ENHANCING AGRICULTURAL RESILIENCE AND SUSTAINABILITY IN EASTERN AND SOUTHERN AFRICA

Key Findings and Recommendations for Ethiopia

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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
EIAR	Ethiopian Institute of Agricultural Research
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

AGRICULTURE IN ETHIOPIA

Ethiopia's economy is predominantly agricultural, with more than 80 percent of a population of 107 million people depending on agriculture for their livelihoods. The sector contributes 46 percent of the country's gross domestic product (GDP) and employs 85 percent of the economically active population [1]. Smallholder agriculture is crucial to food security, household income, rural employment and exports. Nevertheless, the country faces serious food and nutrition-security issues, aggravated by drought, human and livestock disease and competition for resources [2]. According to UNICEF [3] about 10 percent of Ethiopians are chronically food-insecure, and in years of drought this share increases to 15 percent.

Ethiopian agriculture is largely rainfed. Erratic rainfall levels can seriously undermine cropping systems by reducing yields or causing crop failure [4]. Major droughts occur approximately every 10 years and as often as every 3 years in semi-arid areas, such as the Central Rift Valley. Climate change is also expected to increase extreme drought and flooding, further challenging farmers' resilience capacity [1]. Farmers also face the related challenges of soil degradation and erosion.

More than 99 percent of Ethiopian farmers are smallholders, operating fewer than five hectares of land [5]. In addition, the country typically utilizes traditional crop-production systems, predominantly based on unsustainable agronomic practices that contribute to soil erosion and degradation. It is essential that these challenges be addressed to ensure agricultural development and the future sustainability of crop production in rural communities.

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A New Approach to Agriculture

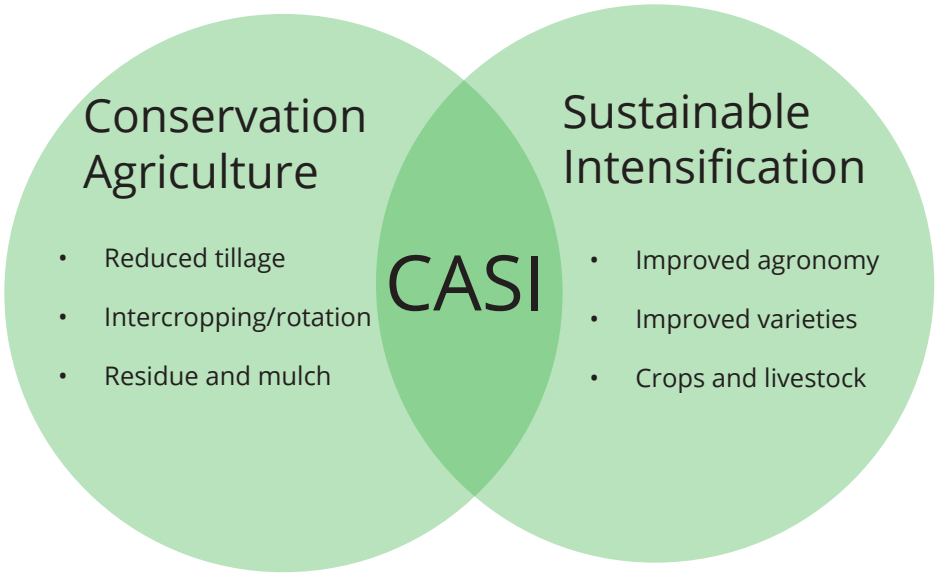
Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) was a project implemented between 2010 and 2018 in five African countries (Ethiopia, Kenya, Malawi, Mozambique and Tanzania) and two spillover countries (Rwanda and Uganda). The project's 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 Ethiopian Institute of Agricultural Research (EIAR); 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 agroecological 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-Ethiopia.
Note: Improved agronomy includes the use of fertilizer and herbicide; crops and livestock include fodder and forage.

SIMLESA-Ethiopia

In Ethiopia, maize is the largest contributor to total crop production and the second-largest in terms of land area allocated to cereals. Maize is grown across numerous agroecological zones, ranging from the mid-lowlands to mid-highlands, predominantly under rainfed systems but with small areas under irrigation. Legumes are also produced as a source of protein in local diets.

Project Sites

SIMLESA-Ethiopia covered 35 districts in the major maize- and common-bean-growing regional states of Oromia, Amhara, Southern Nations Nationalities and Peoples, Benshengul-Gumuz and Somali. These five states constitute 92 percent of the country's crop production and area (Tab. 1). SIMLESA-Ethiopia implemented the program across three agroecological zones with a view to generating lessons for scaling the new approaches more broadly. The three zones represented humid (Bako, Pawe and West Gojjam), semi-humid (southern Ethiopia) and dry (Central Rift Valley and Jigjiga) conditions. In addition, site selection emphasized locations where maize and legumes were the subjects of in-depth research.

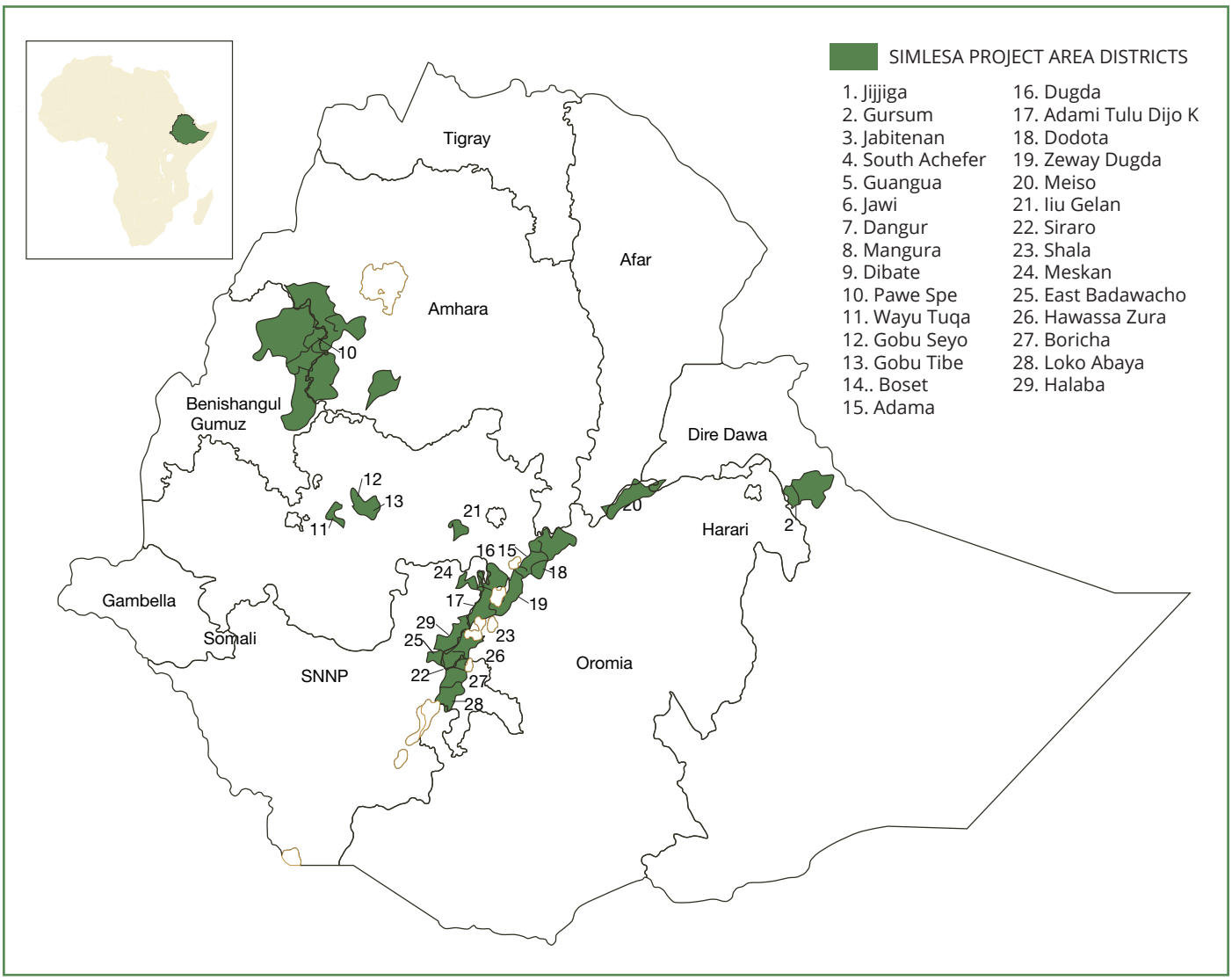
SIMLESA-Ethiopia began its activities in nine districts of the Central Rift Valley and western Ethiopia in 2010. In 2012, the project expanded to include new districts and more agroecologies and livestock systems. By 2015 the project was active in 29 districts (Fig. 2) and by its completion in 2018 it had reached 35 districts by adding West Badewacho, Arsi Negele, Shashamane, Ilu-Gelen, Diga and Sibu-Sire under the scaling out program of the best-bet practices tested in neighboring intervention districts.

Table 1. Crop area and production across SIMLESA-Ethiopia's project sites, (2016/17)

Regional state	Crop area (million hectares)	Production (million metric tons)
Amhara	4.44	9.53
Oromia	5.71	14.39
Somali	0.08	0.15
Benishangul-Gumuz	0.25	0.54
Southern Nations Nationalities and Peoples	1.12	2.51
Subtotal	*11.60*	*27.12*
Tigray	0.94	1.84
Afar	0.01	0.02
Gambella	0.01	0.02
Harari	0.01	0.02
Dire Dawa	0.01	0.02
Total	*12.57*	*29.04*
SIMLESA-Ethiopia areas as a share of all regional states (%)	*92.2*	*93.4*

Source: SIMLESA-Ethiopia.

Figure 2. SIMLESA-Ethiopia's project sites



Source: SIMLESA-Ethiopia.

Partners

SIMLESA-Ethiopia was implemented in collaboration with a wide range of partners and projects. EIAR was the primary implementing partner, under the Ministry of Agriculture and Natural Resources. Other national partners included regional agricultural research institutes, volunteer farmers, seed businesses, and farmers' cooperative unions. SIMLESA-Ethiopia also interacted with numerous other projects (Tab. 2).

Table 2. Projects collaborating with SIMLESA-Ethiopia

Collaborating project	Integration/interaction with SIMLESA-Ethiopia
Adoption Pathways, a multi-agency initiative focusing on eastern and southern Africa	Investigated to what degree SIMLESA's "best bet" conservation agriculture practices were adopted in and around SIMLESA-Ethiopia hosting communities
CGIAR Research Program on Grain Legumes, Tropical Legume-II	Produced and promoted legume varieties for maize-legume cropping-system intensification
CGIAR Research Program on Grain Legumes, Tropical Legume-III	Produced and promoted legume varieties for maize-legume cropping-system intensification
Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa	Investigated and recommended promising rhizobium bacteria/biofertilizer/ inoculants specific to soybeans and common beans to improve crop productivity (SIMLESA-Ethiopia used the recommended inoculants for maize-legume cropping-system trials and to scale "best bet" practices)
Stress Tolerant Maize for Africa	Evaluated stress-tolerant maize varieties and different spatial arrangements of plants to improve the efficiency of resource use (SIMLESA-Ethiopia scaled these varieties)
Drought Tolerant Maize for Africa	Evaluated, identified and recommended maize varieties that tolerate the effects of low rainfall (for use in SIMLESA-Ethiopia's hosting communities)
Drought Tolerant Maize for Africa Seed Scaling	Supported the production and scaling of drought-tolerant maize varieties in SIMLESA-Ethiopia's project sites
Farm Mechanization and Conservation Agriculture for Sustainable Intensification	Evaluated and recommended farm machinery to support smallholder farmers' adoption of minimum tillage practices
Alliance for a Green Revolution in Africa	Assisted in the scaling of SIMLESA-Ethiopia's "best bet" conservation agriculture practices

Source: SIMLESA-Ethiopia.

Strategic Approaches to Reaching Farmers

SIMLESA-Ethiopia employed a wide variety of approaches to scaling its activities (Tab. 3). The dominant approach was the country's agricultural extension system (via district bureaus), with EIAR providing technical support. AIPs provided another strategic approach to scaling the dissemination and uptake of CASI practices. Over time, the AIPs also became a valuable means of overcoming constraints to large-scale equitable adoption. The AIPs facilitated the collective acquisition of inputs through public and private sources; collective product sales, especially of grain and produce; and the development of skills, such as marketing and how to use new equipment. The project commissioned Ethiopia's well-organized extension system, under the Ministry of Agriculture, to disseminate information on the new practices in close collaboration with farming communities.

Table 3. SIMLESA-Ethiopia's approaches to scaling, 2010–2018

Approach	Method	Lead actor/ implementer	Audience	Resource provider	Intended outcome/ benefit
Agricultural innovation platforms	Outreach via stakeholder meetings, information and communications technologies, mass media, publications, demonstrations	Cooperatives, community-based organizations, brokers, facilitators	Farmers' groups and other stakeholders	Stakeholders	Increased innovation, lower transaction costs, greater economies of scale
Extension services	Demonstrations, structured training, interaction with farmers' groups, farm visits	Public extension	Farmers	Government	Higher adoption rates
Commodity-based promotion (seed)	Demonstrations, group meetings, TV, radio	Public and private sector	Farmers growing the commodity and companies	Seed companies	Consistent seed quality and maximum profits
Ministerial promotion	Mass media, individual, demonstrations, exchange visits, and so on	Public extension	Farmers	Ministry of Agriculture and National Resources	Broader outreach to farmers leading to higher adoption rates
Advisory services, nongovernmental organizations (for example, Sasakawa, World Vision)	Training, farm visits	Private extension	Farmers	Ministry of Agriculture and National Resources	Improved production and productivity
Cooperative organizations	Leaflets, demonstrations, group meeting, mass media	Cooperative members	Cooperative members	Members, government	Lower transaction costs, greater economies of scale
Educational institutions (for example, farmer training centers)	Demonstrations, visits, media, written materials	Educational institutions	Farmers	The government, development partners	Integrated research, training and extension; higher adoption rates
Participatory agricultural extension (such as through the Ethiopian Institute of Agricultural Research)	Group meetings, Demonstrations, visits, media, written materials, PRA	Public extension, nongovernmental organizations	Farmers	Government	Farmer learning and empowerment, higher adoption rates
Media-based information dissemination	Print media (especially leaflets), television, traditional music, SMS and voice message via cell phones, the Internet (CIMMYT's website)	Government	Farmers, agricultural officials	Government, SIMLESA	Mass dissemination/ reach
Social networks	Social networks	All	All	Not applicable	General information dissemination (particularly referrals)

Source: SIMLESA-Ethiopia.

Commissioned Scaling Initiatives

Unlike SIMLESA's activities in Kenya, Malawi, Mozambique and Tanzania, where multiple not-for-profit and private organizations contributed to scaling activities, SIMLESA-Ethiopia scaled its activities using the country's robust extension system. The system provided enormous advantages in terms of scale, funding and organization. CIMMYT contracted the Zonal Agricultural Bureau to deliver SIMLESA-Ethiopia portfolios across several districts. Thereafter, the research team undertook a thorough participatory assessment to determine what was possible strategically, especially in terms of potential reach and the likelihood of achieving adoption and other outcomes.

> **"SIMLESA-Ethiopia scaled its activities using the country's robust extension system."**

KEY FINDINGS

SIMLESA-Ethiopia sought to answer 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?

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

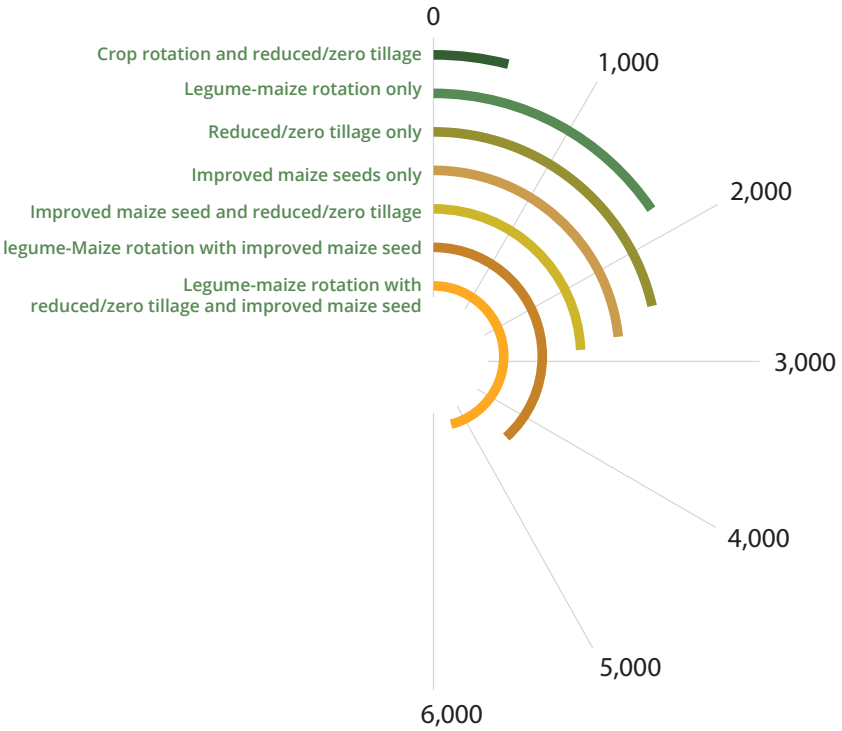
Although the CASI approach comprises numerous components best applied synergistically [7], farmers usually adopt individual components to suit their unique circumstances, such as their resource endowments, social networks, and wealth status [8]. Nevertheless, benefits accrue when farmers adopt a combination of practices, or all of them (Fig. 3).

Examples of SIMLESA-Ethiopia's positive results include the following:

Growing maize under conservation agriculture increased yields by 17 percent [9]. Although converting from conventional to minimum tillage practices can require an additional investment in herbicide, the overall net benefits are higher.

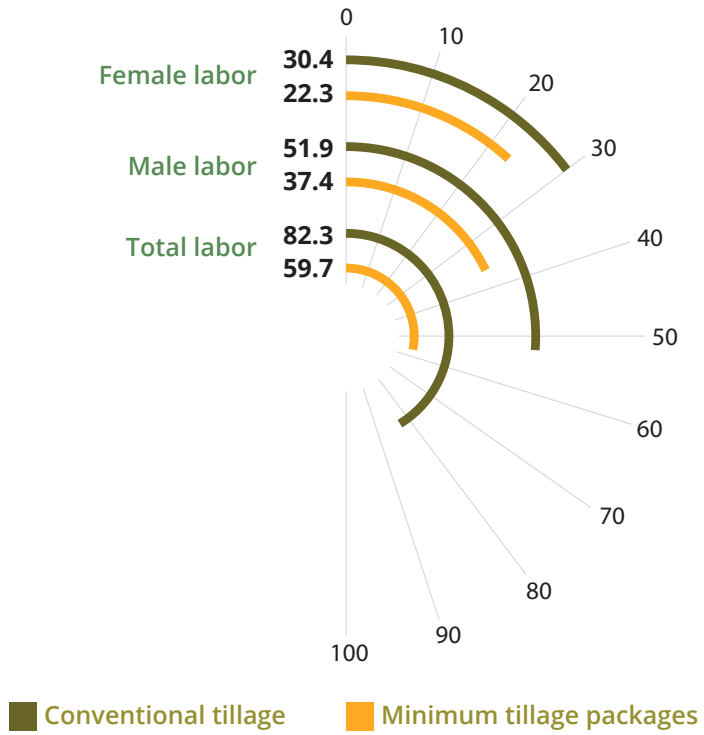
1. Under water-stressed conditions common bean yields rose by 38–41 percent using CASI approaches compared with conventional methods [10].
2. Maize-legume intercropping using CASI practices is more productive than cultivating maize on its own using conventional methods, whether under normal or extreme rainfall levels in semi-arid and subhumid conditions. Intercropping maize and common beans under the new practices increased yields by 28 and 40 percent, respectively [11].
3. Results in southern Ethiopia indicate that farmers growing maize and common beans using CASI practices doubled their net income per plot when combining intercropping and relay cropping in the same season [12].
4. The new methods also increased crop residues from maize and common beans by 25 and 34 percent, respectively, compared with conventional farming methods [11].
5. Experiment station and onfarm experiments at different locations in Ethiopia showed that CASI practices enhanced the productivity of maize and common beans, while also saving labor and the need for draft animal power. Survey data from northwestern Ethiopia show that minimum tillage practices reduce men's and women's labor use in maize production by about 14 and 9 person days per hectare, respectively (Fig. 4).

Figure 3. Net maize income from different combinations of CASI practices



Source: SIMLESA-Ethiopia.

Figure 4. Days saved in maize production under minimum tillage by gender, south Achefer district



Source: SIMLESA-Ethiopia.

Diversifying the types of crops grown, both concurrently (intercropping) and sequentially (crop rotation), enhances crop productivity and reduces the risk of crop failure. It also reduces the need for smallholders to invest their limited resources in inputs. Using mulch as a permanent soil cover retains soil moisture, thereby improving rainwater use efficiency, especially during dry spells. Minimum tillage reduced runoff by 10–25 percent compared with conventional plowingplowing at Bako [13]. CASI methods also increased water infiltration by 17 percent and soil organic carbon levels by an average of 7 percent. Using crop residues as mulch combined with intercropping maize and common beans also reduced rainfall runoff and the amount of soil lost through erosion. Mulching with crop residues, which is a key component of the CASI approach, also reduced soil loss by as much as 98 percent [13].

Using mulch and herbicide to control weeds reduced both the intensity and the types of weeds growing in maize plots. Under conventional tillage, plots had more species of weeds — including grasses, sedge and broadleaf weeds — whereas broadleaf weeds were the most common type of weed under conservation agriculture [14]. Lack of herbicide in local markets is a barrier to the adoption of minimum tillage. Weed control is needed until crops are established, so timely access to herbicides at reasonable prices, whether through farmers' organizations or agro-dealers, is essential. In high rainfall areas the intensity of weed growth is particularly challenging for farmers, who traditionally use intensive tillage as a control mechanism. Under minimum tillage, weed control without herbicide can compromise the resulting productivity gains.

Increase in crop residues under CASI

25% 

for maize

34% 

for beans

Reduction in labor use in maize production under minimum tillage

14 person days per hectare

9 person days per hectare

Gender and Equity

Ethiopian smallholder farmers depend on their families to provide farm labor. Men's participation in crop production is higher than women's, children's or hired labor across all types of crops, and particularly in the areas of preparing land, planting, weeding, harvesting and threshing.

Male and female maize and legume traders face several challenges, including the need to build suitable storage facilities to store grain, poor access to farmers and markets based on lack of rural roads, lack of reliable information on markets and grain-quality requirements, and limited business skills. These challenges affect both men and women, but improvements might encourage greater participation in maize and legume value chains by women. AIP members benefitted from research and extension services, credit access, and knowledge on postharvest storage and food preparation, which contributed to the food and nutrition security of AIP members and their families.

Among SIMLESA-Ethiopia's smallholder participants, the men primarily controlled crop sales (54 percent of maize, 70 percent of haricot beans, 62 percent of soybeans and 73 percent of cowpeas). They also dominated such activities as trading in maize and legume value chains. Women had limited control in marketing the maize and legumes promoted by SIMLESA-Ethiopia, but they did control 48 percent of the groundnut sales. Women also had a lot of control over the income generated from the sale of milk and dairy products.

Unlike in some countries, Ethiopia's rural youth are still motivated to work in the agricultural sector, particularly in trading, processing and other aspects of value chains.

Crop sales controlled by men

Maize

Haricot beans

Soybeans

Cowpeas

Crop sales controlled by women

Groundnuts

Supporting Mechanisms and Partnerships

SIMLESA-Ethiopia undertook participatory variety selection, which accelerated the release and commercialization of farmer-preferred, high-yielding and stress-tolerant varieties of maize and legumes that were compatible with cropping systems. The project identified 9 hybrid maize varieties and 21 improved legume varieties suitable for local conditions, which have been scaled out for dissemination. Strong partnerships with public and private seed companies increased the availability and accessibility of high-quality seed to smallholder farmers. During 2010–2018, private seed companies, farmers' cooperatives and research centers produced over 26,000 tons of improved seed identified by SIMLESA-Ethiopia.

The vast majority of Ethiopia's maize traders (94 percent) only operate in their local villages or towns. Farmers located near markets were more likely to adopt crop-diversification practices. Similarly, the further households were located from market centers, the less likely they were to implement CASI practices, such as minimum tillage and fertilizer use [15]. Marenya, Bekele and Odendo [16] suggest that building access roads linking rural markets, providing market information services and making financing for transport equipment available could substantially increase farmers' profits and, hence, their incentive to adopt CASI technologies.

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ACHIEVEMENTS

Farmer Reach and Adoption

During 2010–2016, SIMLESA-Ethiopia reached more than 210,289 smallholder farmers, (separate from the commissioned scaling program, which is discussed in the next section). The primary means through which farmers learned about CASI practices were media coverage and farmer field days (Tab. 4). Between 2012 and 2017, an estimated 47,400 farmers adopted different combinations of SIMLESA-Ethiopia portfolios (39,843 men and 7,594 women). This represents 22.5 percent of the farmers reached within the same period. Nevertheless, this estimate is conservative because media outreach included households that were outside the sampling area of the adoption study. These results are comparable with the estimates partners provided for the commissioned outscaling program (25–30 percent) [17]. Through SIMLESA-Ethiopia, more than 4,300 women participated in exchange visits, 18 MSc and 8 PhD students received training, 9 undergraduate students received support with their theses, and more than 297 researchers and partners received training in CASI practices.

Table 4. Approach to scaling and number of farmers reached

Approach to outscaling	2010–2014		2015		2016		Total by gender	
	Men	Women	Men	Women	Men	Women	Men	Women
Training	911	105	641	114	737	131	2,289	350
Farmer field days	13,194	2,424	1,763	281	2,027	323	16,984	3,028
Exchange visits	1,500	432	300	75	345	86	2,145	593
Demonstration plots	656	109	563	89	647	102	1,866	300
Agricultural innovation platforms	75	30	40	20	46	23	161	73
Media coverage	57,750	17,250	38,500	11,500	44,275	13,225	140,525	41,975
Yearly total	74,086	20,350	41,807	12,079	48,077	13,890	163,970	46,319
Overall total							210,289	

Source: SIMLESA-Ethiopia.

Commissioned Scaling

In 2017, SIMLESA-Ethiopia's scaling activities shifted to formal (commissioned) extension initiatives, which exponentially increased the rate of outreach. In 2017 alone, the country's zonal extension bureaus verifiably reached 165,268 households (Tab. 5). This represented a 79 percent increase within one year over the previous seven years and was achieved without media input. With careful planning, and technical support led by CIMMYT, Ethiopia's extension service accurately projected the target reach of 221,937 smallholders. Results of efforts in 2018 are expected to exceed those achieved in 2017 by about 25 percent. Combining these projections with adoption estimates, a sharp and commensurate increase in adoption rates is expected.

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Table 5. Ethiopian farmers reached through commissioned scaling, 2017

Region	District/county	Target levels	Number of men	Number of women	Total number of farmers.	Share of target (%)
East Shewa	ATJK	2,640	2,070	528	2,598	98.4
	Dugda	2,440	1,757	415	2,172	89.0
	Bora	880	634	141	775	88.1
	Adama	940	714	169	883	93.9
	Boset	830	631	158	789	95.1
Hhadiya	East Badawacho	3,340	2,527	261	2,788	83.5
Sidama	West Badawacho	1,660	1,263	131	1,394	84.0
	Boricha	1,300	410	150	560	43.1
	Lokabaya	1,300	400	180	580	44.6
	Bona	1,300	30	10	40	3.1
West Arsi	Siraro	4,450	3,489	951	4,440	99.8
	Shalla	4,650	3,348	1,292	4,640	99.8
	Shashemane	1,400	1,008	372	1,380	98.6
	Arsi-Negele	800	608	132	740	92.5
West Shewa	West Shewa	63,793	33,992	18,951	52,943	83.0
East Wollega	East Wollega	81,374	32,473	17,563	50,036	61.5
West Gojjam		48,840	25,210	13,300	38,510	78.9
Total		221,937	110,564	41,404	165,268	78.6
Share of women reached				25%		

Source: SIMLESA-Ethiopia.

Shiferaw et al. [18] reported that 17 percent of farmers reached through media coverage adopted technologies in the first year. This rapid increase in response to commissioned scaling initiatives was possible because of broader buy-in and support within and beyond the zonal extension bureaus. From the outset, SIMLESA-Ethiopia systematically sought the participation of grassroots public officers. Farmer training centers were particularly effective in engaging multiple local and district stakeholders of influence. In addition, senior public officials often participated in planning and field activities, and in CIMMYT's regular national and program-related meetings. Zonal extension officers, along with the Natural Resources Authority, were crucial in instructing district-level extension workers in informing farmers about CASI practices. This active and committed involvement by the zonal extension bureaus ultimately provided a critical communication link between SIMLESA-Ethiopia and regional policy-makers. In short, Ethiopia took strong ownership in the outreach process, which was a significant contributor to SIMLESA-Ethiopia's success in scaling its portfolio of technologies.

To monitor the adoption of CASI technologies, socioeconomic research teams conducted surveys beginning in 2013 using "snowballing" sampling techniques. These survey data enabled the research team to estimate and extrapolate district-level adoption rates (Tab. 6). Of sample households across all project sites, about 2 percent had adopted a maize-legume rotation with minimum tillage as of 2013, and 3.5 percent had done so as of 2016. With appropriate enabling conditions, the adoption of CASI practices has significant growth potential.

Table 6. Adoption in Ethiopia's subhumid and humid regions, 2013 and 2016

CASI technologies	Share of adopters, 2013	Number of adopting households, 2013	Share of adopters, 2016	Number of adopting households, 2016	Share of adopters, 2013	Number of adopting households, 2013	Share of adopters, 2016	Number of adopting households, 2016
Minimum tillage	0.8	117	12.0	1,924	1.0	573	6	3,754
Maize legume	22.0	3,229	26.0	4,170	34.0	19,467	36	22,523
Intercropping or rotation								
Herbicide use under zero tillage	0.8	117	9.0	1,443	0	0	10	6,257
Maize legume rotation or intercropping combined with reduced tillage	1.8	264	3.0	481	2.0	1,145	4	2,503
Other measures (such as structures to conserve soil)	7.0	1,027	9.0	1,443	3.2	1,832	6	3,754
Sample sizes	614		278		283		410	
Total	32.4	4,755	59.0	9,462	40.2	23,017	62	38,790

Source: SIMLESA-Ethiopia.

OPPORTUNITIES FOR INTEGRATING THE NEW APPROACHES INTO MAIZE FARMING SYSTEMS

Constraints and Drivers of Adoption

The main constraints to farmer adoption of CASI are as follows:

Lack of access to, or timely delivery of, improved or high-quality inputs

Limited access to credit

Unpredictable rainfall causing late planting

Limited market access

Risk aversion

Competition for crop residues needed for mulching with requirements for fuel and feed

The main drivers of adoption are as follows:

Time savings for family members stemming from minimum tillage and herbicide use

Labor (and draft animal power) savings due to minimum tillage and herbicide use

Availability and accessibility of herbicides in local markets

Packages for Farmers

Recommendations to farmers vary depending on the specific agroecology and the internal and external resources available to farmers. SIMLESA-Ethiopia identified two types of packages for the contexts in which SIMLESA operated — that is, humid, subhumid and dry regions (Table 7). Both low- and high-resource options are proposed for each region, but minimum tillage (one pass) combined with intercropping/rotation of maize and legumes and mulching using crop residues are recommended for all regions. All packages also call for the use of improved varieties of maize or legumes (or both).

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.

Table 7. Summary of CASI options for two agroecological zones in Ethiopia

Agroecological zone	Low input	High input	Low input	High input
Conservation agriculture				
Reduced tillage	One pass			
Crop diversity	Intercrop rotation	Intercrop rotation	Intercrop rotation	Intercrop rotation
Mulch	Crop residues	Crop residues	Crop residues	Crop residues
Sustainable intensification				
Planting density		Increase density		Increase density
Planting date	Plant early		Plant early	
Shallow weeding	X		X	
Herbicide for weed control		X		X
Improved varieties				
Maize	Open-pollinated varieties	Hybrid varieties	Open-pollinated varieties	
Maize				Drought-tolerant varieties
Legumes	Common beans	Common beans, soybeans	Common beans	Common beans, soybeans
Forage		X		X

Source: SIMLESA-Ethiopia.

Training, Education and Extension

Greater understanding is needed on the part of experts, extension agents and farmers regarding the potential of CASI practices, and especially the benefits of reduced tillage. Agricultural experts are used to more frequent tillage (up to seven times per season). Farmers also erroneously believe that the more frequently the land is tilled, the finer the soil and more productive it will be. Traditionally, farmers who could not or did not till their land were perceived as "lazy." For these reasons, efforts to scale the adoption of the new practices depend on demonstrations in farmers fields that provide scientists, extension agents and farmers with first-hand experience of the new approaches at different phases of the growth cycle. To this end, higher ratios of extension agents to farmers, which positively affect adoption [15], are needed.

Markets, Value Chains and Credit Access

While some farmers show strong interest in reduced tillage, adoption can be constrained by the availability of improved seed, herbicide and other inputs in local markets [19]. In most cases, herbicide is essential to suppress weed growth at the beginning of the season before crops are established [7]. Herbicides are new to southern Ethiopia and hence are in short supply. In addition, time lags occur between the release of new seed varieties and demand for them by farmers, which prompts supply by seed producers. Seed producers and companies also tend to overlook legumes, which reduces crop diversity. Alternative sources of fodder for livestock are needed, especially in low-potential maize-growing areas where crop residues are insufficient. Farmers may also need support in accessing credit to pay for purchased inputs. And, in order to attract the participation of women into agriculture, stakeholders must find ways to improve value chains for products that women have more of a control of, such as milk and groundnuts.

Government Interventions

Fertilizer subsidies positively affect adoption of CASI practices. Marenya et al. [15] suggest that a targeted subsidy for machinery and herbicide be considered based on the potential environmental and social benefits of reduced tillage.

Social Networks and Agricultural Innovation Platforms

A variety of social networks and farmer cooperatives can be used to support technology dissemination and adoption. Such networks can be enhanced through farm visits, farmers' field schools and AIPs. AIPs need to be strengthened through greater private-sector participation. AIPs can also be instrumental in increasing market access, mitigating transaction costs, leveraging better and more stable prices for marginalized smallholders, providing affordable and secure transport, and providing banking and credit services. Women and youth also need to be targeted to encourage and facilitate their participation.

Seed Systems

Many new varieties suitable for maize-legume cropping systems need to be scaled up and out. Research institutions; private, parastatal and community-based seed growers; and other relevant stakeholders need to be brought together to produce and supply high-quality seed. In Ethiopia, the role of the private sector in the agricultural input supply system is not well developed; inputs are supplied by public and parastatal organizations, such as state seed enterprises and farmers' cooperative unions. Private seed enterprises have recently emerged and are actively seeking new markets. The entry of multiple private actors should be encouraged.

Successes to Date

Encouraging initiatives by the federal and regional offices have promoted and scaled CASI practices in areas where they enhance the productivity and sustainability of maize-based production systems:

1

Amhara Regional State Bureau of Agriculture has scaled maize-lupine intercropping in its extension program. Extension manuals were prepared in English and local languages to be used by the extension agents and farmers.

2

Oromia Bureau of Agriculture and Natural Resources reduced tillage as part of the Sustainable Land Management Program in some districts.

3

The Ministry of Agriculture and Natural Resources established a unit focusing on CASI technologies; it developed recommendations and manuals to trial CASI practices in selected districts.

4

The government established a national level conservation agriculture task force to coordinate different government and civil society initiatives promoting the application of both climate-smart and conservation agriculture practices.

5

At the federal level, the Ministry of Agriculture and Natural Resources adopted a framework for scaling CASI practices through the National Extension Program. The initiative targets recommendations identified in biophysical and socioeconomic feasibility assessments to promote the adoption and benefits of the new approaches to smallholder farmers.

CONCLUSION

If the new CASI approaches are to be broadly adopted in Ethiopia, ongoing government support is needed in the form of enabling policies, institutions, and markets. The fact that the government extension system has been the predominant promoter of the technologies is a positive indication of momentum. Given the focus on farmers' groups in Ethiopia, collective approaches to adoption are optimal, but they must target context-specific biophysical and socioeconomic factors. Evidence demonstrates the multiple benefits of CASI approaches. Crop diversity enhances productivity and reduces the risk of crop failure on plots planted with improved maize varieties or using chemical fertilizer (or both) [20]. CASI technologies also provide extra resilience in seasons of moisture stress, and save time, labor and draft animal power, thereby increasing profitability and making farming a more feasible economic activity for resource-poor farmers, especially women. With more that 80 percent of the population involved in agricultural production, and with ongoing degradation of natural resources, the new CASI approaches offer a pathway to sustainability and resilience for Ethiopia's farmers.

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