ENHANCING AGRICULTURAL RESILIENCE AND SUSTAINABILITY IN EASTERN AND SOUTHERN AFRICA

Key Findings and Recommendations for Tanzania

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TARI Transforming Agriculture

CIMMYT

SIMLESA
Sustainable Intensification of Maize and Legume Systems for Food Security in Eastern and Southern Africa

Australian Government
Australian Centre for International Agricultural Research

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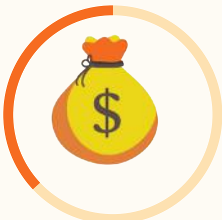
List of Acronyms

ACIAR	Australian Centre for International Agricultural Research
AIP(s)	agricultural innovation platform(s)
CASI	conservation agriculture-based sustainable intensification
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ILRI	International Livestock Research Institute
NGOs	nongovernmental organizations
QAAFI	Queensland Alliance for Agriculture and Food Innovation, University of Queensland, (Australia)
SIMLESA	Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa
TARI	Tanzania Agricultural Research Institute

AGRICULTURE IN TANZANIA

Agriculture is the backbone of Tanzania's economy, accounting for about one-third of the country's gross domestic product (GDP), providing livelihoods for more than 80 percent of the population [1], and contributing 85 percent of all exports. Food insecurity remains the major challenge in Tanzania 424,136 people (7% of the total) in 21 councils were identified to be food and nutrition insecure. 9,916.9 MT of maize equivalent was recommended for this population between March and April, 2015. However, 1,148,288 people were projected to be food insecure in May 2015 [2, 3]. The major risks smallholder farmers face are related to climate change (drought, excessive rainfall), outbreaks of diseases and pests, and lack of access to improved technologies. It is expected that extreme drought and flooding will become more frequent, intense and unpredictable in future [4]. It is projected that by 2050, yields of maize, sorghum and rice will fall by 13, 8.8 and 7.6 percent, respectively, due to climate change [5]. Market-related risks include lack of access to both inputs and outputs, price volatility and unreliable markets for agricultural goods. Financial risks include increased input costs and lack of adequate cash or credit [6]. This calls for adoption of climate-smart agriculture, emphasizing sustainable intensification in cropping systems.



Agriculture accounts for about

33%

of the country's gross domestic product

It provides livelihoods for more than

80%

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And it contributes

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A New Approach to Agriculture

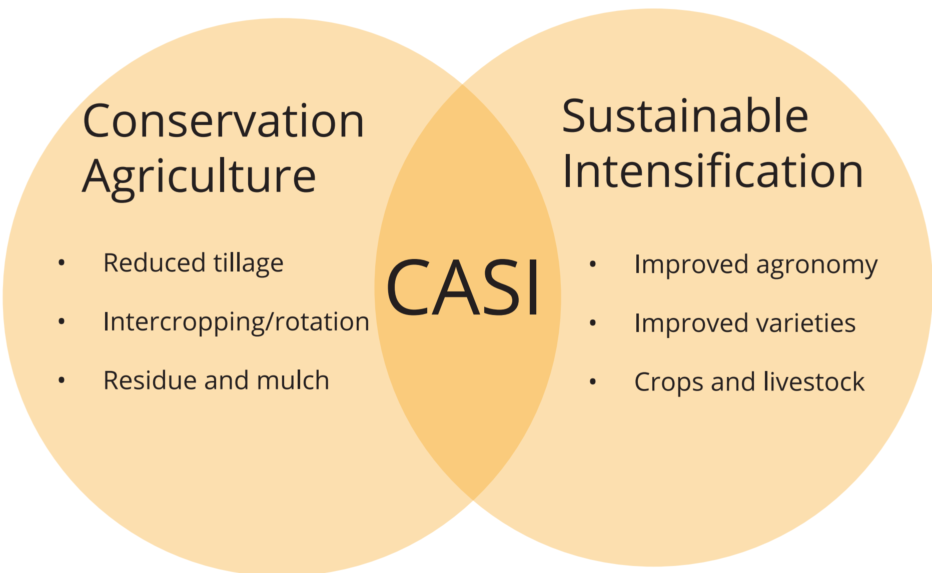
Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) was a project implemented between 2010 and 2018 in five African countries (Ethiopia, Kenya, Malawi, Mozambique and Tanzania) and two spillover countries (Rwanda and Uganda). The project's goal was to increase African smallholders' food security, productivity and income levels by integrating sustainable intensification practices to increase productivity, while simultaneously protecting the natural resource base. The particular mix of technologies developed by SIMLESA are known as "conservation agriculture-based sustainable intensification," or CASI (Fig. 1). By utilizing 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.

The project — financed by the Australian Centre for International Agricultural Research (ACIAR) — was led by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with numerous partners, including national agricultural research institutes (NARIs), in this case, the Tanzania Agricultural Research Institute (TARI); CGIAR centers, such as the International Center for Tropical Agriculture (CIAT), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the International Livestock Research Institute (ILRI); and the Queenland Alliance for Agriculture and Food Innovation (QAAFI) of the University of Queensland, Australia.

Project Overview

SIMLESA undertook onfarm research in different agro-ecological zones to assess the benefits of conservation agriculture-based sustainable intensification and to develop appropriate technology packages for smallholder farmers. The project succeeded in increasing the range of maize, legume and fodder/forage varieties available, and involved farmers in seed-selection trials so they could identify their preferences. SIMLESA helped establish agricultural innovation platforms (AIPs) to progress members — including farmers, seed producers, agro-input dealers, nongovernmental organizations (NGOs) and extension workers — along the value chain. The platforms serve farming communities, help mobilize resources, and support up- and out-scaling. SIMLESA also provided training and capacity strengthening for national agricultural research systems and worked with government, business and civil society organizations to provide an enabling environment for the benefits of the newly introduced technologies to be realized by farmers.

Figure 1. Conservation agriculture based on sustainable intensification



Source: SIMLESA-Tanzania.
Note: Improved agronomy includes the use of fertilizer and herbicide; crops and livestock include fodder and forage.

SIMLESA-Tanzania

Maize is an important crop in Tanzania, accounting for more than 45 percent of total cultivated area and 75 percent of all cereal production. Between 2000 and 2010, the area of land under maize cultivation grew by 54 percent. Nevertheless, maize yields remain low, at an average of about 1.2 metric tons per hectare for the 2000–2010 period.

Maize accounts for

45%

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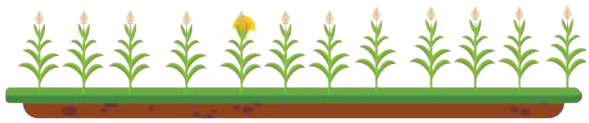


Strategic Approach

SIMLESA-Tanzania established onfarm exploratory trials and long-term on-station trials to test and scale promising technologies across different agroecologies. Having selected "best bet" practices based on research results and farmers' preferences, the practices were scaled out by a private seed company, NGOs and farmers' networks chosen through a competitive grant scheme.

Project Sites

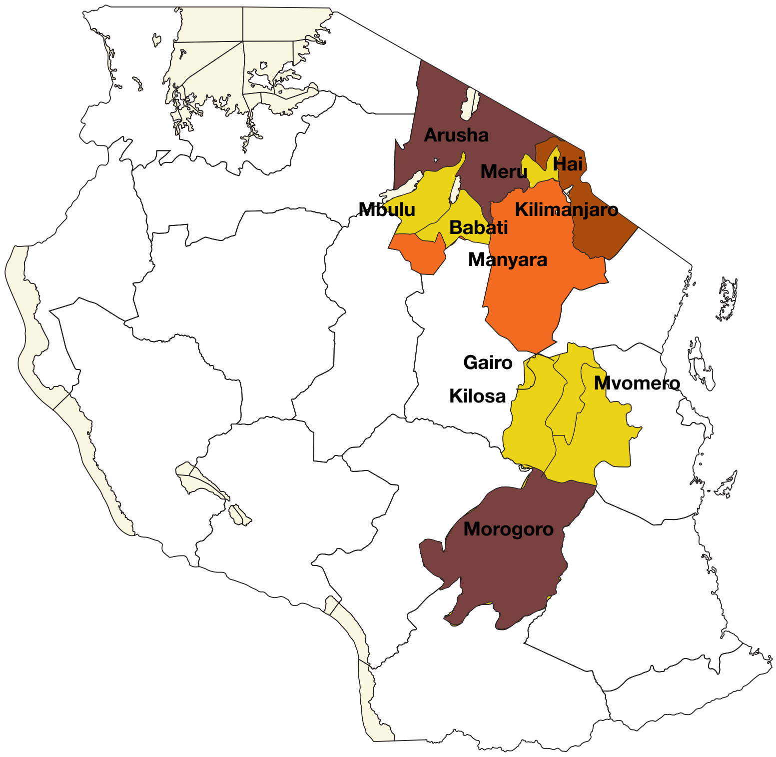
The project was implement in northern and eastern zones as shown in fig. 2. The sites were carefully selected to provide a contrast in agroecological conditions and in the intensity of integration between crop and livestock production. This integration is important because it determines nutrient availability, especially where farmers cannot afford mineral fertilizer. It also provides case studies on competing uses of crop residues as soil cover and as animal feed. The sites ranged from very low altitude, 400 meters above sea level, to as high as 2,000 meters above sea level.

Partners

Important partners directly involved in developing, evaluating and testing improved maize and legume varieties were ARI-Selian and Ilonga. TOSCI conducted all aspects of the variety trials to generate the required data for releasing the newly developed varieties. Numerous seed companies and agro-dealers undertook the sustainable production and supply of seed to farmers, respectively.

> Integration between **crop and livestock production …** is important because it determines **nutrient availability,** especially where farmers cannot afford **mineral fertilizer.**

Figure 2. Map of Tanzania showing project sites (districts in yellow) and regional boundaries



Source: SIMLESA-Tanzania.

KEY FINDINGS

This section summarizes SIMLESA-Mozambique's key cross-cutting research findings in the context of the following questions:

How can CASI increase the farm-level food security, crop yields and incomes of smallholder farmers?

In what ways do CASI approaches contribute to increasing the resilience of farming systems, protecting the natural resource base and mitigating the risks associated with climate change?

What key factors in terms of government policies, agricultural programs, rural institutions or market arrangements would enable the diffusion of CASI methods among farmers?

Does CASI contribute to a balanced approach to agricultural progress for both men and women, and how might resource-poor farmers — in particular — benefit from these technologies?

What market enhancements, including seed systems and value chains, are needed to encourage the adoption of CASI practices?

The project's findings were complex. The new approach works by integrating multiple technologies with synergistic effects over different time horizons. In addition, CASI was purposively implemented across a range of agroecologies, which makes it challenging to directly compare results from one region to another. Nevertheless, the key findings that emerged are described below.

Farm-Level Food Security, Productivity and Incomes of Smallholder Farmers

1. Both on-station and on-farm experiments at different locations show the potential of CASI practices to enhance maize-legume productivity.
2. Maize-legume intercropping under minimum tillage performed substantially better than under conventional tillage practices.
3. Ratooning pigeon peas in maize–pigeon pea intercropping (that is, cutting plant growth to induce new shoots) reduced seed costs by up to 33 percent.
4. Farmers profits rose by 30 percent using CASI practices compared with conventional farming methods.

Strategies to Improve Resilience, Reduce Risks and Protect Natural Resources

1. Retaining crop residues for use as mulch combined with reduced tillage shows promise for improving the efficiency of nitrogen use for smallholder farmers.
2. Results of soil analysis show higher soil moisture content, soil organic matter and total nitrogen levels with the use of CASI practices compared with conventional methods. This suggests that adopting the new practices longer term will positively affect soil fertility and improve crop development and growth, thus enhancing resilience to climate change.

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In Tanzania, about

60%

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49%

of female-headed households use improved varieties

Gender and Equity

1. Households tend to use more family labor than hired labor in crop production. The new approaches show significant promise in saving almost 50 percent of the time required for farm activities compared with conventional practices.
2. Women in female-headed households undertake a much higher share of the work involved in farm activities compared with women in male-headed households. It is therefore likely that such women will particularly benefit from the new approaches.
3. A majority of the farmers tend to purchase more improved varieties of maize than of legumes. The exception is soybeans, which is preferred by more female-headed than male-headed households. Greater access to improved varieties of both crops is, therefore, needed in order to increase the adoption of the CASI practices.
4. Rural youth in Tanzania are motivated to pursue agriculture as a source of livelihood, so interventions promoting the new approaches should incorporate opportunities targeting this demographic.
5. SIMLESA-Tanzania facilitated greater gender equality among smallholder farmers, specifically for women in the coastal zone (Morogoro) who have more control over income derived from maize and legume sales. These women are taking a more active role in marketing, selling, and making decisions about the revenues derived from their crops. Further efforts to empower women in other parts of the country, such as the northern region (Arusha and Manyara), are needed.
6. Some of the AIPs supported by SIMLESA-Tanzania are assisting their members in improving maize and legume yields. The AIP model needs to be scaled out to other communities in the region to facilitate faster adoption of CASI technologies.

Supporting Mechanisms and Partnerships

About 60 percent of male-headed households and 49 percent of female-headed households in Tanzania use improved varieties, but that means a considerable number still use recycled seed. Future work should focus on improving farmers' access and ability to buy and use improved maize seed.

ACHIEVEMENTS

Farmer Reach and Adoption

In 2016, 80 percent of smallholders in the northern region, and about 85 percent of smallholders in eastern region had adopted at least one CASI technology. That year, about 3 percent of smallholders in both the northern and eastern zones had adopted the full package of CASI technologies, but 15 percent of those in the northern zone and 17 percent of those in the eastern zone had adopted at least three CASI technologies (Tabs. 1 and 2).

The shares of smallholder farmers who had adopted at least one CASI technology by 2016:

80% Northern region

85% Eastern region

The shares of smallholder farmers who had adopted at least three CASI technologies by 2016:

15% Northern region

17% Eastern region

As of 2016

3%

of smallholders in both the northern and eastern regions had adopted the full package of CASI technologies

Table 1. Number of farmers reached by gender, as of 2018

District	Target	No. of men reached	No. of women reached	Total no. of men and women reached	Success rate (%)
Babati	8,000	338	254	592	7.4
Arumeru	14,522	2,813	1,589	4,402	30.3
Hai	18,434	3,523	1,656	5,179	28.1
Gairo	17,358	5,715	4,955	10,670	61.5
Morogoro	21,745	9,774	9,301	19,075	87.7
Mvomero	24,902	10,272	10,844	21,116	84.8
Total	104,961	32,435	28,599	61,034	58.2
Share of women reached					47%

Source: SIMLESA-Tanzania.

Table 2. Number of households reached by gender of household head, as of 2018

District	Target	No. of female-headed households	No. of male-headed households	Total no. of households
Mvomero	6,000	3,500	2,711	6,211
Gairo	6,000	1,613	2,902	4,515
Morogoro rural	8,000	1,511	4,301	5,812
Total	20,000	6,624	9,914	16,538
Share of female-headed households reached				40%

Source: SIMLESA-Tanzania.

Training and Capacity Strengthening

SIMLESA-Tanzania supported the development of human resource capacity in agricultural research (Tab. 3). From 2010 until mid-2018, the program fully supported nine MSc and one PhD students in undertaking their degrees.

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Table 3. SIMLESA-Tanzania's support for long-term training by gender, as of June 2018

University	Degree/discipline	Gender
University of KwaZulu-Natal, South Africa	PhD in social economics	Male
Sokaine University of Agriculture, Tanzania	MSc in legume breeding	Male
Sokaine University of Agriculture, Tanzania	MSc in legume breeding	Male
Sokaine University of Agriculture, Tanzania	MSc in agronomy	Male
Sokaine University of Agriculture, Tanzania	MSc in extension	Female
Sokaine University of Agriculture, Tanzania	MSc in agronomy	Male
Sokaine University of Agriculture, Tanzania	MSc in maize breeding	Male
Sokaine University of Agriculture, Tanzania	MSc in crop protection	Male
Nelson Mandela University, South Africa	MSc in agronomy	Female
Sokaine University of Agriculture, Tanzania	MSc in breeding	Female

Source: SIMLESA-Tanzania

OPPORTUNITIES FOR INTEGRATING THE NEW APPROACHES INTO MAIZE FARMING SYSTEMS

Packages for Farmers

Recommendations for farmers vary depending on the agroecological context and available resources. Technologies form “a basket” from which farmers can choose depending on their socioeconomic and biophysical environment. Prescriptions can be fully adopted or farmers can select the combinations they deem most suitable to their circumstances. In addition, the use of good agricultural practices is key to success. Studies suggest that household characteristics — such as family size, age, gender and education level — climatic conditions, social capital, asset ownership, land tenure and training are important factors in decision-making on whether to adopt CASI practices [7, 8].

SIMLESA-Tanzania identified the following as key factors supporting the adoption of the new technologies by farmers.

Social capital. Membership in farmers’ groups and AIPs enhanced the exchange of information and increased farmers’ knowledge about the new technologies, thereby supporting the likelihood of adoption.

Asset ownership. In addition to being more able to purchase of inputs, wealthier households had greater capacity to bear the risk associated with adopting the new technologies.

Access to markets. Households located near markets were more likely to adopt legume intercropping and conservation tillage practices.

Farm size. Smallholder farmers are more motivated to intensify their production through the use of CASI practices in order to optimize their profits by area. Farmers with more land are less likely to intensify because they have greater capacity to grow multiple crops, leave land fallow or shift cultivation practices.

Low- and High-Potential Areas

Based on these findings, a number of packages are proposed to suit the agroecological contexts in which SIMLESA-Tanzania operated (Tab. 4). In areas requiring low resource investment (that is, for resource-poor farmers), the practices recommended are minimum tillage, use of herbicide, use of animal manure and use of soil cover (mulching using crop residues). These options reduce soil degradation, thereby increasing sustainability. In areas where higher resource investment is possible (by wealthier farmers), the practices recommended are minimum tillage, use of herbicide, use of fertilizer, intercropping maize with beans/pigeon peas and permanent soil cover using crop residues or natural hay. To address the need for pasture for livestock, it is important that forage be introduced in the contours and borders of fields. These options work best when the local government enforces laws that prevent free grazing.

“To address the need for pasture for livestock, it is important that forage be introduced in the contours and borders of fields.”

Table 4. Summary of CASI options for two of Tanzania's agroecological zones

	Low-potential areas		High-potential areas	
Type of agricultural practice	Low-input	High-input	Low-input	High-input
Conservation agriculture				
Reduced tillage	Direct seeding, herbicide use	Rip lines, direct seeding, herbicide use	Rip lines, direct seeding, herbicide use	Rip lines, direct seeding, herbicide use
Crop diversity	Intercropping maize with pigeon peas, common beans, or cowpeas	Intercropping maize with pigeon peas, common beans, or cowpeas	Intercropping maize with pigeon peas, common beans, or cowpeas	Intercropping maize with pigeon peas, common beans, or cowpeas
Mulch	Partial crop residues and natural hay	Partial crop residues and natural hay	Partial crop residues and natural hay	Partial crop residues and natural hay
Sustainable Intensification				
Plant density	Wider spacing	Wider spacing	High density	High density
Planting date	Direct seeding at field-capacity moisture level	Direct seeding at field-capacity moisture level	Herbicide application, direct seeding at field-capacity moisture level	Herbicide application, direct seeding at field-capacity moisture level
Shallow weeding	Recommended	Recommended	Recommended, followed by slashing once crops mature	Recommended, followed by slashing once crops mature
Fertilizer	Diammonium Phosphate	Diammonium Phosphate	Diammonium Phosphate	Diammonium Phosphate
Herbicide use for weed control	Glyphosate at a rate of 3 liters per hectare	Glyphosate at a rate of 3 liters per hectare	Glyphosate at a rate of 3 liters per hectare	Glyphosate at a rate of 3 liters per hectare
Improved Varieties				
Maize	Drought-tolerant maize varieties (TAN-600, TAN-250, TAN-309), improved open-pollinated varieties (SITUKA-M1, SITUKA-M2, WEMA)	Drought-tolerant maize varieties (TAN-600, TAN-250, TAN-309), improved open-pollinated varieties (SITUKA-M1, SITUKA-M2, WEMA)	Drought-tolerant maize hybrids (TZH-538, SARI-208, SARI-308), improved open-pollinated varieties (vumilia-K1)	Drought-tolerant maize hybrids (TZH-538, SARI-208, SARI-308), improved open-pollinated varieties (vumilia-K1)
Legumes	Drought-tolerant, early maturing and high-yielding pigeon pea varieties (Ilonga 14-M1 and M2, Tumia and cowpea Vuli 1&2)	Drought-tolerant, early maturing and high-yielding pigeon pea varieties (Ilonga 14-M1 and M2, Tumia and cowpea Vuli 1&2)	Drought-tolerant, medium maturing variety (MALI), common bean (JESCA), pigeon pea varieties (Karatu, Kiboko and Tumia)	Drought-tolerant, medium maturing variety (MALI), common bean (JESCA), pigeon pea varieties (Karatu, Kiboko and Tumia)

Source: SIMLESA-Tanzania.

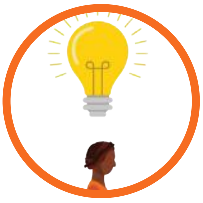
Factors Preventing Widespread Adoption of CASI Technologies

High input costs. High input costs (for seed and agrochemicals) were the biggest impediment for farmers.

Lack of availability of inputs. In some cases, lack of timely availability of inputs, such as new seed varieties, herbicides, and basic conservation agriculture equipment, presents a constraint.

Potential short-term need for manual labor. In areas without mechanization, the short-term drudgery of manual weeding presents a disincentive to adoption for some farmers.

Inadequate extension services. Insufficient expertise in the application of the new approaches has slowed the pace of adoption.



The need for informed decision-making. CASI concepts have been proven to be beneficial, but this information needs to be effectively communicated to higher level decision-makers.

In addition to these constraints, in the broader context, appropriate policies, programs and other interventions are instrumental in creating the environment and structures to enable farmers to adopt new approaches in the long term and become integrated into value chains. This involves both discrete and collaborative efforts by government, private enterprise and civil society organizations. The following interventions or enhancements are recommended to support the adoption of the new technologies by farmers.

Government Policy

Successfully promoting the widespread adoption of CASI practices across Tanzania requires government support. Under the Comprehensive Africa Agriculture Development Programme, Tanzania committed to allocating 10 percent of its budget to agriculture, but has not met that target (investment levels averaged about 4 percent per year during 2012–2017 [9]). It is also important that the government (1) lift trade barriers suppressing farmers' commodity prices and (2) lower some tariffs for necessary agricultural inputs, such as fertilizer, herbicide, and farm equipment (two-wheel drawn planters and rippers, jab planters, and so on). As SIMLESA-Tanzania draws to completion, it will be important for the government to provide agricultural development funds to support continued scaling of CASI practices.

Agricultural Innovation Platforms

Scaling efforts via AIPs and stakeholder involvement reached large numbers of farmers within a short time period. Further success will require building farmers' capacity to implement the new approaches, for example, through short-term training. Integrating AIPs into the local extension system would support the sustainability of information dissemination and the successful adoption of CASI approaches. CASI expertise should be represented in local government councils and through regular agricultural policy meetings at regional, district and subdistrict levels.

Training

Given the dominance of the agricultural sector in Tanzania, CASI approaches should be included in the curricula of primary, tertiary and higher learning institutions.

Civil society and nongovernmental organizations

These organizations could participate in scaling the adoption of CASI practices by promoting producer associations/cooperatives, as well as training and education. Some NGOs can participate in co-funding the scaling strategies and activities, as exemplified the Small Farmers Network of Tanzania, and Research and Community and Organizational Development Associates.

CASI mainstreaming in Tanzania

CASI practices have been mainstreamed by partners, including the Small Farmers Network of Tanzania, and Research, Community and Organizational Development Associates. CASI's improved seed system has been adopted by the private seed company Suba Agro.

CONCLUSION

In the absence of an integrated approach to sustainable intensification, agriculture in Tanzania will be ill-prepared to deal with the future effects of global climatic and economic changes. Many of these changes are projected to have negative consequences and require greater resiliency, of both farmers and farming systems. The widespread application of CASI practices has great potential to deliver positive benefits, such as increased productivity, savings in labor and other resources, improved soil health and overall sustainability. Cumulatively, these gains will contribute to improving smallholder farmers' livelihoods, building their resiliency to challenging events, and increasing their food security. Success in widely scaling the new farming approaches and technologies very much depends on political will, in terms of both policy and financial support. Without this support, resource degradation in agricultural farmlands will continue unabated, together with low production levels, food insecurity, poor health, and economic and national instability.

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This report was prepared as one of the outputs of the SIMLESA program. SIMLESA was financed by the Australian Centre for International Agricultural Research (ACIAR) and implemented by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with numerous partners, including national agricultural research institutes, other CGIAR centers (ILRI and CIAT), and the Queensland Alliance for Agriculture and Food Innovation (QAAFI) of the University of Queensland, Australia and ASARECA. We would like to especially acknowledge the many years of technical and administrative support of CIMMYT scientists during the implementation of the SIMLESA program, including the preparation of this report. The contribution of all our collaborators (those mentioned here and many more not mentioned), including farmers who hosted trials, local businesses, government departments and researchers are gratefully acknowledged.