selection of smallholder farmers without any prior knowledge or consideration of particular characteristics of the beneficiary population, using the randomly generated numbers from the total amount of names listed. Every village, household and person has an equal chance of being included in the sample.
- ❖ The location of the demonstration plots was assumed to be centrally located within the villages. These plots formed the basis of having a 25 km radius cluster for sampling purposes.
- ❖ We also assumed that every smallholder within the cluster had an equal chance to be sampled.

3 RESULTS AND DISCUSSIONS

This section highlights our study findings on farmers' adoption patterns of conservation agriculture-based sustainable intensification in eastern and southern Africa. We find varying levels of exposure to CASI practices; maize–legume diversification and residue retention were common among smallholder farmers at the project inception while there was increasing interest in adopting other practices such as planting of cover crops especially those with high protein content as livestock feed and minimum tillage with herbicide application to control the weeds.

Reduced soil disturbance during production is key to the application of CASI. Though not widely spread, it was considerably adopted in Uganda, Mozambique and Kenya. A disaggregated analysis of CASI adoption by gender indicates high adoption rates of zero/minimum tillage in women-headed households in Mozambique, Uganda and Kenya while Kenyan women had the highest adoption rates for zero tillage on their own managed plots. Ethiopia, Tanzania and Rwanda had the least adoption rates of CASI among both men and women-headed households and were more pronounced in women-headed households in Ethiopia and Rwanda.

The later subsections highlight the impacts of households adopting CASI on labour and production costs, yields, farm area and adopting populations. The adoption of conservation tillage/reduced tillage in combination with other practices such as mulching and herbicide use resulted in huge savings among smallholder farmers in Ethiopia, Kenya, Malawi, Rwanda, Tanzania and Uganda and this was reflected in low production cost for farmers who adopted full CASI on their plots. There was also a considerable increase in maize yields per hectare on CASI plots compared to baseline yield before SIMLESA implementation in the region. These yields over time have guaranteed household incomes and food security for smallholder farmers. Moreover, the returns on each dollar investment per hectare on CASI plots were reasonably motivating especially in Ethiopia, Mozambique, Kenya, Rwanda and Malawi as seen from benefit-cost ratio analysis.

3.1 Exposure to CASI practices

A number of channels were used to expose farmers to CASI practices over the project period across the countries including the use of on-station demonstration plots, farmer groups, media, field days, seed companies and agro-dealers among others. Necessary efforts were made by existing SIMLESA extension networks to train farmers on a range of practices such as raising cover crops, crop rotation, mulching, minimum and zero tillage, residue retention on the farm after harvesting, use of herbicides in zero tillage and maize–legume intercropping for improved sustainable production. The number of farmers aware of the existing CASI practices as a result of these efforts is reported in table 3. The number of farmers who reported having been exposed to CASI practices were high for traditional production methods such as maize–legume intercropping and crop rotation. However, Ethiopia and Rwanda had the lowest levels of awareness towards maize–legume intercropping

Table 3. Percentage of farmers aware of CASI practices in 2018

CASI Practices	Ethiopia	Kenya	Malawi	Mozambique	Rwanda	Tanzania	Uganda
Cover crops	5%	34%	22%	13%	19%	14%	1%
Crop rotation	64%	78%	89%	46%	55%	31%	95%
Herbicides use	2%	43%	62%	12%	1%	18%	78%
Maize–legume Intercropping	33%	96%	88%	71%	55%	85%	83%
Minimum tillage	2%	34%	37%	49%	21%	6%	73%
Mulching	7%	52%	74%	23%	21%	11%	50%
Residue retention	9%	65%	65%	75%	26%	43%	45%
Zero tillage	3%	41%	67%	15%	16%	15%	9%

On average, 41% and 67% of surveyed farmers in Kenya and Malawi had been exposed to zero tillage while awareness was lowest in Uganda and Ethiopia at 9% and 3% respectively. However, Uganda recorded the highest levels of exposure to minimum tillage (73%)[13]. Similarly, the exposure to the use of herbicides in Uganda was high (78%) compared to 1% in Rwanda.

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[13] *In the questionnaire, minimum tillage was understood to mean reduced plough passes. This was understood by the project teams over the years as some progression towards reducing tillage. In many parts of ESA, farmers will turn the soil multiple times before planting to have a fine seedbed (especially in Ethiopia being influenced by teff production practices). In Southern Africa farmers redo the ridges. As an entry point, one of the SIMLESA recommendations was for farmers to do a maximum of one tillage operation. This explains why awareness of*

3.2 Adoption trends across project countries

There are farmers who decided to adopt but at different points during the project implementation period. Early (2010/11) adopters were few, as can be expected for new methods (as shown in figure 2).

The adoption of cover crops by farmers remained low between the two reporting periods across the project countries. However, farmers in Kenya, Malawi, and Rwanda appear to have shown increasing interest in adopting and planting cover crops with adoption rates of 10% in Rwanda and Malawi and 21% in Kenya. This was up from 3.2% of farmers in Kenya who had adopted cover crops in 2010 (and 1% in Malawi and 2% in Rwanda during the 2010/11 reporting period).

The proportion of farmers adopting mulching as a farming practice was between 32–37% in Kenya and Malawi, and 22% in Uganda. Ethiopia and Tanzania had the lowest proportion of farmers adopting mulching in both reporting periods remaining at 4.8% and 3% respectively in 2018. Although the overall proportions are still low in Ethiopia and Tanzania, they represented a 15- and 6-fold increase above baseline respectively. Retention of residue on the farm after harvesting the crop is one of the most challenging decisions faced by smallholder farmers. The need for livestock feed may hamper efforts towards the adoption of this practice. Farmers would either cut and carry the residue or graze on the farm. This can be evidenced by low proportions of adopting farmers in Ethiopia, Rwanda, Tanzania and Uganda.

Crop rotation and intercropping were highly adopted among farmers across all the countries. Malawi and Uganda recorded the highest percentage of adopters of crop rotation. In Malawi, the adoption rate of crop rotation rose from 7.9% in 2010 to 73.2% in 2018 and in Uganda, it rose from 7.9% in 2014 to 76.6% in 2018.

The use of herbicides in crop production remained low except in Kenya, Malawi, and Uganda. For instance, farmers in Rwanda seem not to have applied any appreciable amounts of herbicides. Adoption of herbicide use in minimum and zero

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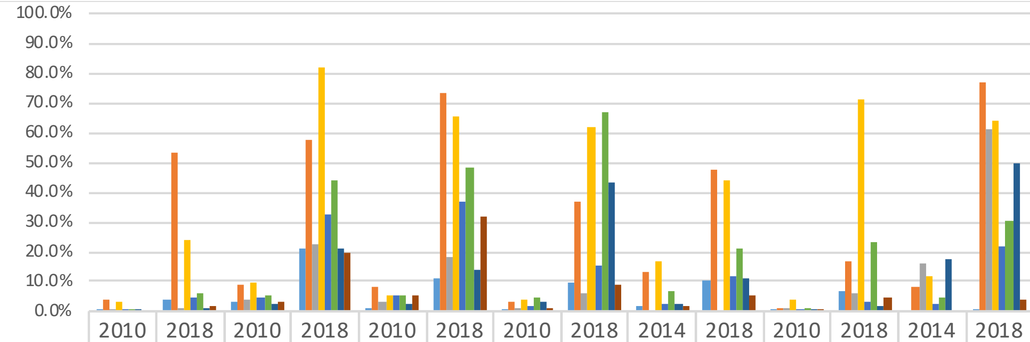
minimum tillage (a progression from multiple tillage) was higher than zero tillage. For example, zero tillage involved only seed furrows using riplines and planting basins in Uganda, seed holes in Mozambique and Malawi. In Kenya minimum tillage involved making ridges but leaving them undisturbed thereafter.

tillage seem to be on course in Uganda as shown in figure 2 with the proportion of adopters rising from 16.1% to 61.1% in a span of 4 years.



	Ethiopia 2010	Ethiopia 2018	Kenya 2010	Kenya 2018	Malawi 2010	Malawi 2018	Mozambique 2010	Mozambique 2018	Rwanda 2014	Rwanda 2018	Tanzania 2010	Tanzania 2018	Uganda 2014	Uganda 2018
Cover crops	0.5%	4.2%	3.2%	21.3%	1.2%	10.8%	0.7%	9.6%	1.7%	10.7%	0.6%	7.1%	0.0%	0.3%
Crop rotation	3.9%	53.4%	8.8%	57.4%	7.9%	73.2%	3.4%	37.0%	13.0%	47.3%	1.4%	16.8%	7.9%	76.6%
Herbicides use	0.1%	0.9%	3.8%	22.7%	3.4%	18.0%	1.3%	6.0%	0.0%	0.0%	0.9%	6.4%	16.1%	61.1%
Maize legume Intercrop	3.1%	24.2%	9.9%	81.7%	5.6%	65.4%	4.2%	61.9%	17.0%	43.7%	3.6%	71.3%	11.9%	64.1%
Mulching	0.3%	4.8%	4.5%	32.7%	5.7%	36.8%	1.8%	15.5%	2.7%	11.7%	0.5%	3.0%	2.7%	21.9%
Residue retention	0.5%	6.4%	5.7%	44.2%	5.2%	48.5%	4.9%	66.8%	7.0%	21.0%	1.4%	22.9%	4.9%	30.1%
Minimum tillage	0.1%	1.4%	2.7%	21.4%	2.3%	14.2%	3.2%	43.2%	2.3%	11.3%	0.4%	2.0%	17.6%	49.8%
Zero tillage		1.8%	3.3%	19.8%	5.2%	31.9%	1.1%	8.9%	2.0%	5.7%	0.7%	4.3%	0.0%	3.6%

Figure 2. Incidences of single CASI observations regardless of combinations at the beginning and end of the project

Minimum and zero tillage (*which means no more than one plough pass for seedbed preparation and one shallow weeding*) are not common agricultural practices among most farmers. In SIMLESA communities, this practice was much higher than is typically observed. **The adoption of minimised tillage was highest in Uganda (50%), Mozambique (43%), Kenya (21%), Malawi (14%) and Rwanda (11%).** At the end of the project, Mozambique had made the highest increase in the adoption of minimum tillage. **Zero tillage (*which means only seed furrows are opened*) was adopted at a rate of 32% (Malawi), 20% (Kenya), 9% (Mozambique) and 6% (Rwanda).** It is apparent that post-SIMLESA, extension networks need to step up efforts in creating awareness, training and reassuring farmers on the potential benefits of minimising or eliminating (zero) tillage. Despite low proportions of farmers practising zero tillage, Kenya and Malawi made significant improvements (15% and 26%) for farmers adopting this practice in the eight years of the project.

Adoption of various CASI combinations:

Figure 3 summarises the rate of adoption of *not only single* CASI practices, but also *combinations* of practices that were observed on different maize–legume (ML) plots. Overall, the picture of the adoption of combinations is important because it is the adoption of combinations of practices that make the greatest impact and may lead to sustainable farming (Manda et. al, 2015).

Incidences of no CASI practices: Incidences of no CASI practices were the lowest in Kenya (10% of households implemented no CASI practices). Ethiopia had the highest incidences of households that did not implement any CASI practice (42%). The other 5 countries had incidences of no CASI of between 15–32%.

Maize–legume diversification was the most widely adopted CASI: Overall, the most widely adopted practice was maize–legume diversification (MLD). The MLD practice was defined as maize–legume[14] intercropping or where the plot was under maize–legume rotation during the time of the interview. Overall, MLD was observed at 65% in Rwanda, and 58% in Ethiopia and Malawi. The lowest rate of MLD was in Kenya (40%) similar to Mozambique (43%)

Adoption of conservation tillage: As a CASI practice, conservation tillage (CT) implemented alone or in combination with other CASI practices was between 3–12% of farmers in Kenya. The adoption of CT as part of a complete CA package was 19% in Kenya but with no herbicides[15] and 8% in Tanzania. In all seven countries, CT was adopted at a rate of at least 7% in Kenya and up to 43% in Uganda in combinations involving *at least two* CASI practices. The highest incidences of CT were in Malawi at 41% (CT only) followed by Uganda (31%), Rwanda and Mozambique (24%) implemented all CT only. The adoption of CT with mulching and MLD (complete CA) was only in Kenya (19%) and Tanzania (6%).

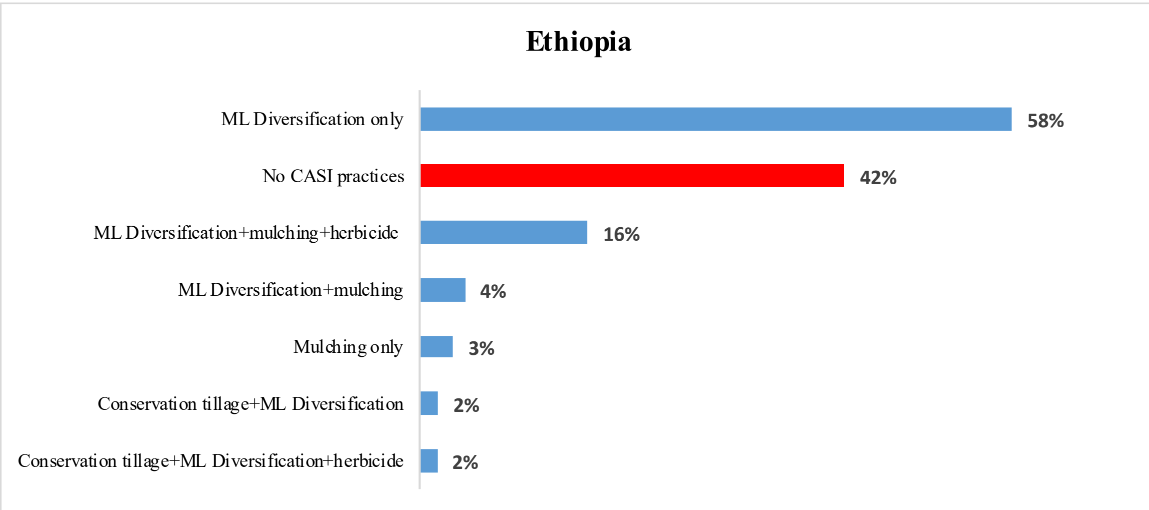
Adoption of Mulch: The highest incidence of mulching was in Uganda at 43% (as part of MLD + herbicide combination) and in Kenya at 37% (also as part of MLD + herbicide

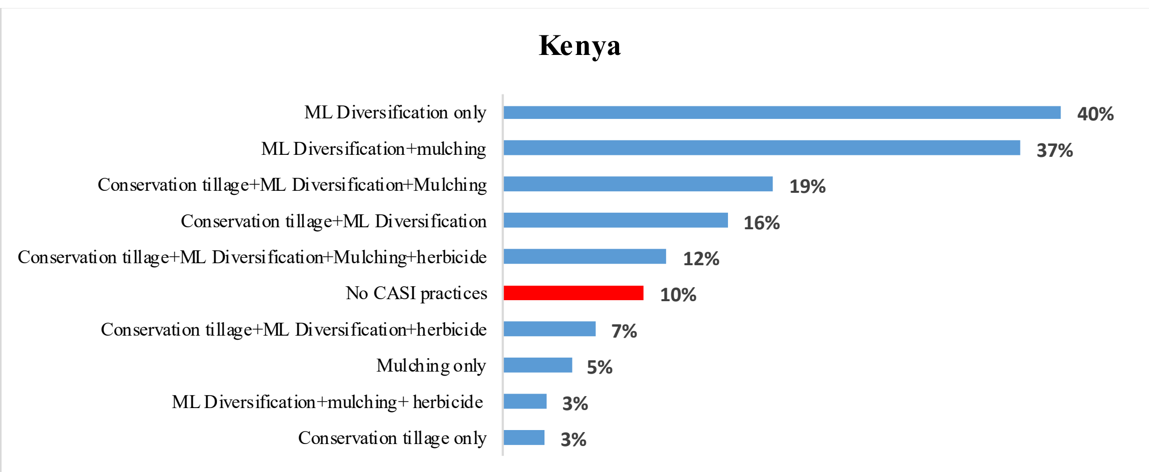
[14] There were many different legumes such as several varieties of common beans, peas and groundnuts.

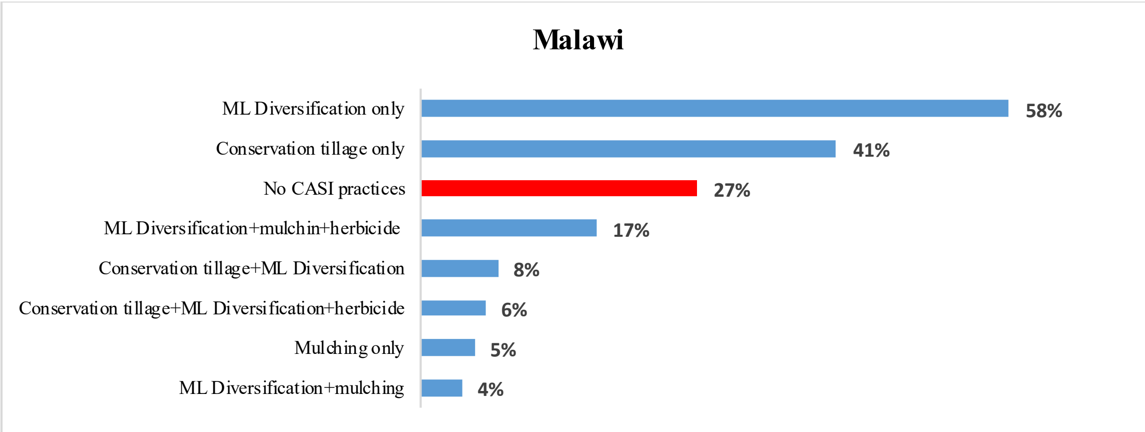
[15] There was another 12% instances of CA in Kenya but with herbicides

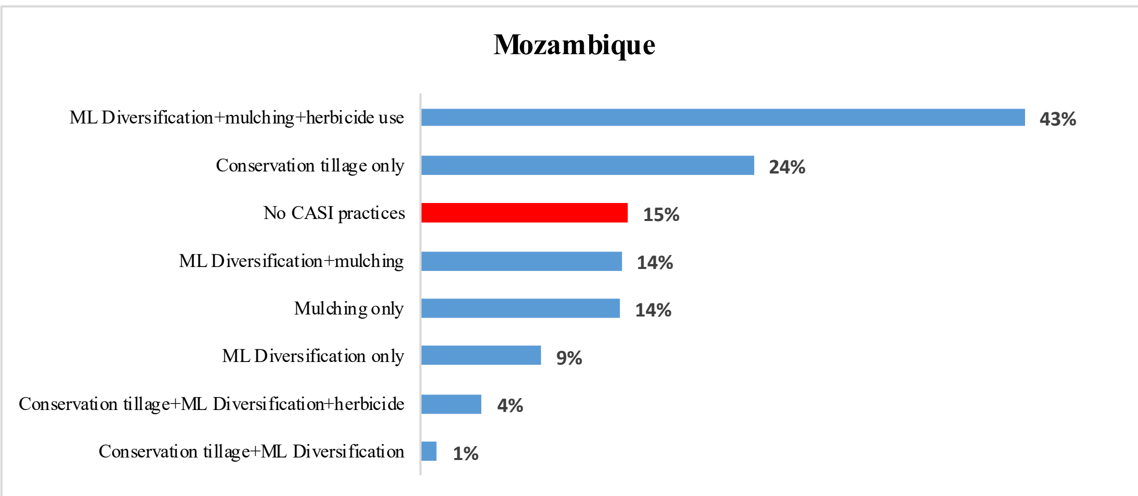
combination), and was lowest in Ethiopia at 4% (mulch only). Otherwise, the application of mulch was between 5–26% in various combinations as shown in figure 3.

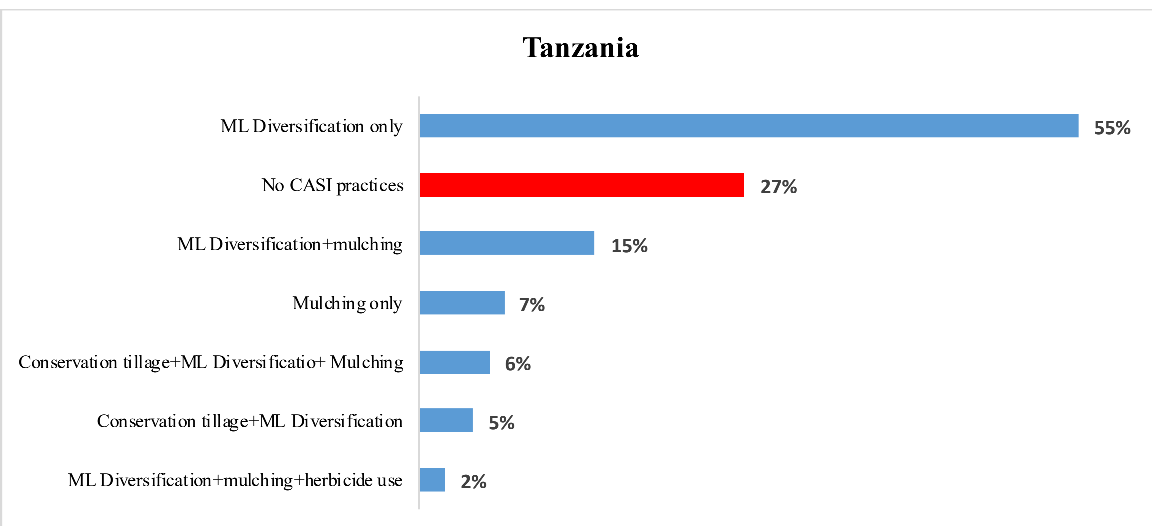
Adoption of Herbicide: There were no instances where herbicide was used as the only CASI practice. Herbicide use was observed at a 43% adoption rate in Uganda as part of MLD + CT + herbicide combination and 12% in Kenya as part of the complete CA combination that had herbicides. Otherwise, in the rest of the countries, herbicide use was observed between 2–17%.






Malawi
ML Diversification only
58%
Conservation tillage only
41%
No CASI practices
27%
ML Diversification+mulchin+herbicide
17%
Conservation tillage+ML Diversification
8%
Conservation tillage+ML Diversification+herbicide
6%
Mulching only
5%
ML Diversification+mulching
4%


Mozambique
ML Diversification+mulching+herbicide use
43%
Conservation tillage only
24%
No CASI practices
15%
ML Diversification+mulching
14%
Mulching only
14%
ML Diversification only
9%
Conservation tillage+ML Diversification+herbicide
4%
Conservation tillage+ML Diversification
1%


Tanzania
ML Diversification only
55%
No CASI practices
27%
ML Diversification+mulching
15%
Mulching only
7%
Conservation tillage+ML Diversificatio+ Mulching
6%
Conservation tillage+ML Diversification
5%
ML Diversification+mulching+herbicide use
2%

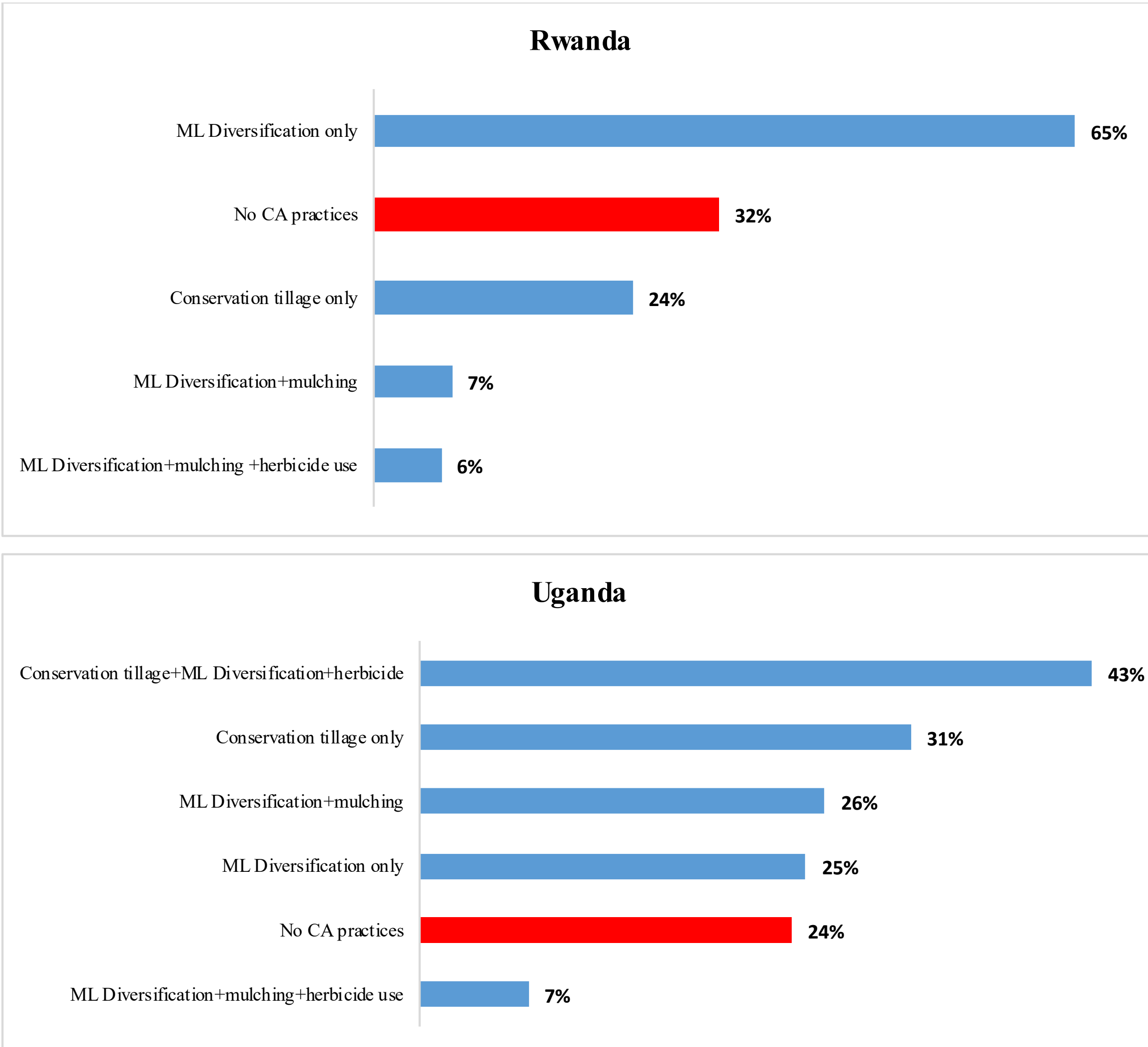


Figure 3. Percent adopters of CASI combinations by country, 2017/18

3.3 Adoption of CASI by gender

In this section we present disaggregated analysis of adoption of CASI between male and female headed households and managers of agricultural activities on specific plots across participating countries. In Figure 3 we summarize adoption of CASI by the share of CASI plots in female – and male-headed households. We do similarly for the share of CASI plots managed individually by men, women and jointly.

<u>In Ethiopia:</u> Most of the CASI plots were in female headed households (male headed households being the majority. Most (at least 84%) of the CASI practices were in jointly managed plots. About 91% of the CASI plots under zero/minimum till were in jointly managed plots. The bottom line for Ethiopia is that most of the CASI plots were jointly managed (Fig. 3). This might be reflective of the preponderance of joint plot management in Ethiopia, given the land tenure history in the country. The current government policy (backed by law) is to have both spouses' names on the title (Holden and Bezu, 2014[16]).

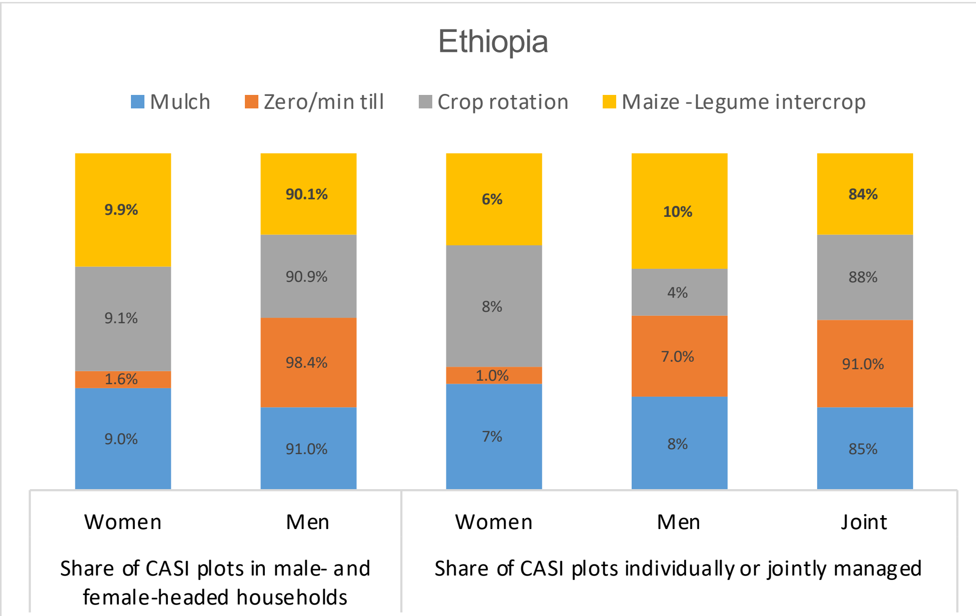


Fig. 4: *Share of CASI plots by household headship and plot management (Ethiopia)*

<u>In Kenya:</u> In *Kenya*, 43-48% of the CASI plots were in jointly managed plots. In Kenya 29-37% of the CASI plots were managed by women with the share of CASI plots under zero/minimum tillage being 31% compared to 21% percent for the share managed by men a 10-point gap in favour of women-managed plots (WMPs). Also 34% of CASI plots under minimum or zero tillage were managed by women. In terms of share of CASI plots in women headed households this is no more than 30%.

[16] *Holden, S.T., Bezu, S., 2014. Joint Land Certification, Gendered Preferences, and Land-related Decisions: Are Wives Getting More Involved? CLTS Working Paper No. 6/2014. Centre for Land Tenure Studies, Norwegian University of Life Sciences, Ås, Norway.*

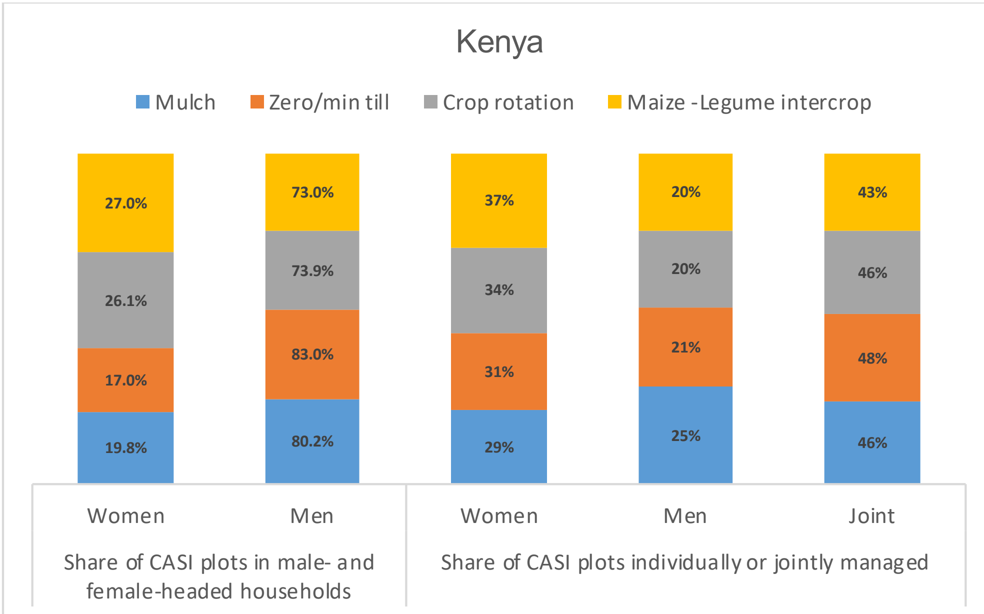


Fig. 5: *Share of CASI plots by household headship and plot management (Kenya)*

<u>In Malawi</u>: In Malawi, 70-76% of the CASI plots were jointly managed. However, the share of individually managed CASI plots managed by women was consistently higher (17-18%) compared to 7-14% of CASI plots being individually managed by men. A maximum of 15% of CASI plots were found in female headed households.

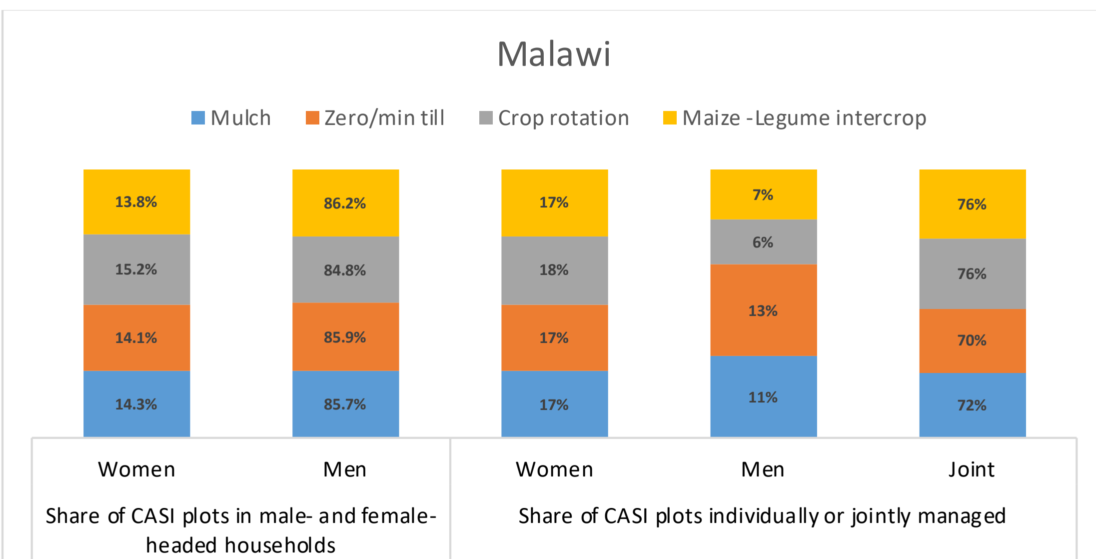


Fig. 6: *Share of CASI plots by household headship and plot management (Malawi)*

<u>In Mozambique</u>: The picture somewhat resembles Kenya with 54-62% of the plots being jointly managed. However, the share of CASI plots managed by men was 22-30%

compared to the share managed by women (13-16%). In terms of household headship, 90-96% of the plots were in households managed by men (so only 4-10% share are in households managed by women).

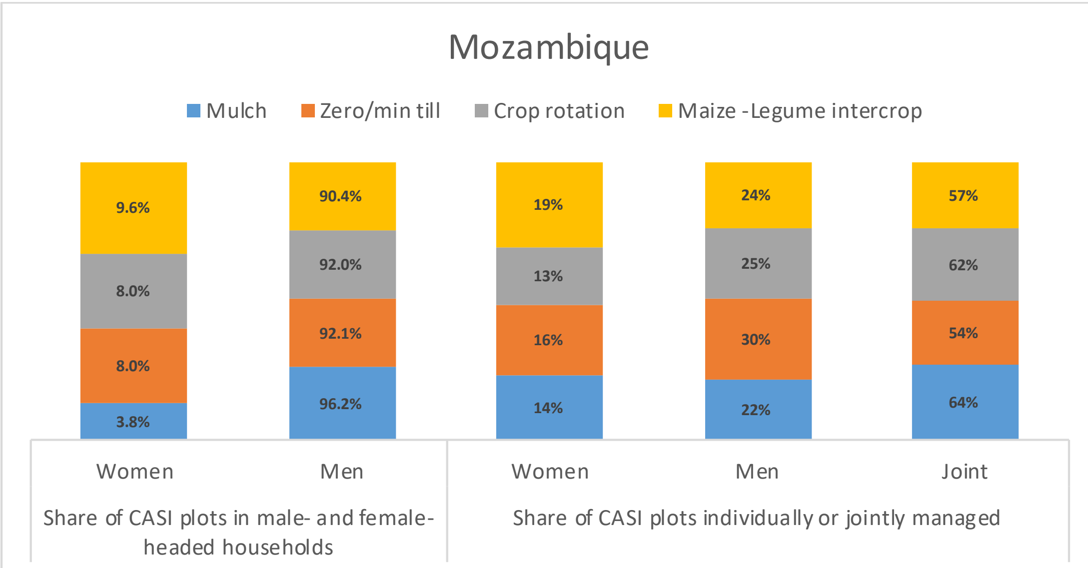


Fig. 7: *Share of CASI plots by household headship and plot management (Mozambique)*

<u>In Rwanda</u>: The share of CASI plots that were managed jointly in Rwanda ranged between 57-88% depending on the practice. Except for zero/min till and mulch the share of CASI plots (under rotations and intercrops) managed by women (20 and 23%) was comparable to that managed by men (19 and 20%) respectively. The majority (66-85%) of CASI plots were found in male headed households.

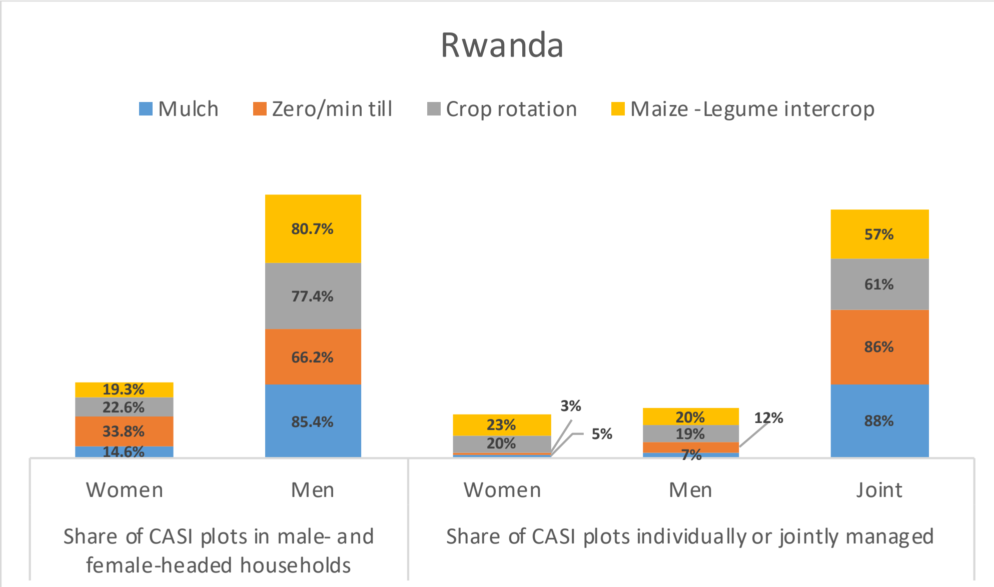


Fig. 8: *Share of CASI plots by household headship and plot management (Rwanda)*

In Tanzania: The share of CASI plots in male headed households was 87-91% and the share that was jointly managed was 61-81%. Somewhat similar to Kenya, the share of plots under zero/min till was 16% for WMPs compared to 9% share of plots managed by men. It is apparent that the share of CASI plots managed by women compared to that managed by men is not spectacularly different.

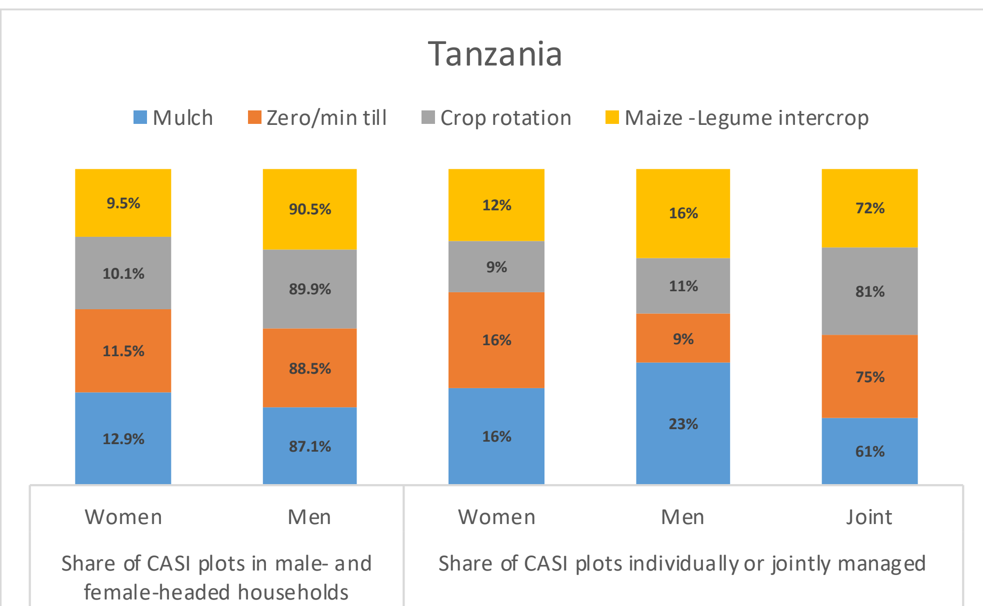


Fig. 9: *Share of CASI plots by household headship and plot management (Tanzania)*

In Uganda: The share of plots under crop rotation and intercropping that were managed by women was higher (21 and 22%) compared to the share managed by men (10 percent in both cases). However approximately 33% of the CASI plots were under individual management.

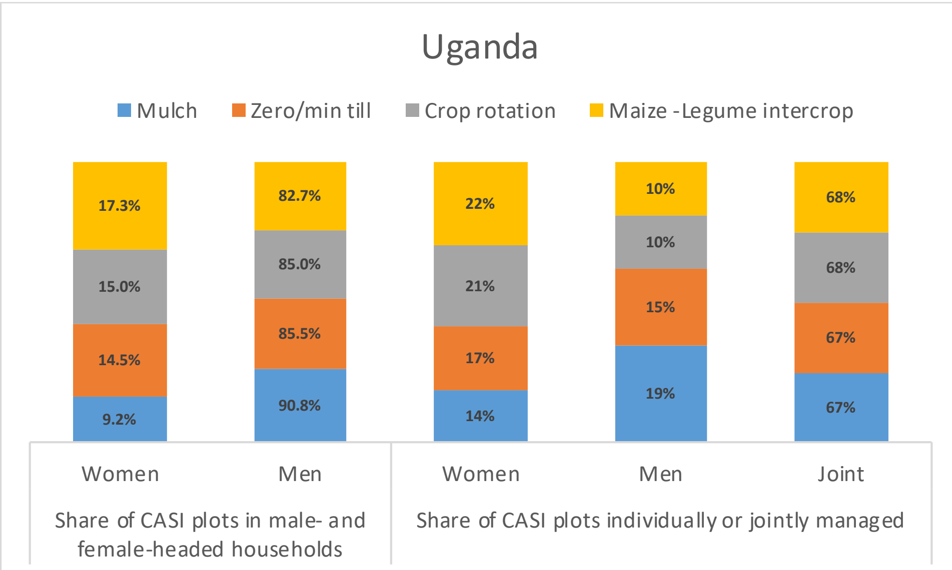


***Fig. 10:** Share of CASI plots by household headship and plot management*

In summary: Of all the countries Kenya seemed to have a more balanced application of CASI between joint and individually managed plots. A maximum of 48% of CASI plots were under joint management. Where the share of CASI plots was higher for women managed plots were higher than that of men managed plots, the plots tended to be under maize-legume intercrops or maize-legume rotations (Kenya, Malawi and Uganda) or under zero/min till (Kenya, Malawi and Tanzania). The preponderance of CASI plots on jointly managed plots is a function of the fact that most of the plots are jointly managed in the first place. However, it is noteworthy that that the share of CASI plots managed by women (depending on the specific practice) ranged from 5% (Rwanda) to 37% (Kenya). The gender implications can be surmised as follows. Most plots are jointly operated, so the share of CASI plots under joint management is consequence of that. adoption is higher on these. Other than Ethiopia, the *share of* CASI plots *managed plots* by women was often similar (sometimes nominally higher) than the share managed by men (e.g. KE, Malawi). The same is also true of share of CASI plots managed by male headed households. Although there are few clear differences based on plot manager between, the application of CASI mostly in jointly managed plots can suggest that labor-saving CASI options might benefit women. Women have been shown to be the main providers of sowing and weeding labor for example with labor contribution slightly above 50% in Malawi, Tanzania and Uganda (Palacios-Lopez, Christiaensen, and Kilic, 2015)[17]. The above results are driven by the fact that on average 85% of all households across the seven countries are male headed. In terms of plot management 64% are jointly managed and 36 individually managed by women (19%) and by men (17%). Therefore, nearly one fifth of all plots are managed by women and considering joint management, women therefore participate 83% of the time in the management of all plots (81% for men). It is clear to see why CASI research and extension should be inclusive and involve women at an equal rate with men because they equally share responsibilities in managing household plots, either as sole managers or jointly with spouses.

Table 4: Plot management and household headship by sex (proportions)

Country	Plot manager				Household head		
	Women	Men	Joint	N	Male	Female	N
Ethiopia	0.06	0.07	0.87	1526	0.87	0.13	873
Kenya	0.33	0.22	0.46	5292	0.76	0.24	807
Malawi	0.33	0.22	0.46	2906	0.87	0.13	624
Mozambique	0.16	0.25	0.59	2475	0.91	0.09	851
Rwanda	0.13	0.14	0.73	1090	0.79	0.21	289
Tanzania	0.13	0.15	0.72	1471	0.90	0.10	958
Uganda	0.18	0.14	0.68	1680	0.84	0.16	300
Total	**0.19**	**0.17**	**0.64**	**16440**	**0.85**	**0.15**	**4702**

[17] *Palacios-Lopez, A., Christiaensen, L., & Kilic, T. (2015). How much of the labor in African agriculture is provided by women?. The World Bank.*

3.4 Area under various CASI combinations

In this section, we summarise the proportion of the farm area that was under various CASI combinations conditional on adoption. In other words, given that a farmer adopted, many portions of their farm are under various CASI combinations. The general trend is that when various combinations are considered, the portion of the farm under CASI practice was fairly large. As presented below, this masks the fact that only a small portion of the plots had full combinations of CASI. Optimal combinations of CASI are what is needed for maximum yield and environmental impact (Manda *et. al*, 2015). Generally, maize–legume intercropping or rotations account for the bulk of the area under CASI.

In Ethiopia: Only 14% of the maize–legume (ML) area was not under any CASI practices. Conservation tillage in combinations with ML diversification and/or herbicide was implemented on 23% of the area. ML diversification (in various combinations) was found on 64% of the ML area (Fig. 11).

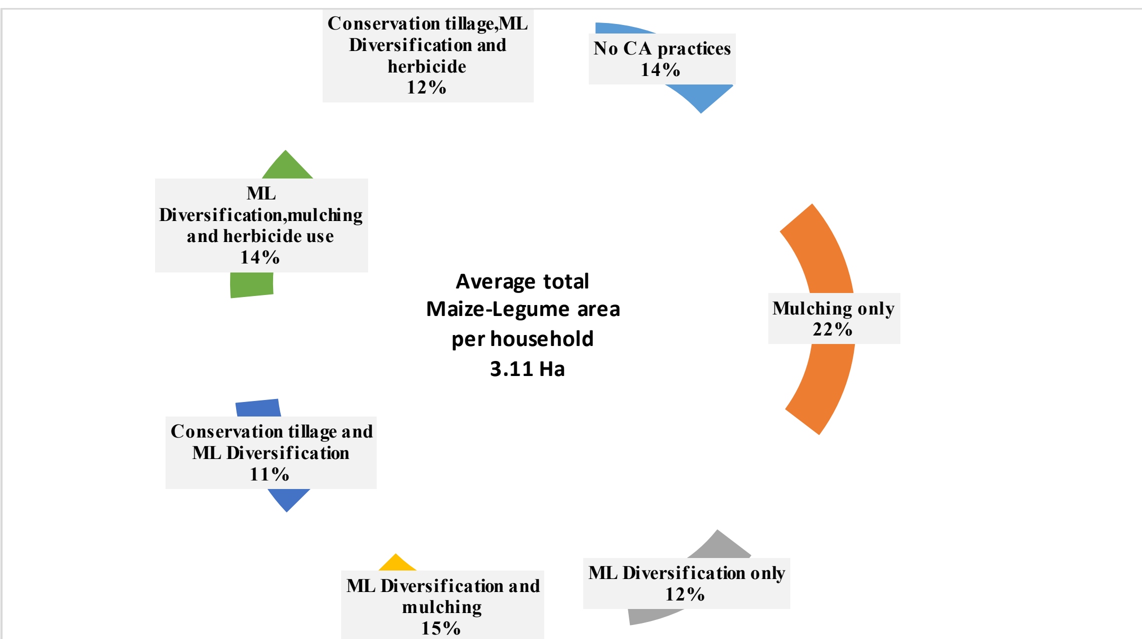


Figure 11. The proportion of maize–legume area under CASI combinations in Ethiopia

In Kenya: Conservation tillage (in various combinations) was followed on approximately 56% of the ML area. Moreover, 25% of the ML area was under at least 2 CASI practices. On average, 21% of the ML area in Kenya was under what can be called full CA application (with or without herbicide) (Fig. 12).

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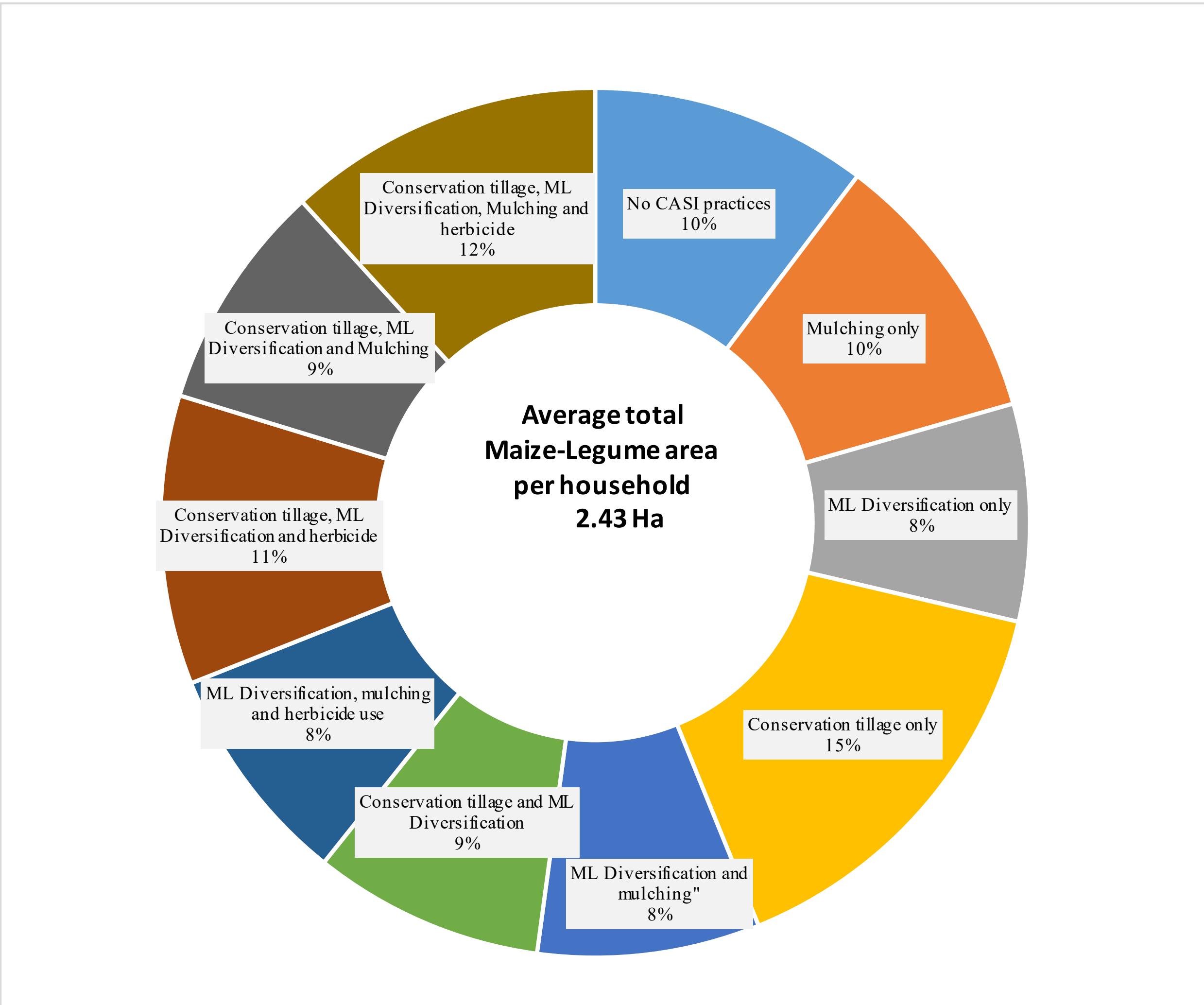


Figure 12. The proportion of maize–legume area under CASI combinations in Kenya

In Malawi: Full CA (with or without herbicide) was observed on 23% of the ML area. Conservation tillage (in various combinations) was observed in 35% of the ML area. In 67% of the ML area, at least 2 CASI practices were observed. ML diversification was observed in 79% of the ML area (Fig. 13).

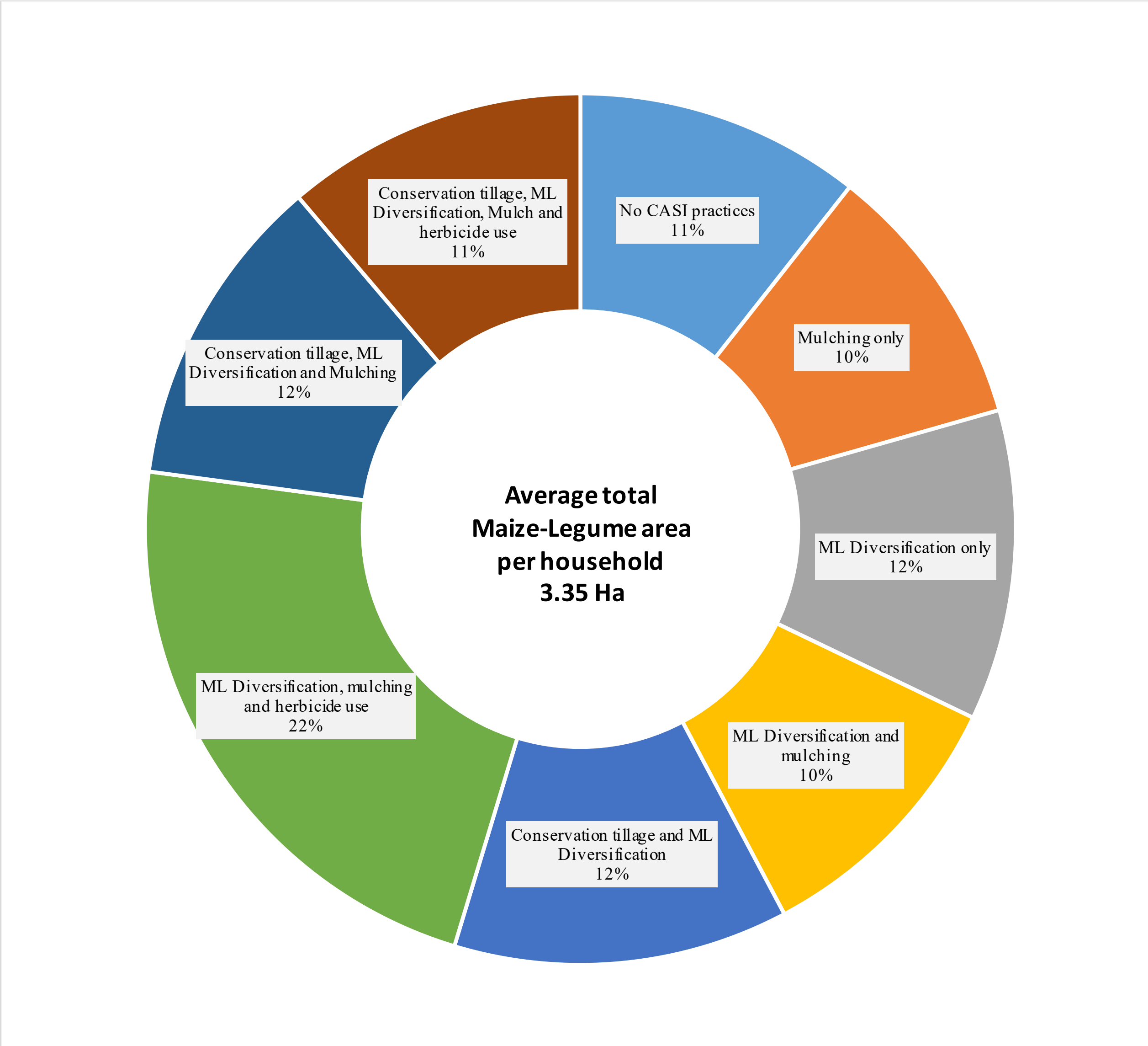


Figure 13 The proportion of maize–legume area under CASI practices in Malawi

<u>In Mozambique</u>: 28% of the ML area could be considered to be under full CA (14% being conservation tillage + mulching + ML diversification+ herbicide). Conservation tillage in various combinations could be found in 42% of the cultivated area. The implementation of at least two CASI technologies was found on at least 63% of the ML area. Mulching (in various CASI combinations) was observed on 62% of the ML area (Fig. 14).

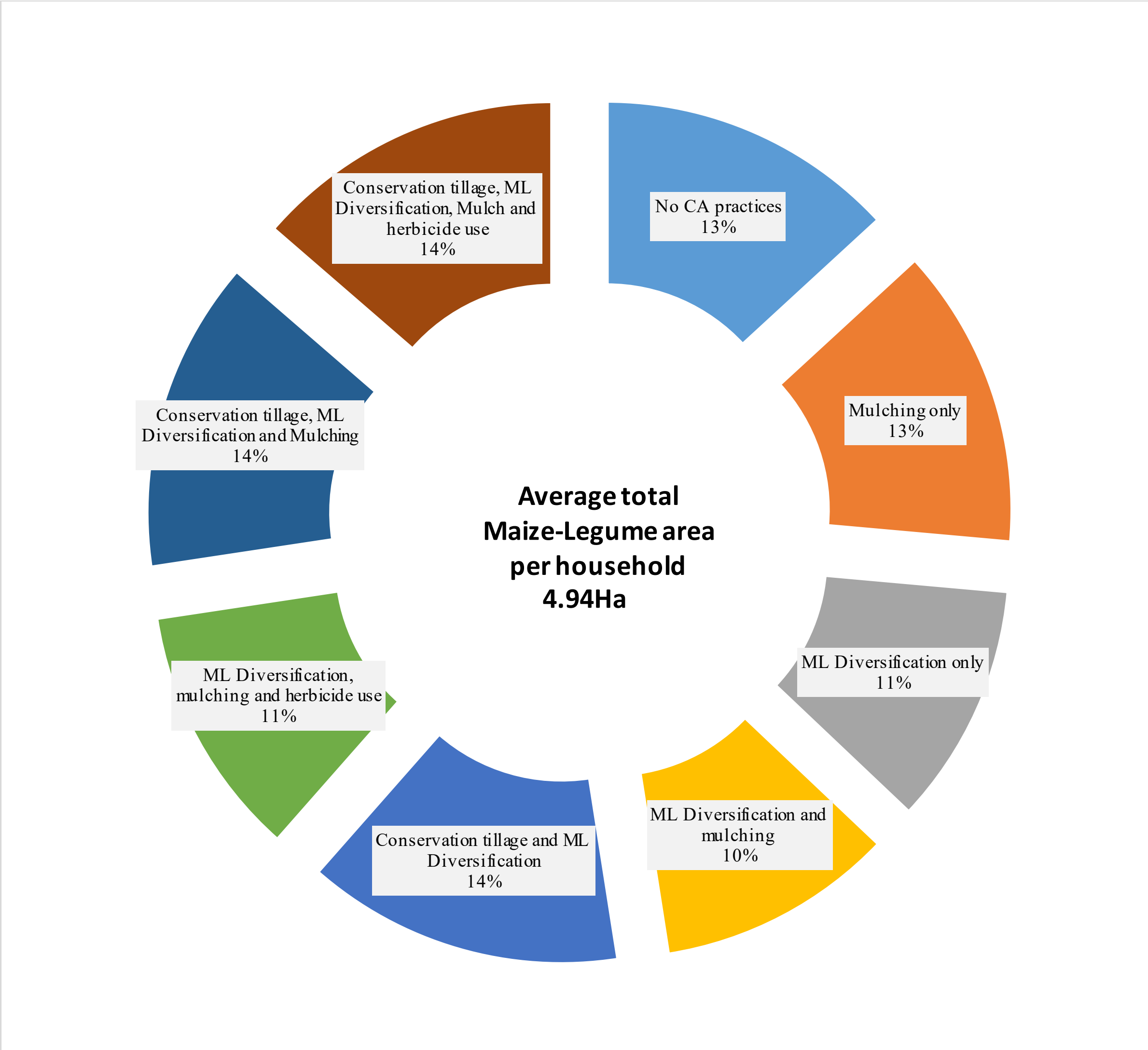


Figure 14. The proportion of maize–legume area under CASI practices in Mozambique

In Rwanda: 31% of the ML area was under full CA practices and 70% of the area was under at least two CASI practices. Mulching (in various combinations) was observed in 48% of the ML area, and 83% of the ML area was under at least one CASI practice (Fig. 15).

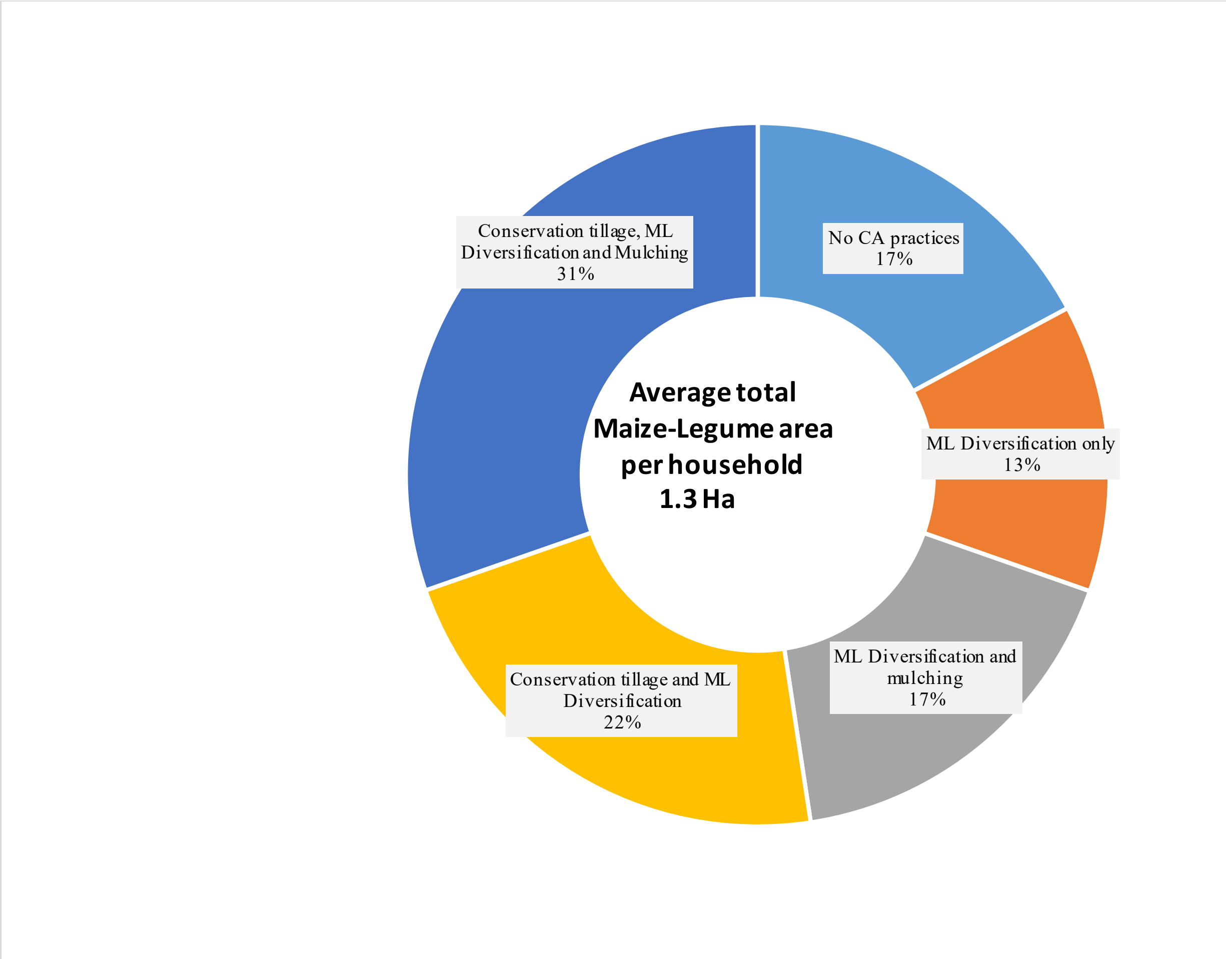


Figure 15. The proportion of maize–legume area under CASI practices in Rwanda

The area under conservation tillage with maize–legume diversification and mulching was still low and this requires the creation of more awareness of CASI technologies through established extension networks within the country.

In Tanzania: 17% of the ML area was under no CASI practices. Complete CA was on 15% of the ML area. 37% of the area was under two CASI practices and 52% was under 2–3 CASI practices (Fig. 16).

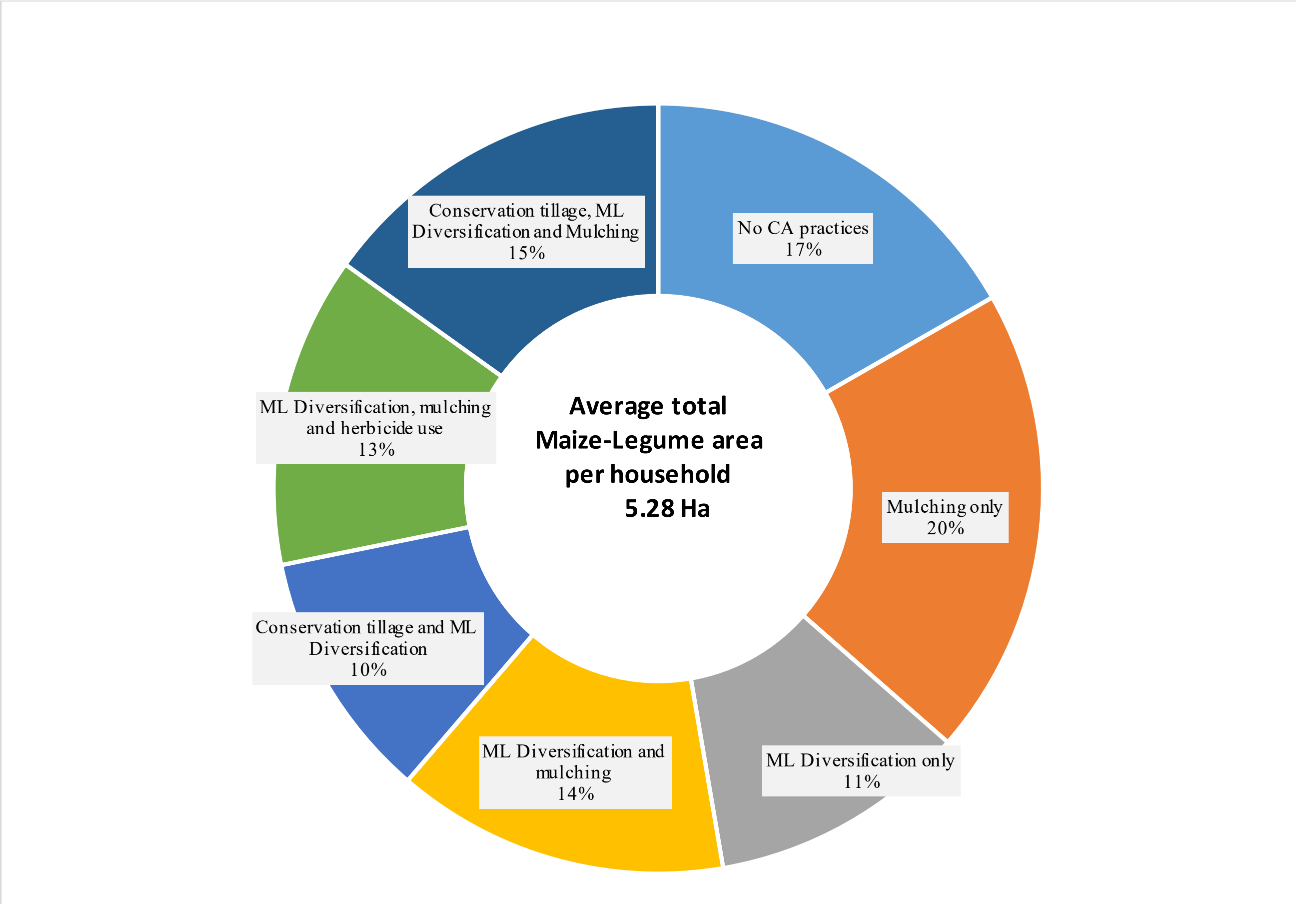


Figure 16 The proportion of maize–legume area under CASI practices in Tanzania

<u>In Uganda</u>: 8% was under no CASI practices and 29% was under full CA practices of CT + MLD + Mulching + herbicide. In the sampled households, 80% of ML area was under at least 2 CASI practices (Fig. 17).

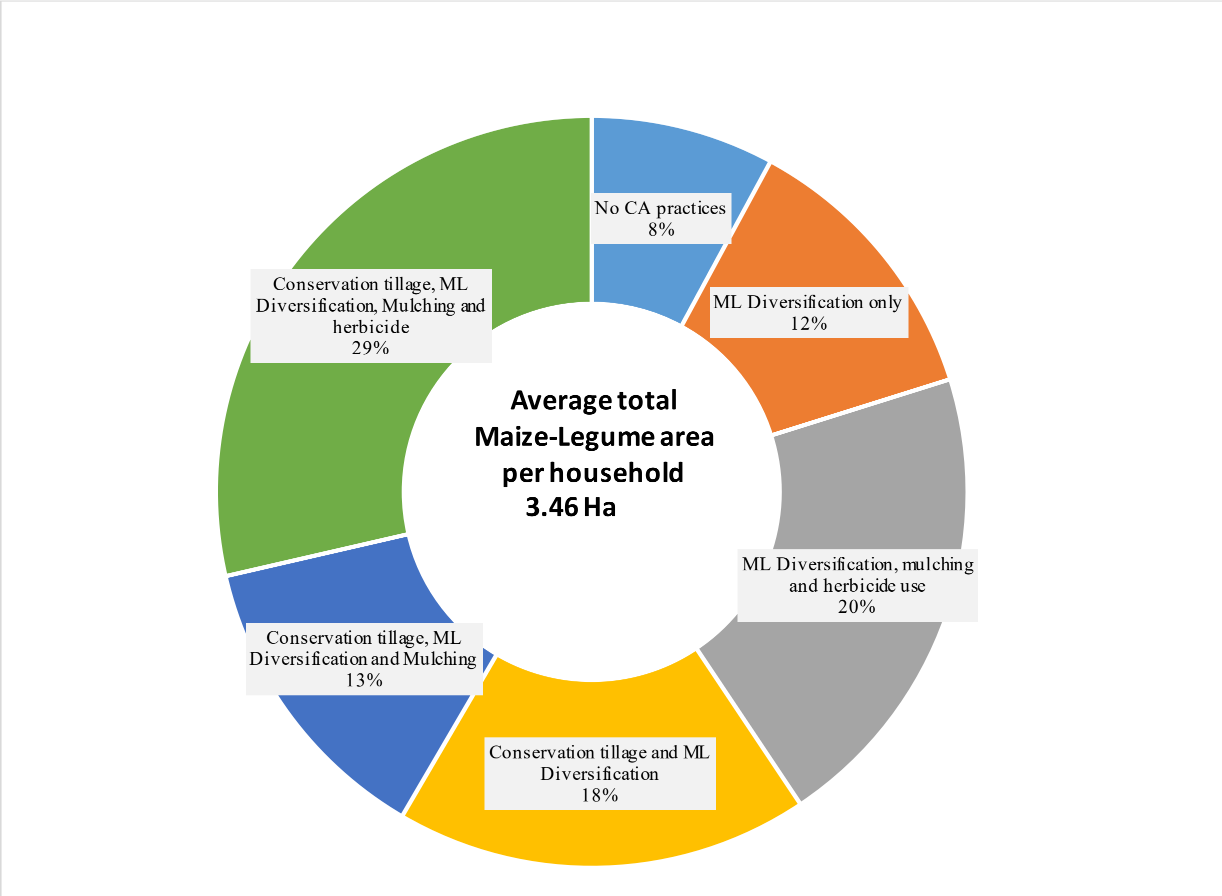


Figure 17. The proportion of maize–legume area under CASI practices in Uganda

3.5 Impacts on tillage labour

Figure 18 summarises the labour impacts of CASI practices.

Ethiopia: As expected, Conservation Tillage (CT) appears to have been a major driver of differences in labour between systems. On plots with CT, labour was reduced by 64% (75% when herbicide was used) perhaps during land clearing to reduce the need for tillage in seedbed preparation. The application of mulching in the absence of CT appears not to impact labour savings positively.

Kenya: Tillage labour savings were as much as 84% (CT+MLD+herbicide) and 80% for (CT+ MLD+ Mulch + herbicide). These savings appear to be related to the use of herbicides since labour savings are comparatively low (25%) for CT+MLD and 27% for mulching only. In conversations with the Kenya team, it seems that the use of herbicides may not gain much policy traction (interest). Therefore, alternative cost-effective weed management techniques in CA systems need to be identified.

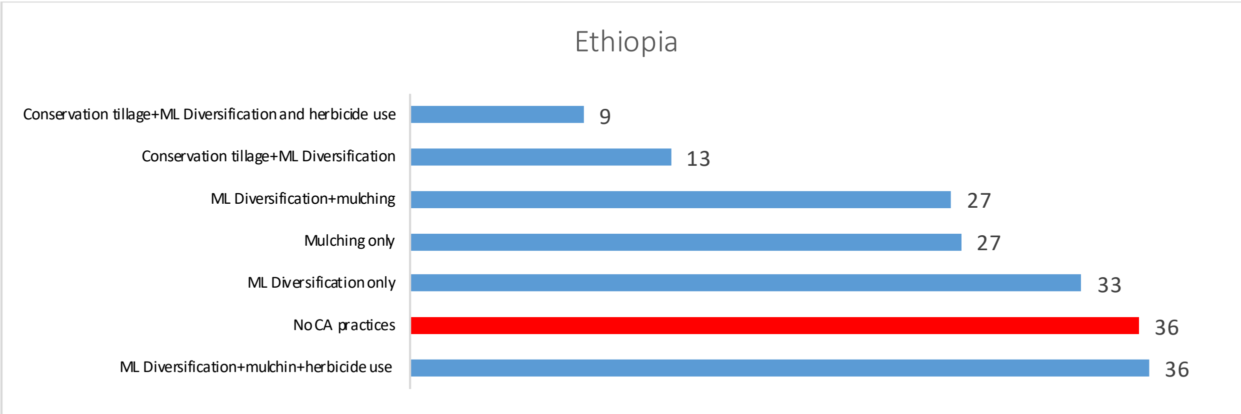
Malawi: Large labour savings were possible with CT + MLD + Mulch + Herbicide (62%) and 45% in the case of both CT + MLD and CT + MLD + Mulch combinations. In fact, labour usage was highest (29 person-days per ha) in plots where mulching was the only CASI practice observed suggesting that tilling and then mulching the plot is a labour-intensive practice. It is understandable if the stubble is cleared, set aside and then returned as mulch.

Mozambique: Labour savings were 32–36%whenever CA-relevant practices were implemented though Mulching + MLD had the least labour savings (5%). Although comparatively lower (compared to the other countries), these indicative savings are not trivial.

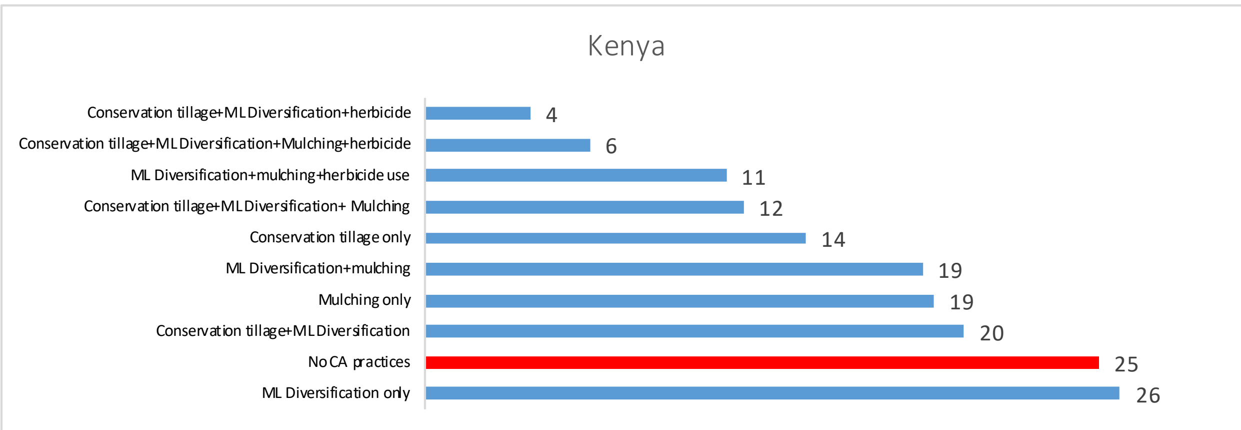
Rwanda: The two types of combinations observed led to 77% (CT + MLD + Mulching) and 82% labor reduction (CT + MLD). This seems to agree with the labor data from Kenya, Ethiopia and Malawi where mulching appears to be a labor increasing practice unless herbicides or reduced tillage are in the picture.

Tanzania: The highest labour usage was observed on plots with MLD + mulch + herbicide. But in the case of CT + MLD, the labour usage was 5 person-days/ha, an 86% labor reduction compared to the CT + MLD and 76% reduction compared to plots with no CA related practices (which had a tillage labor usage of 21 person-days per ha). The correlation between mulch and high labor requirements appear to be repeated in Tanzania.

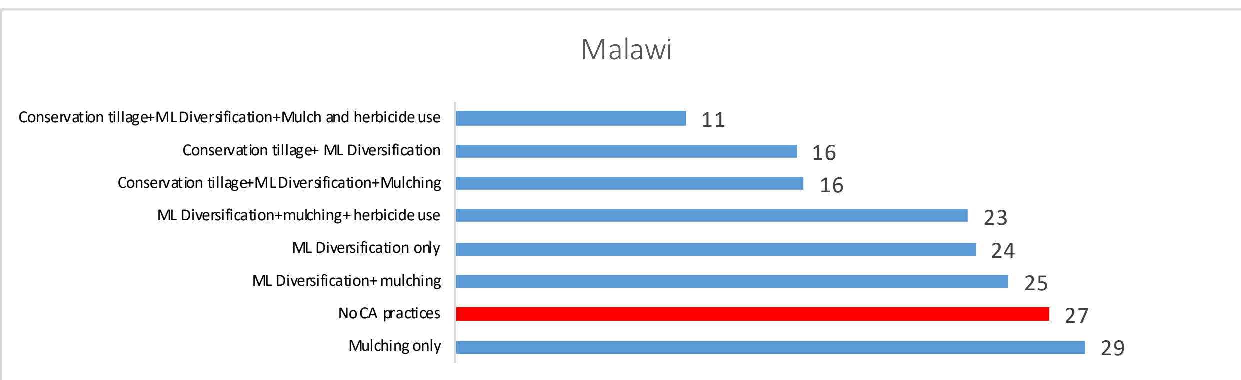
Uganda: Reductions of about 50% (CT+ MLD+ Herbicide), 54% (MLD + Mulch + Herbicide) and 86% (CT + MLD + mulch + herbicide) compared to no CA practices were observed. In all cases for Uganda, observations had herbicide inputs.



Ethiopia
Conservation tillage+ML Diversification and herbicide use
Conservation tillage+ML Diversification
ML Diversification+mulching
Mulching only
ML Diversification only
No CA practices
ML Diversification+mulchin+herbicide use
9
13
27
27
33
36
36



Kenya
Conservation tillage+ML Diversification+herbicide
Conservation tillage+ML Diversification+Mulching+herbicide
ML Diversification+mulching+herbicide use
Conservation tillage+ML Diversification+ Mulching
Conservation tillage only
ML Diversification+mulching
Mulching only
Conservation tillage+ML Diversification
No CA practices
ML Diversification only
4
6
11
12
14
19
19
20
25
26



Malawi
Conservation tillage+ML Diversification+Mulch and herbicide use
Conservation tillage+ ML Diversification
Conservation tillage+ML Diversification+Mulching
ML Diversification+mulching+ herbicide use
ML Diversification only
ML Diversification+ mulching
No CA practices
Mulching only
11
16
16
23
24
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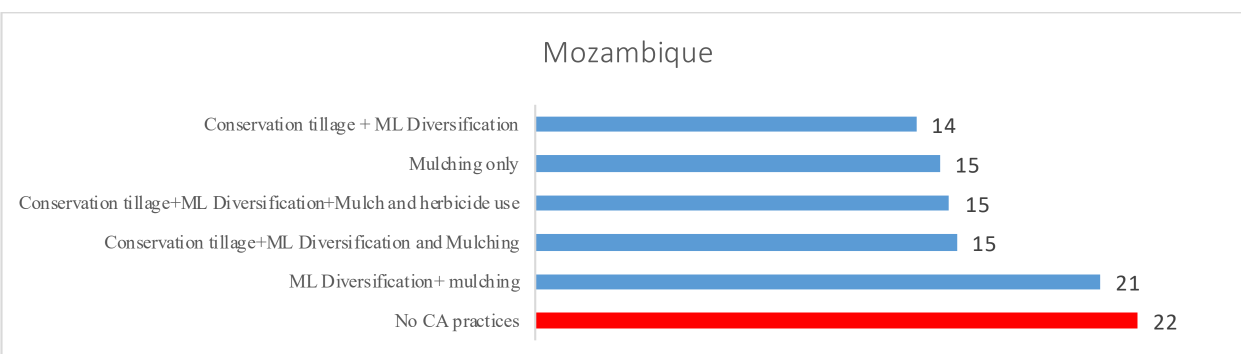

Mozambique
Conservation tillage + ML Diversification
Mulching only
Conservation tillage+ML Diversification+Mulch and herbicide use
Conservation tillage+ML Diversification and Mulching
ML Diversification+ mulching
No CA practices
14
15
15
15
21
22

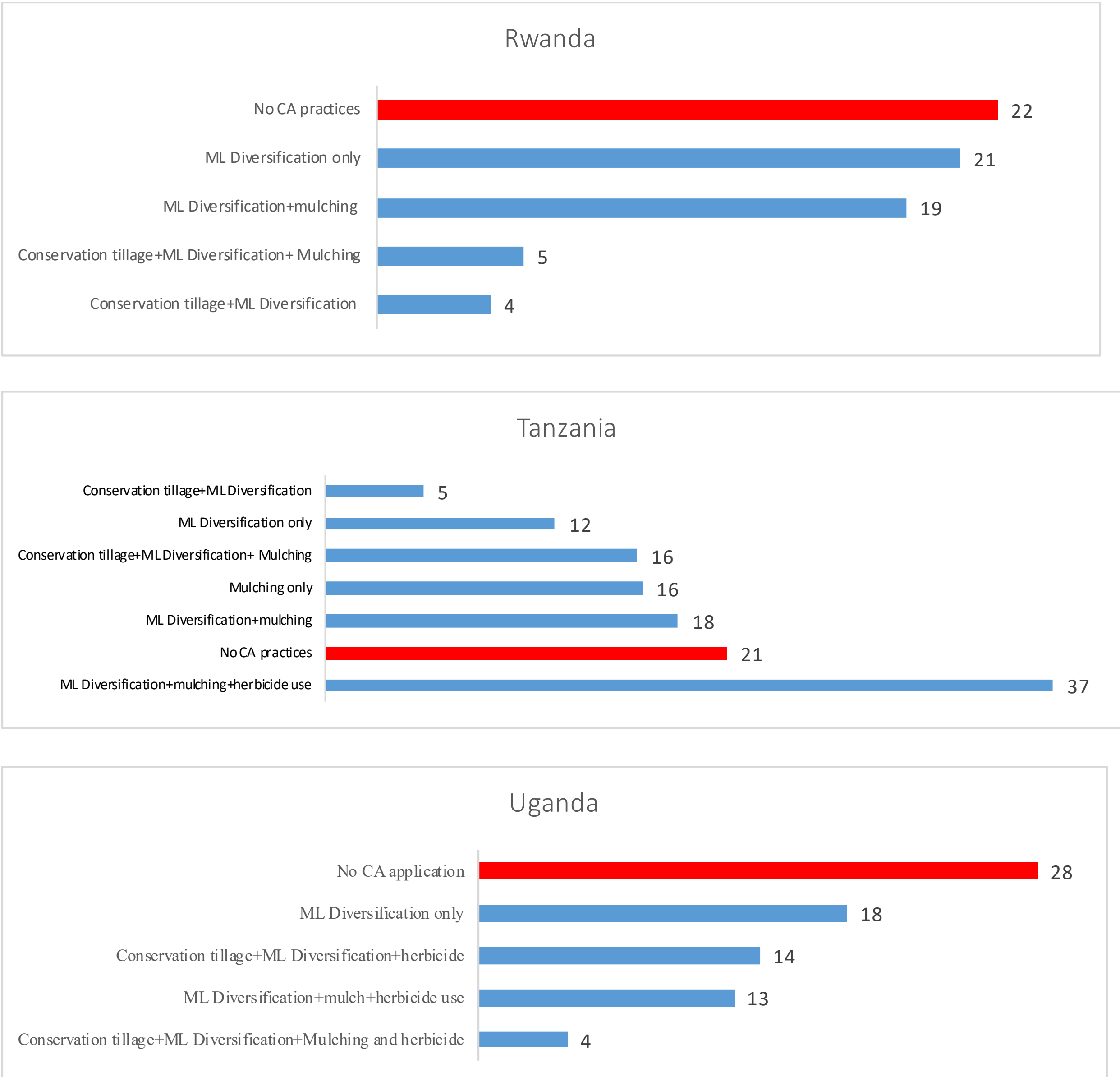

Figure 18. Impacts of CASI combinations on tillage labour by country 2017/18 season (Person-days/ha)

3.6 Aggregated impacts of SIMLESA program

The economic impact of CASI practices could only be realised when and if CASI is widely diffused and adopted. Adoption, as defined by Rogers (2003), is a decision of full use of an innovation as the best course of action available while diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. Diffusion itself emanates from individual farmer's decisions to adopt upon the careful comparison of benefits vis-a-vis their costs.

Setting up of CASI demonstrations plots in the villages provided the necessary information and knowledge about conservation agriculture and significantly reduced farmers' learning costs. In a couple of seasons, some farmers were persuaded to actively participate in project activities; some hosted the demonstrations on their farms. This helped in spreading the benefits of CASI in communities and in attracting more farmers at first and gained momentum with support from the project partners. The rate of adoption of CASI over time was varied since project inception. The small number of early adopters were mostly opinion leaders and lead farmers in the communities. These were central to the spread of CASI and to influencing early majority adopters in communities. However, to achieve an early majority, there's a need to diversify adoption pathway strategies including sustained investments in scaling out and mainstreaming CASI in the National Government's Agricultural Extension Program. We consider the impacts of CASI adoption on yields, costs, area and adopting population and labour in subsequent subsections.

Summary of the packages for CASI

Since farmers seek to optimise their production by combining various technologies in a plot, we disaggregated our analysis into 3 common combinations observed in the region: Partial CASI 1: Comprised of plots under minimum/zero tillage and maize–legume diversification (M/ZT+ML). Partial CASI 2: Comprised of plots under minimum/zero tillage and mulch (M/ZT+MULCH). Full CASI: Comprised of plots under minimum/zero tillage, maize–legume diversification and mulch (M/ZT+MLD+MULCH).

Partial CASI 1 refers to a situation where a farmer practices zero/minimum tillage with the combination of maize–legume diversification on the same plot. Note that maize–legume diversification entails maize–legume intercropping and rotation on the same plot in subsequent seasons.

Partial CASI 2 is a combination of zero/minimum tillage and use of mulching on the same plot for the production of maize and legume. Mulching has broadly been used to include plots that had cover crops planted or residue retained after harvesting for moisture and soil structure preservation.

Full CASI is a combination of all conservation agriculture principles. This entails the combination of zero/minimum tillage, maize–legume diversification and mulching either with or without herbicide application.

3.6.1 Benefit-cost ratios of CASI practices

We estimated the benefit-cost ratios of CASI when applied to maize–legume plots. During production, farmers benefit from group and social networks amongst themselves thereby minimising their production costs thus the study could not capture the opportunity costs and in-kind payments but rather only the cash costs incurred in production. The cash costs included costs for seeds, fertilisers, manure, hired machinery and labour. We relied on officially published FAO data for prices of maize across the countries (FAOSTAT, 2017) and December 2018 foreign exchange rate between the local currency and US dollar.

We begin by considering the total harvested maize output under various CASI combinations as shown in table 3. Under Partial CASI 1 (M/ZT+ML combination), the maize output per hectare was 4.3MT/ha in Ethiopia (the highest in Eastern Africa) followed by Uganda and Rwanda which had the least yields of 1.3MT/ha. Smallholder maize production under Partial CASI 2 (M/ZT+MULCH combination) had equally better yields with Ugandan farmer harvesting 3.8MT/ha. Under the application of full CASI (M/ZT+MLD+MULCH) practices, maize output was the highest in Ethiopia (3.9MT/ha) followed by both Kenya and Malawi producing 3.6MT/ha. Spillover countries like

Rwanda and Uganda witnessed better yields under CASI compared to baseline yields which justifies the importance of adopting resource-saving technologies like CASI compared to conventional technologies for smallholder farmers for improved household nutrition and food security.

Most smallholder incomes are revenues generated from the sale of farm produce. In Sub-Saharan Africa, agriculture accounts for about 70 percent of rural household income, rural non-farm activities for about 20 percent, and transfers for about 10 percent (Word bank, 2015). It is on this basis that farmers seek out for best production practices that can guarantee optimum profits at the least production cost possible[18]. Given prevailing agricultural commodity prices across the region, maize retailed at better prices in Rwanda, Mozambique, and Malawi compared to the rest.

[18] It is understandable that in risky production environments and limited market access, many farmers may have safety-first behavior. Thus, some farmers may opt for stable but low yielding practices as opposed to profit maximisation as is commonly understood.

Table 5. Impact of technology combinations on yields and costs.

Country	Harvested Quantities (Kgs) per hectare			Price (USD/ Ton) FAOSTAT (2017)	Gross revenue per hectare (USD)			Cash costs per hectare (USD)			Gross margins (USD)			Benefit-cost ratio		
	Partial CASI 1	Partial CASI 2	Full CASI		Partial CASI 1	Partial CASI 2	Full CASI	Partial CASI 1	Partial CASI 2	Full CASI	Partial CASI 1	Partial CASI 2	Full CASI	Partial CASI 1	Partial CAS 2	Full CASI
Ethiopia	4,286		3,937	186	797	-	732	190	0	91	607	-	641	4.19		8.02
Kenya	2,640	1,052	3,631	292.5	772	308	1,062	330	275	245	443	32	817	2.34	1.12	4.34
Malawi	1,339	2,712	3,621	304.2	407	825	1,102	142	209	296	266	616	806	2.88	3.95	3.73
Mozambique	1,802	1,596	2,356	383.1	690	611	903	131	79	136	559	532	767	5.27	7.74	6.65
Tanzania	1,800	789	2,191	197.8	356	156	433	207	101	164	149	55	270	1.72	1.55	2.65
Uganda	3,494	3,839	1,079	180	629	691	194	147	162	157	482	529	37	4.27	4.27	1.24
Rwanda	1,595	1,394	1,556	418	667	583	650	170	91	188	497	492	462	3.93	6.40	3.46
Cross country Average	**2,422**	**1,897.00**	**2,624**	**280**	**617**	**529.00**	**725**	**188**	**131**	**182**	**429**	**376**	**543**	**3.51**	**4.17**	**4.30**

Disaggregated comparison of gross revenue per hectare under maize production reveals higher returns in Ethiopia ($797) and Kenya ($772) under zero/minimum tillage and maize–legume diversification. Under similar combinations, Tanzanian farmers had the lowest returns ($356) per hectare which appear related to high production cost per hectare coupled with low maize prices per ton. The FAOSTAT (2017) data shows that farm gate prices were lowest in Tanzania (see table 5 above). However, note that Kenyan smallholder farmers had the highest production cash cost per hectare across the region under partial CASI combinations. The gross revenue under full CASI practices per hectare was $1,102 in Malawi followed by Kenya ($1,062).

3.6.2 Gross margins and benefit-cost ratios

Ethiopian smallholder farmers had the highest gross margins per hectare under partial CASI (M/ZT+ML) followed by Mozambique ($559) as shown in table 3. Kenya had the lowest gross margins under partial CASI (M/ZT+MULCH) with smallholder farmers earning $32 followed by Tanzania $55 per hectare net cash expenses. Adoption of full CASI practices had better returns per hectare compared to the other 2 combinations across SIMLESA countries except for Uganda and Rwanda. For instance, a smallholder farmer in Ethiopia would earn $641 per hectare per season under full CASI with an average production cost of $91. Despite Ethiopia having the least production cost per hectare, smallholder farmers in Kenya, Malawi, and Mozambique earned more in gross margins compared to its farmers, notwithstanding the steep production cost outlay they faced.

The Benefit-Cost Ratio (BCR) for adopting M/ZT+ML practices was higher in Mozambique (5.27) compared to Tanzania (1.72). This implies that quantitatively (monetary), the benefits that accrue to smallholder farmers per hectare in Mozambique significantly outweigh associated production costs. Thus, the farmers earn $5.27 for each $1 spend while a Tanzania farmer earns $1.72 for each dollar spent on costs. This combination was more profitable and promising among smallholder farmers in Mozambique, Ethiopia, and Uganda.

The BCR for adopting M/ZT+MULCH combination was highest in Mozambique, followed by Rwanda and Uganda. However, its costs almost outweigh associated benefits and are therefore not profitable for most farmers in Kenya and Tanzania as evidenced by a BCR of 1.12 and 1.55 respectively. BCR analysis favours the adoption of full CASI practices in all the countries except for Uganda with Ethiopian farmers, being the greatest beneficiaries earning $8.02 for every $1 spend on production, followed by Mozambique, Kenya, Malawi, Rwanda, Tanzania and Uganda as shown in table 5.

3.6.3 Aggregate CASI adoption

It is critical to tease out the actual number of farmers adopting the technologies in the respective countries and the region. To achieve this, we used the latest FAOSTAT (2017) on farming populations in rural areas. We then estimated the number of farmers in target agro-ecological zones typified by the SIMLESA project to be 35% of the number of farmers in each country. From survey data (2018), the computed proportion of CASI adopters in project zones of influence was about 12% which was also representative of about 0.48 ha per farming household on average in the region as shown in Table 6 below.

Table 6. Computed farming population and area under CASI in SIMLESA zones

Country	Rural population in SIMLESA agro-ecological zones (FAOSTAT, 2017)	Households in SIMLESA agro-ecological zones	Farming population National FAOSTAT, 2017)	Enumerated maize area in SIMLESA zones (Ha)	Average area under CASI (ha)			Mean area under at least 2 CASI combination per household
					Partial CASI 1	Partial CAS 2	Full CASI	
Ethiopia	82,727	16,545	16,545,400	785.07	0.34		0.76	0.55
Kenya	36,150	7,230	7,230,000	871.27	0.21	0.26	0.20	0.22
Malawi	15,259	3,052	3,051,800	440.2	0.40	0.29	0.41	0.37
Mozambique	19,114	3,823	3,822,800	1056.2	0.65	0.82	0.64	0.70
Rwanda	9,071	1,814	1,814,200	183.47	0.24	0.20	0.39	0.28
Tanzania	37,131	7,426	7,426,200	1443.9	0.55	0.82	0.76	0.71
Uganda	35,634	7,127	7,126,800	263.43	0.33	0.91	0.36	0.53
ESA			**47,017,200**	**5,043.54**	**0.39**	**0.55**	**0.50**	**0.48**

The annual adoption growth rates of the 3 CASI combinations are shown in Table 7 below with an average of 3.8 in the region for partial CASI1, 1.7% for partial CASI2 and 3.2% for full CASI. Malawi, Kenya, Mozambique and Uganda had the highest adoption growth rates with an average of 4.2% compared to the regions and an indication of concerted efforts by SIMLESA extension networks in these countries.

Table 7. Impact of technology combinations on adopting farmer populations[A]

Country	Annual adoption growth rates			Farming population (FAOSTAT, 2017)	The proportion of CASI adopters (survey)			The population of CASI adopters			
	Partial CASI 1	Partial CASI 2	Full CASI		Partial CASI 1	Partial CAS 2	Full CASI	Partial CASI 1	Partial CAS 2	Full CASI	Total adopters
Ethiopia	2.3%	0.4%	1.7%	16,545,400	1.8%	0.0%	3.6%	12,508	-	25,017	37,525
Kenya	4.9%	2.9%	4.4%	7,230,000	16.2%	2.9%	18.9%	49,193	8,806	57,392	115,391
Malawi	5.1%	3.0%	4.6%	3,051,800	13.6%	3.0%	22.6%	17,432	3,845	28,968	50,245
Mozambique	4.3%	3.3%	4.1%	3,822,800	11.7%	11.3%	36.1%	18,785	18,143	57,961	94,890
Rwanda	2.3%	1.1%	2.0%	1,814,200	5.8%	2.7%	6.2%	4,419	2,057	4,724	11,201
Tanzania	2.8%	-0.4%	1.5%	7,426,200	4.6%	1.9%	7.2%	14,347	5,926	22,457	42,730
Uganda	4.9%	2.1%	3.9%	7,126,800	24.9%	4.2%	15.1%	74,532	12,572	45,198	132,302
ESA	3.8%	1.7%	3.2%	47,017,200				191,217	51,350	241,717	484,283

[A]For the steps used in computing the adoption numbers in Table 7, please see Box 1 below

Adoption of CASI1 combinations was common among Ugandan smallholder farmers (25%) compared to 1.8% in Ethiopia while Mozambique had the most farmers adopting CASI2 combinations. Mozambique Malawi and Kenya had the highest proportion of smallholder farmers adopting full CASI practices.

The actual population of farmers adopting full CASI practices was the highest in Mozambique (57,961) followed by Kenya (57,392) while Rwanda had the least (4,724) as shown in table 7. The total number of adopters of at least any two combinations of CASI practices across the region was 484,283 with Uganda and Kenya having the highest adopters followed by Mozambique and Malawi.

Box 1: Computation of CASI adopters in Eastern and Southern Africa

A) We summed the rural population in respective countries as reported by FAOSTAT (2017). Note that the average household has 5 members. Thus, we divided the total rural population by 5 to calculate the total number of households.

B) The farming households are assumed to be 35% of the rural households in agro-ecological zones where SIMLESA was implemented.

C) To get the adopters of CASI in each country (adopters national), we multiplied the number of farming households by the adoption rate of full CASI practices as computed from the SIMLESA benefits survey of 2018. Note that the average adoption rate of full CASI was 12%.

D) To compute the number of those adopting in each project trial and scaling sites, we multiplied the number of adopters nationally by the average proportion of adopters in each trial site.

E) The reported number of CASI adopters in table 6 for ESA is based on national computation in C.

3.6.4 Aggregate maize area under CASI

Using FAOSTAT (2017) data on areas under maize in 7 countries, we estimated the total area under specific CASI combinations as defined in the previous section. We then computed the maize area in each agro-ecological zone typified by the SIMLESA project as 35%. The computed average proportion of area under CASI practices with maize in these agro-ecological zones and districts was 9%. Disaggregating by specific CASI combinations revealed that the proportionate maize area under CASI 1 was 12.9% in Rwanda, followed by Mozambique (9.3%), Malawi (8.5%) and Kenya (7.8%) while Tanzania had the least (3.6%). The actual total maize area under M/ZT+ML combinations was highest in Mozambique (5,362.1ha) followed by Kenya, Ethiopia, Tanzania, Malawi, Uganda and Rwanda as shown in Table 8 below.

Table 8. Estimated area under of maize area under CASI[A]

Country	Maize area (FAOSTAT, 2017)	The proportion of CASI area in SIMLLESA zones (survey 2018)			The area under CASI in 2017/18			
		Partial CASI 1	Partial CAS 2	Full CASI	Partial CASI 1	Partial CAS 2	Full CASI	Total
Ethiopia	2,173,543	7.5%	0.0%	16.7%	5,135.0	0	11,433.9	16,568.9
Kenya	2,092,459	7.8%	9.6%	7.6%	5,141.2	6,327.6	5,009.3	16,478.1
Malawi	1,725,367	8.5%	6.2%	8.6%	4,619.7	3,369.6	4,674.0	12,663.3
Mozambique	1,830,368	9.3%	11.6%	9.1%	5,362.1	6,688.2	5,246.7	17,297.0
Rwanda	297,447	12.9%	10.6%	20.8%	1,208.7	993.2	1,948.9	4,150.7
Uganda	1,185,006	7.2%	10.7%	9.9%	2,687.6	3,994.1	3,695.4	10,377.1
Tanzania	4,093,984	3.6%	9.7%	3.8%	4,642.6	12,509.2	4,900.5	22,052.2
ESA	13,398,174				28,796.7	33,881.8	36,908.9	99,587.4

[A]For the steps used in computing area under CASI in Table 8, please see Box 2 below

The actual area under full CASI was highest in the Eastern and Southern Africa (36,908.9 ha) compared to the area under partial CASI 2. Ethiopia recorded the highest full CASI adoption by area followed by Mozambique and Kenya. This could be attributed to widespread adoption mulching and maize–legume diversification among smallholder farmers. Rwanda had the least total area under full CASI practices as noted by low zero/ minimum tillage adoption. Despite Tanzania having low adoption rates of specific technology combinations, its smallholder farmers registered the highest total area under CASI as evidenced by 22,052.2 ha followed by Mozambique, Ethiopia, and Kenya respectively. A total of 99,587.4 ha is extrapolated to be under CASI practices in the region. This represents about 1% of the total maize area. In the project sites, a total of 5,043.54 ha was recorded out of which 48% (2,420 ha) were under at least two CASI practices.

Box 2: Computation of Area under CASI in Eastern and Southern Africa

A) We sum the total maize area in the respective countries as reported by FAOSTAT (2017).

B) Maize area in agro-ecological zones is assumed to be 35% of arable land in rural areas where SIMLESA was implemented.

C) To get the area under CASI in each district and SIMLESA zones we multiply maize area by average proportion of area under full CASI as computed from SIMLESA benefits survey of 2018. Note that average proportion of land area under full CASI was 9%.

D) To compute the area under full CASI in each project trial and scaling sites: we multiply the maize area under full CASI at district level by proportion of area under CASI in the trial sites as typified by SIMLESA (35%).

E) Reported area under full CASI adopters in table 7 for ESA are based on maize area in project villages as captured in the survey.

4. SUMMARY AND CONCLUSIONS

When considered from the perspective of the adoption of at least one CASI technology, only a minority of farmers (maximum of 32%) in the project sites had not adopted any of the CASI practices. It is encouraging that the adoption rate of conservation tillage (in combination with other CA practices) was as much as 43% in Uganda (40% in Malawi). Conservation tillage is an important part of CA. The area under at least two CASI practices (*and involving CT*) was between 9–29% percent. Given the novelty of the CASI practices, both the headcount rates of adoption and the area allocations suggest high levels of success for the SIMLESA project. The adoption potential exists, especially with the right scaling investments. The challenge is to expand this process more widely in the years to come.

5. REFERENCES

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