ENHANCING AGRICULTURAL RESILIENCE AND SUSTAINABILITY IN EASTERN AND SOUTHERN AFRICA

Key Findings and Recommendations for Kenya

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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
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
KALRO	Kenya Agricultural and Livestock Research Organization
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 KENYA

Roughly 80 percent of Kenya's population is engaged in agriculture [1]. Approximately 4.8 million households, each averaging seven members, operate smallholder farms on less than two hectares of land. At any given time, at least 10 million Kenyans are estimated to face chronic food insecurity and poor nutrition [2]. This is mainly attributable to low agricultural productivity due to low technology and input use, low incomes and purchasing power, and adverse weather conditions. An estimated 98 percent of 3.5 million smallholder farmers grow maize, which accounts for 56 percent of the country's cultivated land [3, 4]. Smallholders primarily grow maize and legumes through a system of intercropping and crop rotation, but mono-cropping and relay cropping are also practiced. The most common challenges facing smallholders include low soil fertility, price variability in markets (for produce and inputs), diseases and pests (such as maize lethal necrosis and fall army worm) and variability in rainfall causing drought and flooding.

80%

of Kenya's population is engaged in agriculture

An estimated

98%

of 3.5 million smallholder farmers grow maize

This accounts for

56%

of the country's cultivated land

A New Approach to Agriculture

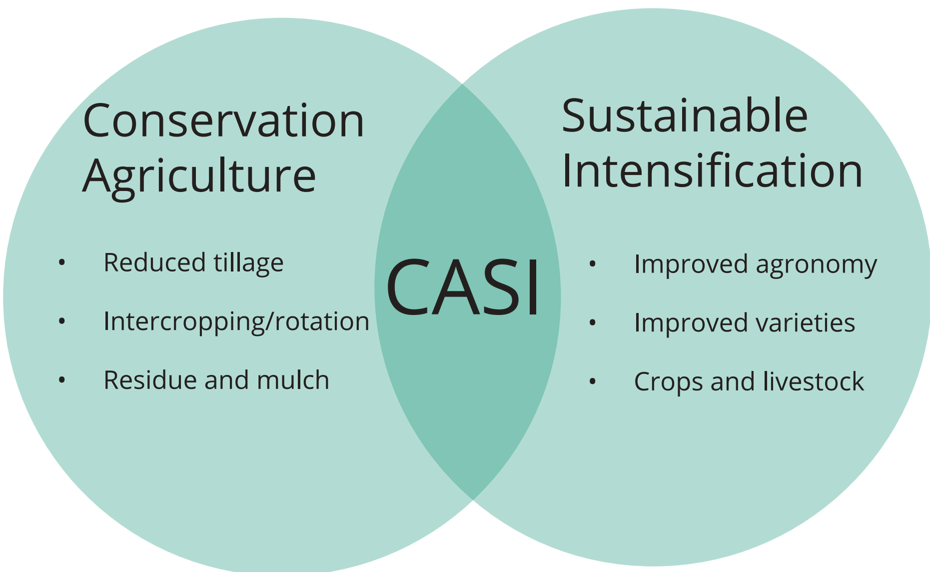
Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) was a project implemented between 2010 and 2018 in five African countries (Ethiopia, Kenya, Malawi, Mozambique and Tanzania) and two spillover countries (Rwanda and Uganda). The project's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

SIMLESA-Kenya

As of 2010, Kenyan maize and bean production was estimated to total 2.4 and 0.3 million metric tons, respectively, against comparable consumption requirements of about 3.6 and 0.9 million metric tons [5]. A profile study conducted in the region revealed that maize and bean yields were low, at 1.2 and 0.5 metric tons per hectare (t/ha), against expected levels of 6.0 and 2.3 2.3 t/ha, respectively. Productivity issues are compounded by low adoption of appropriate farming methods due to lack of local institutional support, lack of access to extension services, and poor transport and other infrastructure [6]. Low productivity is also attributed to rainfall being either low or too high, coupled with land degradation, reduced tree cover and inadequate water resources [6, 7].

Strategic Approach

The majority of Kenyan farmers belong to groups, so SIMLESA-Kenya used cluster approaches to reach out to farmers' groups cost-effectively. This led to the evolution of AIPs, which brought together researchers, extension providers, saving and credit providers, farmers' field schools, and church-based organizations and cooperatives. Activities utilized multiple approaches, many of which were familiar to farmers, such as field demonstrations and participatory variety selection. AIPs were a relatively new approach and were formed and managed locally, with the majority of members belonging to the same regions. The AIPS did, however, include members that operated at regional and national levels, such as credit providers, crop insurance companies and seed companies.

Project Sites

SIMLESA-Kenya operated in two regions, representing about 39 percent of the country's arable land. In eastern Kenya, the initial counties included in the project were Embu, Meru and Tharaka Nithi. Activities were subsequently scaled out to the counties of Meru, Embu, Nyeri and Kitui. In western Kenya, the two counties initially included were Siaya and Bungoma, with subsequent scaling to the counties of Vihiga and Busia (Fig. 2).

Production VS consumption (2010)

Estimated production

Maize

2.4
million metric tons

Beans

0.3
million metric tons

Consumption requirements

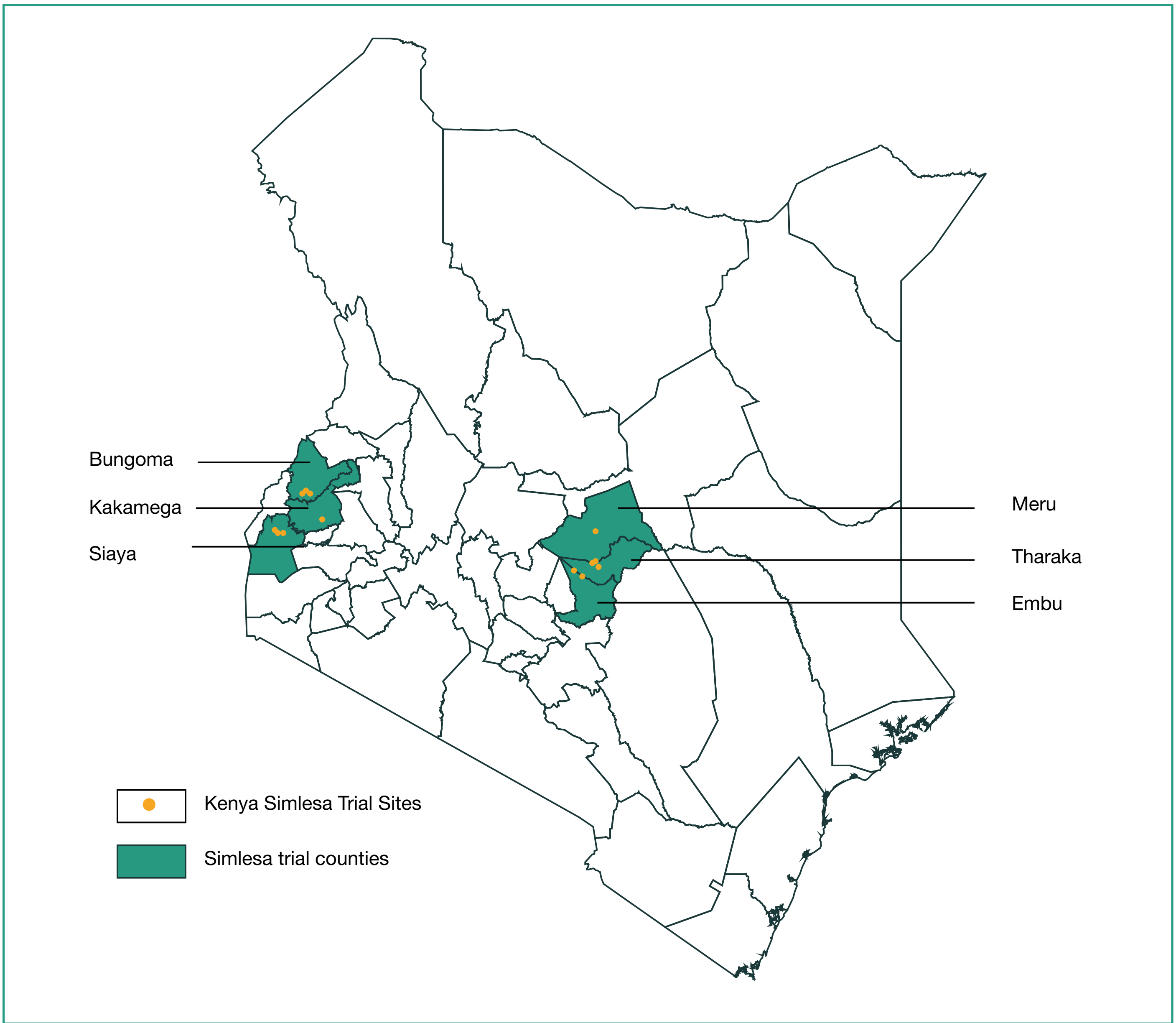
Maize

3.6
million metric tons

Beans

0.9
million metric tons

Figure 2. SIMLESA-Kenya's project sites



Source: SIMLESA-Kenya.

In the western highlands, a large share of land is allocated to food crops (66 percent). Maize is the primary food crop, and beans are the most important legume crop grown by most farmers. Approximately 50 percent of households own cattle, mostly of local breeds. Use of fertilizer is not widespread in this region, and even where it is applied, amounts are below recommended levels. In the central highlands, farmers grow multiple crops, with maize and beans being the most important food crops. Drought-tolerant legumes (mainly pigeon peas) are grown in the lower areas of this region. Most households own one or two head of improved dairy cows. Farmers in the central highlands do apply fertilizer/manure, and at slightly higher rates than farmers in western Kenya. The main constraint to agricultural productivity in these two areas is low adoption of improved agricultural technologies. This is demonstrated by the large yield gap between farmers' yields for both maize and legumes and those obtained on research stations. Farmers' access to markets for key inputs, such as seed and fertilizer, together with the high transaction costs associated with marketing surplus produce, also undermine farmers' incentives to adopt new technologies and sustainable intensification practices.

Partners

SIMLESA-Kenya established linkages with numerous organizations, projects and programs, thereby integrating activities with the region's ongoing research and development priorities:

1. The Adoption Pathways project, a multi-agency initiative focusing on eastern and southern Africa, studied the adoption of SIMLESA technologies both within and beyond SIMLESA-Kenya's operating sites.
2. ICRISAT provided pigeon pea germplasm and technical support for testing, evaluating and producing seed, as well as scaling the practices and seed varieties developed.
3. CIAT provided technical support, such as testing "best bet" options, providing laboratory services for soil and plant material from the trials, and consolidating and analyzing data for scientific publications.
4. The Association for Strengthening Agricultural Research in Eastern and Central Africa provided training in the areas of mainstreaming gender and monitoring and evaluating results.
5. The Agricultural Research Council of South Africa provided short format training on specific topics required by the national agricultural research system.

Table 1. SIMLESA-Kenya's additional partners

Partner	Activity
Conservation Agriculture and Small Holder Farmers in Eastern and Southern Africa	Tested and promoted conservation agriculture tillage practices within and beyond SIMLESA sites in eastern Kenya
CGIAR Research Program on Grain Legumes, Tropical Legume II	Provided legume germplasm for testing, outscaling and release (SB-19, ICGV-90704)
World Agroforestry Centre	Promoted fodder shrubs and assisted with soil fertility management (erosion control and nutrient build up)
Upper Tana Natural Resource Management	Shared research, information, materials (fodder, legumes, and cereals) and resources (such as transport)
International Fund for Agricultural Development	Tested and promoted fodder
International Livestock Research Institute, Biosciences eastern and central Africa	Provided germplasm
Egerton University	Provided legume germplasm

Source: SIMLESA-Kenya.

KEY FINDINGS

This section summarizes SIMLESA-Kenya'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. Other challenges included erratic rainfall distribution resulting in the poor performance of some trials; maize pests and diseases, such as outbreaks of fall armyworms; inadequate parental materials for seed production; and unreliable irrigation. The key findings that emerged are described below.

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

Maize yields were not significantly affected by intercropping with beans, but the reverse was not the case: bean yields averaged 1.2 t/ha under intercropping compared with 2.5 t/ha from mono-cropping. The decline stemmed from competition between the two crops for nutrients and light. The difficulty of implementing maize-bean rotations in land-scarce situations and where farmers are compelled to grow maize as the staple cereal. Although the yield-enhancing effects of CASI practices were modest under these conditions, it is important to note that the greatest advantages of the new approaches are long-term cost reductions and ecosystem improvements — neither of which could be captured in a four-year study. Yield increases observed through the use of the new approaches stemmed from improved field management.

The return to investment for intercropping maize and beans under conservations agriculture was 7 shillings for every shilling invested compared with 2 shillings under conventional methods [8]. This is significant because baseline adoption rates for zero/reduced tillage were only 1 percent compared with the adoption of other CASI technologies at rates of 88 percent for inorganic fertilizers (albeit at low application levels), 65 percent for manure and 72 percent for maize-legume intercropping.

More than 80 percent of the labor associated with conventional tillage farming is attributable to land preparation and weed control. Under conservation agriculture, zero/reduced tillage practices significantly reduce this burden, as does herbicide use to control weeds. Shifting from conventional methods to conservation agriculture, the labor cost fell by 56 percent — from 41,825 to 18,250 Kenyan Shillings (KES) per ha. Based on a wage rate of KES 300 per person day, this represents a savings of 79 person days at a total cost of KES 23,575 [9]. Over time, the average labor requirement using CASI practices was 15–20 days less than under conventional methods [10]. Beyond land preparation, weed-management costs were also significantly less using CASI practices (US$24 per ha) compared with manual weed control (US$88 per ha). Under zero tillage, chemical weed control using glyphosate reduced weed density and ultimately improved maize yields in eastern Kenya [11]. The use of herbicide for weed control is therefore a key component of CASI-based cropping systems.

For every shilling invested the returns were:

6.97 Conservation agriculture

1.87 Conventional methods

80%

or more of the labor associated with conventional tillage farming is attributable to land preparation and weed control

56%

reduction in the cost of labor upon shifting from conventional methods to conservation agriculture

Table 2. Returns to labor and variable costs, 2010–2014

Costs and revenues (US$/ha)	Conventional tillage	Reduced tillage	Reduced tillage plus desmodium	Furrows/ridges
Gross income (A)	1,890.3	2,092.7	1,298.4	2,116.9
Labor costs (B)	933.5	933.5	565.0	587.4
All variable costs, including labor (C)	956.3	958.6	581.2	613.0
Net crop income (D=A-C)	934.0	1,134.3	717.2	1,504.0
Returns to labor (D/B)	1.0	1.2	1.3	2.6
Returns to variable costs (D/C)	1.0	1.2	1.2	2.5

Source: SIMLESA-Kenya.

Resilience, Risk Mitigation and Protecting Natural Resources

In the early years of experimentation, conventional farming methods recorded higher water-use efficiency compared with CASI practices [10]. Water-use efficiency using CASI practices increased over time, however: 5.8–6.8 kilograms (kg) of dry matter per mm compared with 5.5 kg of dry matter per mm under conventional methods [10]. Mulching using crop residues conserved soil water and improved crop yields in drier seasons (less than 300 mm of in-crop rainfall) compared with wet seasons (more than 600 mm of in-crop rainfall) [12]. The different tillage methods and cropping systems did not affect the bacteria populations in soil, but the interaction of maize-bean cropping systems and use of furrows/ridges led to higher populations of fungi and nematode counts.

About 33–35 percent of households used maize residues both as livestock feed and as mulch, whereas 59–61 percent used crop residues either as feed or as mulch. In mixed crop–livestock systems, competition for crop residues presents a constraint to the adoption of the practice of mulching, particularly among smallholder farmers who own crossbred and exotic dairy animals. Introducing alternative feed sources, improving extension services and designing context-specific strategies to address this issue could facilitate the adoption of mulching in these systems. While analysis indicates that using crop residues as feed is profitable, using crop residues as mulch is more economically viable when factoring in the longer term environmental/sustainability benefits.

33–35%

of households used maize residues both as livestock feed and as mulch

59–61%

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Gender and Equity

Some social studies on gender and equity in technology adoption conclude that female farm managers are less likely to adopt conservation agriculture practices — such minimum tillage and use of animal manure — citing socioeconomic inequalities and barriers. Yet SIMLESA-Kenya found no gender differences in the adoption of soil- and water-conservation measures, improved seed varieties, chemical fertilizer, maize-legume intercropping or maize-legume rotations [13]. The reason for these results was not clear, however, so follow-up studies need to collect more data on this issue.

It would appear that the reduced requirement for labor is a key factor in farmers' decisions of whether to adopt CASI practices. The initial need for labor to establish furrows and ridges seems to discourage more women from adopting. Yet the apparent increase in the uptake of zero tillage by women suggests that its labor-conserving benefits may particularly appeal to women with lower access to labor (such as female-headed households).

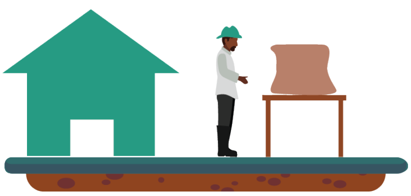
Kenya's youth are active farmers whose engagement in the agricultural sector is induced by the following factors (among others):

1. Farming is often the only employment option for young people with poor education levels.
2. Farming is not only a source of livelihood, but also a source of food security.
3. Farming is the backbone of the Kenyan economy and is often pursued as a second form of economic activity [17].
4. The income derived from farm activities helps young people pay for their children' school fees.

The young farmers that SIMLESA-Kenya interacted with noted that farming required substantial initial capital, making it a difficult enterprise without access to cash reserves or credit. Any CASI interventions targeting this demographic should focus on create opportunities for Kenya's youth to access capital for the purchase of inputs and equipment.

Supporting Mechanisms and Partnerships

Between 72 and 95 percent of maize and bean traders primarily operated within their local villages or towns, indicating lack of market reach. This increases the likelihood of market gluts and collapsing prices, undermining incentives for farmers to sustain their investments in the new practices. Results indicated that farmers who are organized in groups are more likely to adopt improved varieties and fertilizer in Kenya. AIPs generated several benefits for both female and male farmers. In particular, AIPs helped farmers acquire information, procure competitively priced inputs and generate more profitable sales. AIPs also help farmers adhere to market standards by reducing the unit costs of postharvest handling through economies of scale and collective bargaining. Without common and widely accepted minimum quality and pricing standards for maize, developing group-based approaches to marketing (such as warehouse receipt systems and commodity exchanges) will be difficult. For example, in order to form marketing groups to transport products to larger markets, farmers must meet uniform quality standards based on market demand.



72-95%

of maize and bean traders primarily operated within their local villages or towns, indicating lack of market reach

ACHIEVEMENTS

Farmer Reach and Adoption

As of 2013, about 53 percent of the farmers SIMLESA-Kenya had reached in eastern Kenya had adopted at least one CASI practice, and by 2016, the adoption rate was 59 percent. In western Kenya about 20 percent of farmers reached had adopted one CASI technology (maize-legume rotations with minimum tillage) in 2013, and by 2016, this rate had risen to 32 percent.

Farmers reached through field days:

18,000

Farmers reached through mass media:

3,654,000

Farmers reached through Egerton University, Freshco and the National Council of Churches of Kenya:

137,070

Total = 3,809,070

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.

SIMLESA-Kenya identified the following as key factors supporting the adoption of the new technologies by farmers:

1. Labor savings, which were estimated to be about 50 percent
2. Higher crop yields, which were up to 4.5 t/ha for maize and 2.5 t/ha for beans in some cases

Based on these findings, a number of packages are proposed for the agroecological contexts in which SIMLESA-Kenya operated (Tab. 2).

Table 3. Summary of CASI options for two of Kenya's agroecological zones

Type of agricultural practice	Low-potential areas		High-potential areas	
	Low-input	High-input	Low-input	High-input
Conservation agriculture				
Reduced tillage	Planting in holes or ridges made by hand hoe, fertilizer placed and covered with some soil, seed placed and covered with soil, herbicide use	Planting in holes made by hand, furrows made by oxen-drawn implements, fertilizer and seed placement, herbicide use	Planting in holes made by hand, furrows made by oxen-drawn implements or small tractor, fertilizer and seed placement, heracide use	Planting in holes made by hand, furrows made by oxen-drawn implements or small tractor, fertilizer and seed placement, herbicide use
Crop diversity	Intercropping maize with legumes (pigeon peas or cowpeas)	Intercropping maize with legumes (pigeon peas or cowpeas)	Intercropping maize with legumes (beans, soybeans or groundnuts)	Intercropping maize with legumes (beans, soybeans or groundnuts)
Mulch	Using at least half of crop residues	Using at least half of crop residues	Using at least half of crop residues	Using at least half of crop residues
Sustainable intensification				
Plant density	Spacing 75cm x 50cm, 2 maize seeds per hill, alternating rows of maize and legumes	Spacing 75cm x 50cm, 2 maize seeds per hill, alternating rows of maize and legumes	Spacing 75cm x 50cm, 2 maize seeds per hill, alternating rows of maize and legumes; spacing 125cm x 30cm, 2 maize seeds per hill, alternating one row of maize with two rows of beans	Spacing 75cm x 50cm, 2 maize seeds per hill, alternating rows of maize and legumes; spacing 125cm x 30cm, 2 maize seeds per hill, alternating one row of maize with two rows of beans
Planting date	Preparing land before the onset of rains, and dry planting just before the onset of rains	Preparing land before the onset of rains, and dry planting just before the onset of rains	Preparing land before the onset of rains, and dry planting just before or at the onset of rains	Preparing land before the onset of rains, and dry planting just before or at the onset of rains
Shallow weeding	Usually only necessary by hand when herbicide has not worked well	Usually only necessary by hand when herbicide has not worked well	Usually only necessary by hand when herbicide has not worked well	Usually only necessary by hand when herbicide has not worked well
Fertilizer	Diammonium Phosphate (DAP), Calcium Ammonium Nitrate (CAN) and farmyard manure	DAP, CAN and farmyard manure	DAP, CAN and farmyard manure	DAP, CAN and farmyard manure
Herbicide for weed control	Glyphosate and Lasso or Basagran	Glyphosate and Lasso or Basagran	Glyphosate and Lasso or Basagran	Glyphosate and Lasso or Basagran
Improved varieties				
Maize	KSTP-94, Embu-225, Embu-226, KDV-6	KSTP-94, Embu-225, Embu-226, KDV-6	KH500-38E, KH500-39E, H520, H529, PHB- P2859W, KSTP-94	KH500-38E, KH500-39E, H520, H529, PHB- P2859W, KSTP-94
Legumes	Pigeon peas (Ndombolo, Kendi, ICEAP-60/8, ICEAP-00554) or cowpeas (M66, K80, KVU-27-1)	Pigeon peas (Ndombolo; Kendi; ICEAP 60/8; ICEAP 00554;) or cowpeas (M66; K80; KVU 27-1)	Beans (Embean-14, KK8, KK15, KAT-X69, Chelalang); soybeans (SB-19); or groundnuts (ICGV-99568; ICGV-90704)	Beans (Embean-14, KK8, KK15, KAT-X69, Chelalang); soybeans (SB-19); or groundnuts (ICGV-99568; ICGV-90704)
Forage	Brachiarias, desmodiums, calliandra, leucaena	Brachiarias, desmodiums, calliandra, leucaena	Brachiarias, desmodiums, calliandra, leucaena	Brachiarias, desmodiums, calliandra, leucaena

Source: SIMLESA-Kenya.

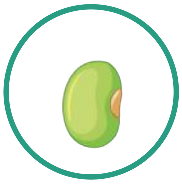
Factors Preventing Widespread Adoption of CASI Technologies

Farmers face several constraints to adopting the new approaches, as described below.

Shortage or late delivery (or both) of seed, pesticide (insecticide and herbicide) and fertilizer

Competition for crop residues for use as livestock feed

Limitations to farmers' knowledge of the new practices and technologies



Poor availability and accessibility of some seed varieties, including groundnuts not being fully found in the formal system

Poor extension services given a low ratio of extension agents to farmers (1 : 1,000 [12] compared with a recommended ratio of 1 : 300 [13]).

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.

Policies and Programs

Over time, the greatest allocation of policy attention and resources has focused on fertilizer and seed interventions. Comparable levels of support have not targeted complementary practices, such as crop diversification, best agronomic practices, soil and water conservation and natural resource management. SIMLESA-Kenya's research team recommends an integrated approach to extension that provides balanced education on the new approaches and technologies, appropriately emphasizing all aspects of agronomy, use of inorganic inputs (fertilizer and herbicide) and resource management. Integrating CASI principles into agricultural education curriculums at all levels of research and extension training would be an effective means of achieving this objective. Another avenue for integrating CASI practices into farming systems would be to make use of social networks — such as farmers' savings groups, social clubs and agricultural and other cooperatives.

Training and Capacity Strengthening

CASI practices are still relatively novel to many Kenyan farmers. Nevertheless, research results show that these new methods offer reasonable yield and income benefits over time, especially in terms of cost savings and if existing constraints can be overcome through effective information and education. To achieve adoption, farmers need to experience and understand the long-term benefits of conservation agriculture practices; they also need an opportunity to experiment with the practices in incremental steps. For these reasons, innovative and intensive extension approaches are crucial. Examples include (1) experiential learning, whereby small amounts of inputs and equipment are subsidized for trial and learning, then supply chains are developed to deliver these inputs cost effectively; (2) programs that distribute small packs of forage-free legume seed; (3) free trials of conservation agriculture equipment; and (4) information campaigns using the most accessible forums, such as local language radio stations.

> **To achieve adoption, farmers need to experience and understand the long-term benefits of conservation agriculture practices...**

CONCLUSION

If CASI practices are not successfully scaled, maize production will remain low and unsustainable in Kenya, and food prices will rise. Moreover, degradation of the natural resource base will continue unabated. Integrating CASI practices into maize production systems in several sites in Kenya returns the greatest gains in crop yield and rainwater use by crops. Intercropping systems are possible in Kenya with no yield penalty for maize, but bean yields can be compromised in some cases. More research is required to determine optimum planting arrangements, while also incorporating the biophysical advantages of intercropping. Among the strongest benefits driving large increases in net incomes is the reduced demand for field labor to prepare land and control weeds, based on reduced tillage and use of herbicide. More than 40 percent of Kenyans are under 15 years old. The majority are located in rural areas where agricultural opportunities must be provided to secure their livelihoods and food security into the future. Effectively integrating CASI practices into Kenyan farming systems will lay a firmer foundation for sustainable agricultural development, improved livelihoods, and economic opportunities.

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