SECTION 4

INSTITUTIONS AND SCALING

22 Enabling policy and institutional environment for sustainable intensification

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Key points

- Agricultural productivity growth will remain the major driving force in the structural transformation of many countries in Sub-Saharan Africa.
- Rapid population growth and climate variability and change are the main constraints and opportunities for the sustainable intensification of agriculture.
- The adoption of conservation agriculture-based sustainable intensification practices will require concerted and coordinated efforts by all players in technology development, policy development and the private sector.
- Caution should be exercised in making blanket recommendations about which approaches to use. Since local conditions and circumstances are unique, combinations of different approaches will be required to suit specific locations.
- The potential of sustainable intensification to lessen resource constraints calls for a deliberate focus on inclusion strategies to ensure that the benefits are accrued equitably.

Introduction

Africa is facing the challenges of a rapidly increasing population and variability in weather patterns. This is prompting a rethink on the development discourse needed to minimise food insecurity. This comes in the wake of the predominance of smallholder farmers and a huge dependence on agriculture to propel economic development. Agricultural productivity growth will be a critical driving force in the structural transformation of many countries in Sub-Saharan Africa in the foreseeable future. To address these challenges, conservation agriculture-based sustainable intensification (CASI) is being proposed as a potential route to agricultural productivity growth. It is being packaged as a systemic approach to managing natural resources while enhancing agricultural productivity. Overall, the key features of the emerging agenda are:

- a systemic approach
- context adaptation
- linking farmers' and scientific knowledge.

A range of policy interventions are required to ensure that CASI is realised in practice. These interventions address three key areas:

1. incentives for private sector investment
2. de-risking agriculture
3. support the emergence of a viable rural nonfarm economy.

Involvement of the private sector is needed in, for example, market-smart input subsidy schemes. This can also contribute to improvement of the soft and hard infrastructure for marketing and trade, information and communication technology and de-risking of agriculture. Social protection through safety programs can help to ensure inclusivity. Meaningful adoption of CASI practices will require concerted and coordinated efforts by all players in technology development, policy development and the private sector.

It is projected that, by 2050, the world population will increase from 7.3 billion to 9.7 billion, with two-thirds situated in urban areas (United Nations 2014). Most of this growth will occur in Africa and 90% of these new urban dwellers will reside in Africa and Asia. In Africa, young people aged between 15 and 35 years comprise 420 million people of the total continent's population of 1.2 billion people (African Development Bank 2012). Every year about 10–12 million youth enter the labour market against a job creation capacity of only 3 million formal jobs per year. The youth face roughly double the unemployment rate of adults and about 35% of female youth and 20% of male youth are completely excluded from employment, education or training (African Development Bank 2012).

Demographic shifts notwithstanding, extreme weather events occasioned by climate change continue to cause changes in the growing seasons, inadequacy of rainfall and droughts (Intergovernmental Panel on Climate Change 2014). The 2015–16 El Niño weather caused one of the worst droughts recorded in 50 years throughout Africa, Asia and the Americas. Changing climatic conditions are creating conditions for pests and diseases to flourish in previously non-endemic areas, with devastating effects on cropping systems and livelihoods. The fall armyworm, a crop-devastating pest in Latin America, has only recently become endemic in Africa (Centre for Agriculture and Bioscience International 2017). The caterpillar has an appetite for more than 100 plant species, including maize, wheat, rice, sorghum, millet and cotton. It was first detected in Nigeria in January 2016. By January 2017, it had reached South Africa and spread to 24 countries within a year. In 2011, the maize lethal necrosis disease hit Africa and spread just as rapidly (Centre for Agriculture and Bioscience International 2017).

Variable weather, along with other drivers such as speculative investment in food markets and investments in biofuels, has led to a rise in the food price volatility index (Food Security Information Network 2017; Pingali 2015). Projections indicate that these short-term price spikes are likely to be more frequent and profound in the future, piling pressure onto a timely supply response. Populist policy responses that may appear beneficial in the short term, such as export bans, may also heighten those spikes and exacerbate food insecurity and malnutrition.

In Africa, land availability has not declined as steeply as it has in Asia. This gives scope for Africa to be a food basket in the future, if land degradation can be stemmed. However, current productivity levels will not generate enough income and employment to match the huge rate of population growth (Larson, Muraoka & Otsuka 2016). Strategies to enhance the productivity of the existing land resources are required.

Quests for increasing agricultural productivity in Africa through a focus on the smallholder sector abound. The sheer size of the sector makes it the leading pathway for any meaningful reduction in chronic poverty (OECD/FAO 2016; Larson, Muraoka & Otsuka 2010). However, given the wide heterogeneity in agroecological systems and market conditions, multiple approaches will have to be employed. These approaches include concerted efforts at developing locally adapted technologies and attendant management practices and easing of access to inputs and output markets and services. They have also involved targeted investment in research and promotion of CASI technologies.
This chapter explores the big-picture lessons of policies focused on increasing adoption of CASI practices in eastern and southern Africa.

Agricultural intensification

Efforts to promote agricultural intensification have been building on traditional techniques for the past couple of decades (The Montpellier Panel 2013). A more recent development has been the promotion of CASI as a systemic approach to sustainably manage natural resources while enhancing productivity (International Maize and Wheat Improvement Center 2014b; eds Kassie & Marenya 2015). This approach requires that enhanced productivity and resilience of agricultural production systems is achieved while conserving the natural resource base (Zeigler & Steensland 2016; The Montpellier Panel 2013; Garnett et al. 2013; International Fund for Agricultural Development 2010; Pretty, Toulmin & Williams 2011; Tilman et al. 2011). This approach includes using an agroecological perspective with more selective recourse to external inputs, striving to maximise synergies within the farm cycle and seeking adaptation to climate change.
The practices typically aim at improving soil fertility, using a combination of organic, biological and mineral resources, and using water more sparingly and efficiently. Attention to enhancing capacities for sustainable agricultural production growth is needed for smallholder farms to be viable (Jayne, Mather & Mghenyi 2010). Overall, the three key features of the emerging agenda are a systemic approach, context adaptation and linking farmers' and scientific knowledge (Zeigler & Steensland 2016; The Montpellier Panel 2013; Tilman et al. 2011). It contributes to the sustainable development goals (SDG 2) on ending hunger, achieving food security and improving nutrition and sustainable agriculture, and (SDG 12) ensuring sustainable consumption and production patterns.

Sustainable intensification has been discussed as a necessary element for raising yields to levels above current national averages. It is premised on the need to drive productivity growth and capture the dividend expected from growing demand for food and rising prices. For instance, through its crop intensification programs, Rwanda has been able to double its cereal yields since 2005. Even though no universally applicable success formula has emerged so far, Rwanda's example gives credence that substantial progress can be made in Sub-Saharan Africa. Research under SIMLESA and other projects has shown that the best outcomes in terms of income were related to simultaneous adoption of CASI practices (Kassie et al. 2015; International Maize and Wheat Improvement Center 2014b; Marenya, Kyotalimye et al. 2015; Marenya, Mentale et al. 2015).

One aspect of CASI is that it can be adapted to the different requirements and levels of assets that farmers have at their disposal. This means that many different types of farmers can adopt CASI practices and broaden their options to better capture market opportunities. While adoption of agricultural technologies in Sub-Saharan Africa during the green revolution was dismal, the situation has started to change. In 2005, adoption of high-yielding maize varieties stood at 45%, 70% for wheat, 26% for rice, 19% for cassava and 15% for sorghum (Binswanger & McCalla 2010). However, adequate incentives and risk mitigation measures are needed to enable smallholder farmers to make the shift to CASI and for impact at wider scales (Diao et al. 2007).

In the past, agricultural intensification discussions focused solely on the role of seeds and fertilisers without concomitant articulation of complementary agronomic practices. However, there is growing recognition of the need to more formally and deliberately support and promote the inclusion of agronomic and natural resource management practices as critical elements of a balanced agricultural sustainable intensification process (International Maize and Wheat Improvement Center 2014a; Kassie et al. 2015).

Does CASI deliver?

Pretty, Toulmin & Williams (2011) looked at 40 projects and programs on CASI in 20 countries in Africa over the 1990s and 2000s that benefited 10 million farmers on approximately 12 Mha. The CASI practices included crop technological improvements, agroforestry and soil conservation, conservation agriculture, integrated pest management and novel policies. They include partnerships applied on crop, horticulture, livestock, fodder crops and aquaculture commodity value chains. The average growth in yield was twofold. Those projects had the following in common:

- science and farmer inputs into development of sustainable technologies and practices
- building of social capital through use of novel social infrastructure
- capacity building and improved access to knowledge and information through use of modern information and communication technology
- engagement with the private sector for supply of goods and services
- a focus on empowering women
- linkages to financial services
- ensuring public sector support for agriculture.

Recent cross-sectional results emerging from the Adoption Pathways Project (ACIAR 2017) provide evidence of win–win–win outcomes in terms of crop income, food and nutrition security, environment and risk if implemented as composites of practices (eds Kassie & Marenya 2015; International Maize and Wheat Improvement Center 2014b). They show the large roles that information, extension and adaptive research play to improve farm management and produce evidence on where and when such benefits would occur.

Policy interventions needed to promote adoption of CASI technologies in eastern and southern Africa

In response to past development shortcomings, Africa's new strategies and development agenda are building on the successes of the Comprehensive Africa Agriculture Development Program (CAADP) of the New Partnership for Africa Development (2017a). CAADP aims in part to end hunger, double productivity, reduce post-harvest losses by half, reduce the number of people living in poverty by half and promote inclusive 6% growth by 2025. It also calls for the creation of an African Investment Bank. The Malabo Declaration of 2014 is a recommitment to the principles and values of the CAADP process and enhanced investment finance in agriculture (New Partnership for Africa Development 2017b). A refreshing departure from the past is the commitment to mutual accountability to the actions and targets of the CAADP results framework by conducting biennial agricultural reviews. This concerted commitment by many countries holds promise for the eventual transformation of agriculture in Africa.

The Science Agenda for Agriculture in Africa (Forum for Agricultural Research in Africa 2017) is an African-owned and African-led process. It articulates the science, technology, extension, innovations, policy and social learning that Africa needs to apply in order to meet its agricultural and overall development goals. The strategic thrusts of the Science Agenda for Agriculture in Africa in the short to medium term are:

- the implementation of CAADP; increase domestic public and private sector investment
- creating an enabling environment for sustainable application of science for agriculture
- to double the current level of agricultural total factor productivity by 2025 through application of science for agriculture.

In the medium- to long-term, the science agenda is to build systemic science capacity at national and regional levels, capable of addressing emerging and evolving needs arising from climate change and urbanisation.

With the right alignment, this emerging policy environment offers promise to spur wide adoption of CASI practices. This alignment needs to prioritise interventions for every unique challenge. With respect to sustainable intensification, a range of policy interventions are required to ensure that it is realised in practice. Many of these interventions build on those already identified in recent development discourse (Zeigler & Steensland 2016; Larson, Muraoka & Otsuka 2016; Feed the Future 2016; Garnett et al. 2013; International Fund for Agricultural Development 2010), those highlighted in SIMLESA's work (eds Kassie & Marenya 2015; Kassie et al. 2015; Marenya, Menale et al. 2015) and specifically those discussed during SIMLESA's high-level policy forum (Waithaka et al. 2016).

These interventions address three key areas:

1. incentives for private sector investments
2. de-risking agriculture
3. support for the emergence of a viable rural nonfarm economy.

Graphical representation of these interventions is presented in Figure 22.1.

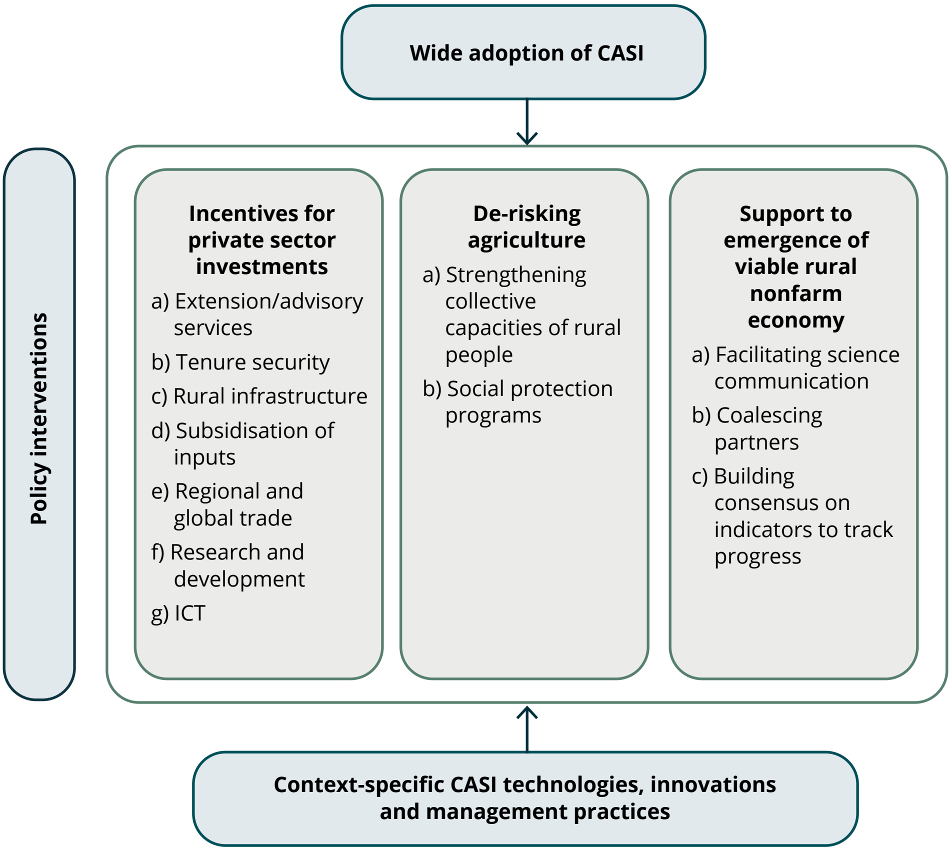

Figure 22.1 **Conceptual representation of policy interventions needed to spur wide adoption of CASI**

Notes: CASI = conservation agriculture-based sustainable intensification; ICT = information and communication technology.

Incentives for private sector investments

Private sector in this context refers to all actors who realise and utilise opportunities presented across value chains for business growth. They include farmers, business service providers, transporters, distributors and researchers. The case for private sector involvement is gaining interest (Zeigler & Steensland 2016; Feed the Future 2016; International Fund for Agricultural Development 2016).

Enhancing access to extension/agrobusiness advisory services

Empirical evidence shows that social returns to agricultural extension exceed returns to research (Pardey et al. 2016). The positive correlation between education and the adoption of CASI practices suggests that investment in rural public education may accelerate the dissemination of agricultural practices (Kassie et al. 2015). An effective and efficient agricultural extension system can enhance the agricultural productivity and production of smallholders through the delivery of innovative agro-advisory services. Several models of agricultural extension that include traditional supply- and demand-driven; participatory and pluralistic extension; private- and NGO-led or a combination have been tested. However, no model has provided a perfect fit for all farming systems, and countries practise a range of combinations (Birner et al. 2009).

Ethiopia and Rwanda have homegrown models of demand-driven, participatory and pluralistic extension service systems. The Ethiopian system includes farmer training centres. These serve as centres for information and knowledge sharing, training and demonstration of technologies and innovation close to farmers' residences. Farmers are organised into development units of 25–30 members with one model farmer leading a group of five followers. On average, there were 21 development agents for every 10,000 farmers in 2014. Although this is lower than the 33 frontline extension workers per 10,000 farmers as stipulated in SIMLESA's joint ministerial communiqué (Waithaka et al. 2016), it was still the highest extension agent to farmer ratio in Africa at the time. The government has also established 25 agricultural technical vocational education and training colleges for training extension workers and offers a full-package extension service (Ethiopian Agricultural Transformation Agency 2014).

This extension system is one of the key drivers of Ethiopia's near self-sufficiency in cereals production. It propelled Tigray region to capture the Gold Award for policies for soil conservation in 2017 (World Future Council 2017). It has been lauded as a model for Africa because of the decentralised and well-structured system, the network of agricultural technical vocational education and training colleges, proximity of the service through establishment of farmer training centres and development of farmer-led institutions. However, reviews still indicate low delivery on pluralism and demand-orientation with room for improvement. Key bottlenecks include low quality of services; a high turnover of development agents due to low resourcing; weak coordination and linkages to research, other actors and the private sector; limited integration of information and communication technology; and low attention to gender and inclusion (Ethiopian Agricultural Transformation Agency 2014).

Rwanda's Twigire Muhinzi model of agricultural extension is similar in many respects to the Ethiopia model. In 2016, the model was supported by 14,800 farmer promoters (one per village) and 2,500 trained farmer field school facilitators (Ministry of Agriculture and Animal Resources of the Republic of Rwanda and Belgian Development Agency 2016). The frontline advisers are supported by the decentralised extension service personnel made up of district and sector agronomists and the Rwanda Agriculture Board. It covers over 1 million households representing up to 50% of the rural population.

Unlike Ethiopia, Rwanda's model incorporates the use of information and communication technology. Short messaging via mobile phones is used to disseminate basic extension services to farmers at minimal cost. Farmers receive instructions from the Rwanda Agriculture Board through frontline extension agents at the beginning of the agricultural season on timing, land preparation, planting, fertiliser application, weeding, etc. The crop intensification program also relies on the farmer promoters to link the Twigire groups to agrodealers and markets and to promote the land consolidation initiative. Its main drawback is its total dependency on donor funding, which may compromise its sustainability in the future. There is a need to strengthen the linkage between local governments and the Ministry of Agriculture with regard to extension service delivery.

Tenure security

Secure land access or tenure has been shown to positively impact adoption decisions (Kassie et al. 2010). Long-term tenure security has the greatest potential to enhance adoption of CASI practices that have long gestation periods before benefits accrue (Kassie et al. 2015). Differences in capital accumulation, productivity and therefore output per worker or labour productivity are, in part, driven by differences in institutions and government policies (Dao 2017; Hall & Jones 1999). Those differences can be assessed using the World Bank's property rights and rule-based governance indicator (World Bank 2017a). This indicator is based on whether property and contract rights are reliably respected and enforced. It assesses the extent to which private economic activity is facilitated by an effective legal system and rule-based governance structure. The average rating for SIMLESA participating countries on this indicator is 3.5 from a maximum of 6. This implies low assurance of property and contract rights, which may potentially be limiting investments in CASI.

From 1997 to 2008, Ethiopia piloted a land certification program for 5 million households in four regions. This represented a shift in policy from state land ownership and frequent redistribution to a regime where farmer user rights—the ability to temporarily transfer these rights or use them as collateral in financial market—were recognised (Deininger et al. 2008). The program had impacts on land rental market participation, long-term agricultural investments, rural off-farm employment and productivity. However, those who shifted into nonfarm employment engaged in unskilled or food for work programs. This suggests that a skills and competence program was required to enable shifts into more skilled lucrative nonfarm employment. Effectiveness of tenure policy in driving productivity growth, sustainable intensification and enhancing resilience has to be backed with a complementary risk management strategy and investments in skill formation and job creation (Siba 2015).

Unlike Ethiopia, in much of Sub-Saharan Africa, access to land and investments in land are regulated within a legal pluralistic framework involving customary, statutory, and religious frameworks (Narh et al. 2016). Ownership remains largely held under customary and communal land rights systems at about 60%, with limited state ownership (Rights and Resources Initiative 2015). A pluralistic legal environment of formal and informal institutions provides an alternative form of property ownership and means of accessing land. Kenya and Ghana provide two contrasting pathways to land reforms within the context of a pluralistic legal environment for land ownership and management.

Kenya's land reform policies aim for a singularised legal framework in which all rights in land are formalised through title registration and certification (Kenya Law Reports 2012). Rights in communal land are registered and recognised as a legal tenure regime equal in status to private and public tenure. In the case of Ghana, statutory and customary property rights systems are formally acknowledged to coexist and the formalisation of rights in land is undertaken either through state-sponsored or customary sector-managed land registration, leading to a consolidation of legal pluralism (Narh et al. 2016).

Despite Kenya's singularised legal framework, citizens have continued to draw on customary institutional frameworks to legitimise their claims to land. The effect is that divergent claims may be held in formal and informal institutions. A system that legally recognises existing land rights systems, such as in Ghana, coupled with legal and business advisory support would be less costly than an entirely new land rights system that is likely to be subverted (Narh et al. 2016).

Current land reforms in both countries are still relatively new and yet to be extensively evaluated in the literature. What is emerging is that formalisation of property rights can be delivered through tenure conversion, from informal tenure to freehold title, but also by extending greater legal recognition to informal or customary tenure arrangements (Narh et al. 2016). This holds promise in enhancing investments in CASI technologies towards improved production and productivity. This analysis suggests that there is room to enhance adoption of CASI practices through improvements in long-term tenure security.

Rural and town infrastructure

Transport connectivity in particular is an essential part of the enabling environment for inclusive and sustained growth. In Africa, the vast majority of farmers are still disconnected from local, regional and global markets, contributing to a high cost of transportation. Transportation costs in Africa have impeded trade more than tariffs and other trade restrictions. The cost of transportation in Sub-Saharan Africa in 2009 ranged from US$0.06 to US$0.11/t/km, compared to US$0.04–0.05/t/km in Brazil, China, United States and western Europe. The costs have been characteristically higher for landlocked countries, including some of the SIMLESA countries (World Bank 2009) and rural communities. The cost and physical separation has denied farmers access to advanced inputs, such as fertiliser and improved seeds, or output markets to sell their produce at more competitive prices.

These challenges are expected to persist. Most of Africa's population is predicted to remain rural in absolute numbers through 2030 and beyond (OECD/FAO 2016). Relying on the public sector to deliver the huge infrastructure required is a daunting task and competes with equally important priorities such as provision of health and education services. Public–private partnerships to develop roads can open up new markets and reduce transaction costs for producers and retailers. Roads are needed to increase consumer demand and supply of inputs and outputs to stimulate development of the nonfarm economy. In Ethiopia, expansion of rural and town infrastructure has attracted firms, generating off-farm employment and benefited the rural economy at large (Shiferaw et al. 2015).

Target 9.1 of the United Nations' sustainable development goals seeks to 'Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human wellbeing, with a focus on affordable and equitable access for all'. The revised Rural Access Index was proposed in the draft indicator framework for the sustainable development goals as an indicator to inform these investments. The Rural Access Index measures the rural population that lives within 2 km of the nearest road that is considered to be in 'good condition'. Initial studies using Kenya data indicate a strong correlation between agricultural production and the Rural Access Index (World Bank 2016, 2017b). The percentage estimates of the revised Rural Access Index are available for eight pilot counties: Ethiopia (22), Kenya (56), Mozambique (20), Tanzania (25), Uganda (53) and Zambia (17) in Africa, and Bangladesh and Nepal in South Asia. In the six African countries, about 148 million people are estimated to have no access, which translates to a Rural Access Index of 32%. This indicates a significant infrastructure gap in rural access. In Tanzania, for instance, only 25% of the rural population lives within 2 km of a road in good condition (World Bank 2016, 2017b). Significant resource allocation is required to close the infrastructure gap; for instance, it is estimated that Kenya would need about US$2 billion to rehabilitate and extend its entire road network.

Regional economic communities have also embarked on a range of infrastructure projects that have the potential to connect rural communities to regional and global markets. One example is the northern road corridor running from Mombasa seaport to inland Bujumbura and serving Kenya, Uganda, Rwanda, Burundi and eastern Democratic Republic of Congo under the East African Community (East African Community 2017). Such corridors will not only link markets between the countries, but will also provide access to seaports and hence global markets for landlocked countries.

Subsidies on seeds and fertilisers

The case for input subsidies in Africa is based on the premise that, as a short-term measure, they may induce farmers to adopt the use of inputs and thereby increase agricultural productivity. On the other hand, there are reservations about their impacts, as they divert funding for long-term investments in research and infrastructure, which are also needed for increased productivity. There are also arguments that agricultural subsidies are expensive, their benefits do not reach target communities and they distort agricultural markets by encouraging farmers to overuse that which is subsidised. After widespread withdrawal of input subsidies in the 1990s under structural adjustment programs, they emerged again in earnest after Malawi's success in 2006 and 2007 (Denning et al. 2009). Malawi's example led to the increased implementation of smart subsidies estimated for some 10 African countries to be US$1 billion annually, equivalent to almost 30% of agricultural budgets (Jayne & Rashid 2013). However, there are still weaknesses in design and implementation, particularly late input delivery. Other weaknesses are the continued lack of emphasis on improving program effectiveness and efficiency, limited attention to graduation processes and inadequate attention to integration with complementary policies and programs.

SIMLESA research has shown that input subsidies have powerful effects in predicting adoption of CASI practices. Setting input subsidy expenditures at levels comparable to those recently observed in Malawi increased adoption by more than 100% in Ethiopia and Kenya, and by about 70% in Tanzania (Marenya, Menale et al. 2015b). The powerful effect of subsidies has been explained by their cost-reducing nature. Research under SIMLESA and related projects has shown that the best outcomes in terms of crop income were related to simultaneous adoption of combinations of recommended practices. It is important to consider the effects of subsidy programs on long-term development of input distribution systems, given the crowding-out effects on the still-developing private sector (eds Kassie & Marenya 2015).

Seeds

Various forms of evidence have suggested that there is great potential in the private seed sector. Besides subsidies, institutional support to develop new and improved varieties, provide quality assurance, upgrade laboratory and market infrastructure, enforce regulations and contracts and simplify procedures can provide potential opportunities that promote the seed sector. Market research on locally preferred genotypes can also support efforts by seed entrepreneurs to popularise preferred varieties and train farmers on their agronomy and post-harvest management. The capacity, human resources, skills, physical facilities and access to international genetic resources of many crops of the apex national research organisations, public universities, international centres and seed companies suggest that these institutions have potential to take charge of variety testing and development (Marenya, Kyotalimye et al. 2015).

The harmonised seed trade regulations in the Association for Strengthening Agricultural Research in Eastern and Central Africa, the Common Market for East and Southern Africa and the East African Community regions offer opportunities to speed up cross-border movement and trade in seed (Common Market for East and Southern Africa 2014). For example, member countries should take advantage of multiple releases to increase access to quality seed by farmers through the cross-border seed business. Harmonised trade agreements create opportunities to more efficiently move sustainably-produced agriculture products to markets that need them, benefiting both the environment and consumers.

There is an additional need to recognise and integrate the informal seed systems as they are gradually transformed to more formal systems. For instance, formal seed systems do not produce seeds for most of these crops. This is left to informal systems (Kimani et al. 2014). Legume crops have been important components in African farming systems. They provide a cheap source of protein and cash income to smallholder farmers and improve soil fertility through nitrogen fixation. Major legume crops include cowpea, field bean, soybean, pigeonpea and peanut. These crops are important in eastern and southern Africa, but their production is limited by low adoption of the new and more productive varieties (Zeigler & Steensland 2016). Quality-declared seed for crops that are not adequately covered under the formal system should be recognised where applicable. This can be through delegation of quality assurance among seed inspectorate agencies, seed companies, NGOs, and research or government enterprises.

Fertilisers

The empirical evidence suggests that fertilisers have potential to drastically enhance productivity. Declining soil fertility, particularly nitrogen and phosphorus, has been a major cause of low crop productivity in Sub-Saharan Africa. For example, almost 80% of African countries are confronted with nitrogen scarcity or nitrogen stress problems (Junguo et al. 2010). Research has shown high response of crops to fertiliser, especially nitrogen and phosphorus. However, the relatively high cost of fertilisers, combined with low agronomic and limited nutrient and water use efficiency, makes the use of fertilisers unprofitable in Sub-Saharan Africa (Jayne & Rashid 2013). Crop response is further affected by limited use of complementary soil and water management practices such as tied ridges, crop residues and organic manure.

The high cost of fertiliser in Africa is driven by many factors including the lack of own manufacturing, storage and blending facilities; poor rural infrastructure; a limited dealer network; small market size; over product differentiation; limited bulk procurement; high freight, port and handling charges; seasonal fluctuations in demand; bulkiness; and the high cost of finance. Forty per cent of the cost of fertiliser in eastern and southern Africa is due to transport from ports of entry to the farmers. For landlocked economies, poor port-handling infrastructure and trade barriers add to the cost of fertiliser. Additional costs to the nearest border point are estimated at US$50–100/t. Low access to credit by actors along the fertiliser value chain also affects demand and supply.

Foster capacity for regional and global agricultural trade

Over the period 1989–2007, only 13% of African exports went to Africa while 64% went to Europe and 23% went to Asia (eds Badiane, Makome & Bahiigwa 2014). Expansion of regional trade enhances the capacity of African countries to raise their competitiveness and benefit from rising demand in regional markets (Zeigler & Steensland 2016). Regional trade also provides the experience needed to break into global value chains and trade. Facilitating intra-Africa trade expansion has high potential to spur entrepreneurship in agriculture towards youth employment and value addition in the regional economy. However, a seamless flow of trade is constrained by over-regulation, high transfer costs and limited product diversification. The answers lie in better trade facilitation towards improving the soft and hard infrastructure for regional trade. This encompasses improving road infrastructure along key corridors; upgrading customs infrastructure, processes and management systems; elimination of non-tariff barriers; development and use of quality standards; and harmonisation of trade facilitating policies (Zeigler & Steensland 2016).

As tariff barriers are gradually reduced across regional economic blocs, there has been a steep rise in non-tariff barriers. The Tripartite Free Trade Area between the Common Market for Eastern and Southern Africa, the East Africa Community and the Southern Africa Development Community established an online non-tariff barriers reporting, monitoring and eliminating mechanism (www.tradebarriers.org). This is supported by a time-bound program for elimination of non-tariff barriers, national focal points and national monitoring committees who meet regularly and report to regional forums. By 2014, some 79 non-tariff barriers to the East Africa Community trade had been cumulatively resolved while 22 remained unresolved (East Africa Community 2014).

Other actions with the potential to make trade and markets function better for value-chain actors and to incentivise investments in the sector include harmonising international standards and greater transparency of sanitary/phytosanitary measures and food labels; intellectual property rights protection; creation of dispute settlement mechanisms; and expediting clearance, movement and release of goods between customs authorities (Zeigler & Steensland 2016; International Fund for Agricultural Development 2010).

Investment in agricultural research-for-development

Policies for promoting productive, sustainable agricultural growth through investments in public agricultural research, development and extension programs have been considered essential to accelerating growth in total factor productivity (Zeigler & Steensland 2016). Each $1 invested in agricultural research and development has been estimated to provide returns of up to $10 or more to the overall economy (Pardey et al. 2016). Overall, public sector expenditure on agriculture in the region still lags behind the Maputo recommendation of at least 10% of the national budget. Although this agriculture spending target was identified as the minimum required to facilitate innovation and technology generation, the average expenditure for eastern and southern African countries stood at 4.4%: 3.3% for Common Market for East and Southern Africa countries and 2.7% for Southern Africa Development Community countries in 2014 (eds Badiane, Makome & Bahiigwa 2014). Along with private sector and collaborative research, public research and development in agriculture has played an essential role in fostering agricultural innovation systems. In the spirit of the Science Agenda for Agriculture in Africa, regional agricultural research systems have catalysed collective actions that allow sharing of proven technologies and innovations as well as scarce resources such as scientist and laboratory infrastructure. National agricultural research systems can be innovation centres for local and national food security. Innovations, technologies and practices developed through publicly funded agricultural research can help producers to be competitive and adapt to climate change. Consumers of agricultural products also have potential to benefit when these efforts lower and stabilise prices and increase access to safe, nutritious food resulting from these investments. Research in this domain can contribute to these efforts by identifying reliable, site-specific and climate-relevant recommendations to minimise risks (Roxburgh 2017).

Information and communications technology for agriculture

Adoption of science-based and information technologies can help producers manage the ever-present risks in agriculture while improving sustainability and competitiveness (Zeigler & Steensland 2016; International Fund for Agricultural Development 2016). For CASI practices, information technology allows farmers to access vital information on market prices, weather, pests and soil health. Precision agriculture and data management tools help producers reduce costs and conserve scarce resources. Public policies that support the development, customisation and dissemination of these technologies to farmers of all scales and the entire value chain are essential if global agricultural output is to be doubled sustainably by 2050. Investments are also needed in market information systems, including information and communication technology, rural internet connectivity and mobile telephone options, to raise awareness on prices, trading regulations and related reforms, supply and deficit zones and stock levels.

Agriculture is considered a high-risk sector. Climate change, biotic and abiotic stresses and the lack of insurance markets and low adaptive capacity of actors heighten the situation. Investment in CASI requires enhancing the capacity of actors to cope with adverse situations, including strengthening social capital and access to social protection. In smallholder agriculture, managing these risks is an important aspect of protecting livelihoods and opening up opportunities for investment. In the context of sustainable intensification in African agricultural production systems, which feature unmitigated production risks and limited or non-existent formal social safety nets, undertaking self-protection is critical. Under these circumstances, emphasis on agricultural practices or technologies that can increase the resilience of crop production against environmental risks is a key feature in protecting livelihoods.

Strengthening the collective capabilities of rural people

Membership-based organisations have a key role to play in helping rural people reduce risk. This stems from learning new techniques and skills, management of individual and collective assets and marketing of produce (International Fund for Agricultural Development 2016). With improved skills, rural people can negotiate with the private sector or government and help hold them accountable. Based on SIMLESA's experience, structured business-focused alliances of institutional actors have represented the successful agricultural innovation platforms that enable and sustain mutual benefits (Marenya, Menale et al. 2015). Each of these actors derives clear benefits, based on their critical but unique roles: marketing, credit, investment, new agricultural technologies, reduced input costs and interaction with policy/decision makers. Many organisations have been shown to have problems of governance, management or representation. However, these organisations are usually best positioned to represent the interests of poor rural people. Capacity building efforts and opportunities to influence policy have been proposed as some of the approaches with the greatest potential to address these concerns (eds Kassie & Marenya 2015). Opportunities to build the social capital of farming communities, and formalising and supporting farmers' groups is an important opportunity to create networks of information exchange, market access and resource mobilisation (eds Kassie & Marenya 2015). Central and local governments can enhance widescale collective action from small pockets of success to empower more farmers. This would in part require retooling of extension workers to enhance their capacity to facilitate innovation platforms, mainstreaming innovation platform approach in the budgeting and planning process, strengthening the legal framework for collective action and reviewing agricultural education curriculums to build capacity in innovation platform approaches (Marenya, Kyotalimye et al. 2015).

Social protection programs

There is general consensus that implementation of agricultural input subsidies and other farm-based support boosts aggregate food production. One area of debate is the unintended consequences of bypassing the most vulnerable rural households, such as the poor and female-headed households (Jayne & Rashid 2013; eds Kassie & Marenya 2015). To address this concern, social protection programs have worked to reduce vulnerability and risk exposure of target groups including youth, women and the elderly. The risks that they try to minimise are those associated with unemployment, disability, old age and sickness. They are packaged as empowerment funding for youth and women groups, cash transfers for the elderly and people with disabilities, and food subsidies. The common challenges reportedly faced by these programs have included capacity limitations, inefficiencies arising from duplicated projects and initiatives, and poor coordination (Jayne & Rashid 2013). Improved targeting is needed to help them improve their risk management (Jayne et al. 2016).

Unconditional cash transfer programs are a popular instrument for poverty reduction and social protection programs. They are implemented by 40 out of 48 countries in Sub-Saharan Africa. Hagen-Zanker et al. (2016) presented an evaluation of cash transfer programs from 165 studies, covering 56 programs in low- and middle-income countries. The programs have shown significant impacts on expenditure on food and other household items, access to schooling or use of health services. The study also found positive impacts on investments in agricultural inputs in Sub-Saharan Africa. This study suggests that cash transfers and other social protection programs can be effective instruments in reducing poverty and spreading of economic autonomy and self-sufficiency.

Support for the emergence of a viable rural nonfarm economy

Agriculture remains a key driver of nonfarm economic development, with each $1 of additional value added in agriculture generating $0.30–0.38 cents in second-round income gains elsewhere in the economy (International Fund for Agricultural Development 2010). A viable rural nonfarm economy requires an environment where people can find greater opportunities and face fewer risks, and where rural youth can build a future. Devolved governance structures in most countries are making this a reality, although most are still in infancy and need to evolve and grow. Greater investment and attention are needed in infrastructure and utilities, particularly roads, electricity, water supply and renewable energy. Also important are rural services, including education, health care, financial services, communication and information and communication technology services, particularly the diffusion of mobile phone coverage in rural areas. Good governance is also critical to the success of all efforts to promote rural growth and reduce poverty, including developing a more sustainable approach to agricultural intensification.

Strengthening the capabilities of rural people to take advantage of opportunities in the rural nonfarm economy has also been central to these efforts (Jayne et al. 2010). Education and skills are particularly important, because they enable rural youth and adults to access employment opportunities and enhance their capacity to start and run their own businesses. Technical and vocational skills development in particular needs to be expanded, strengthened and better tailored to the current needs of rural people. These include microentrepreneurs, workers who wish to remain in their areas of origin and those who may seek to migrate. Strengthening capabilities on all these fronts requires various, often innovative, forms of collaboration, in which governments play effective roles as facilitators, catalysers and mediators and the private sector, non-government organisations and donors are significantly engaged.

There is also a need to demystify CASI, which requires actions in at least three areas:

1. Facilitating science communication experts to simplify CASI into an everyday term for policymakers and the public, like other terms that are now taken for granted (e.g. climate change and food security).
2. Supporting the coalescing of experts and think tanks across the public, private and non-state sectors. Teams should work on the key policy actions for bringing CASI into holistic, interdisciplinary networks or communities of practice. They should build synergistic effects, avoid duplication and ensure learning and the emergence of best practice. A starting point would be to bring together key players to develop action plans as happened in the SIMLESA high-level policy forum.
3. Developing and building consensus on succinct indicators for tracking progress in CASI that are aligned to the sustainable development goals and continental and national frameworks and push for their mainstreaming in national planning and policy documents.

Extracts from the joint communiqué of the high-level policy forum on SIMLESA, Entebbe, Uganda, 28 October 2015

A synthesis of the presentations and discussions made led to the production of a joint communiqué, which was signed by representatives of the ministries responsible for agriculture in Kenya, Mozambique, Rwanda, Tanzania and Uganda. The presentations made at the forum were based on seven policy briefs.

The communiqué was informed by research evidence showing that:

- application of resource conservation practices, crop diversification and livestock integration can increase productivity
- farmers belonging to groups are more likely to diversify cropping patterns, build their resilience by trying out new farming practices, use improved varieties and adopt soil and water conservation practices
- farmers who are close to markets have better access to farm inputs, can readily sell their farm produce and are more likely to adopt maize and legume intercrops and rotations, improved varieties and other CASI management practices.

The communiqué recommended follow-up policy actions to governments and concerted actions from a range of stakeholders in eastern and southern Africa. Examples of actions aimed at promoting CASI through enhanced input access included:

- Governments and development partners working through agricultural extension service agencies should increase frontline extension workers to at least 33 per 10,000 farmers for an effective extension system and other homegrown approaches (e.g. mobile short message services).
- Extension organisations and advisory service providers should train farmers in CASI practices validated under SIMLESA and other players to enhance soil health including the use of organic matter, mineral fertilisers and planting of legume crops like cowpea, soybean and pigeonpea.
- Researchers should establish fertiliser recommendations supported by soil testing by crop and agroecological zones and increase efficiency at farm level by promoting production technologies and practices that enhance nutrient and water use efficiency, to increase returns to fertiliser use.

The full text of the communiqué is available at https://simlesa.cimmyt.org.

Conclusion

Agricultural productivity growth will remain a major driving force in the structural transformation of many countries in Sub-Saharan Africa in the foreseeable future. Unfortunately, this situation will be shrouded by increasing challenges from rapid population growth and climate change and variability.

CASI is a potential route to agricultural productivity growth and enhanced food security into the future. However, meaningful adoption of CASI practices will require concerted and coordinated efforts by all players in technology development, policy development and the private sector.

Multipronged approaches from extension to social protection are needed. Caution should be exercised in making blanket recommendations on which approaches to use. Since local conditions and circumstances are unique, combinations of the approaches will be required to suit specific locations.

CASI's potential to lessen resource constraints calls for a deliberate focus on inclusion strategies to ensure that the benefits accrued are equitable. Robust monitoring and evaluation frameworks are also required to remove the ambiguities related to the measurement of CASI and its impacts, including the relevance and effectiveness of policy actions.

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23 Benefits and trade-offs from alternative adoption pathways

Paswel Marenya, Adam Bekele, Maria da Luz Quinhentos, Martins Odendo, Timanyechi Munthali & Sarah E. Tione

Key points

- Various pathways towards widespread conservation agriculture-based sustainable intensification (CASI) can be effective, including subsistence-based, market-oriented and policy-driven pathways.
- Both the subsistence-led and the market-led pathways can be enabled by investing in agricultural advisory systems such as increasing the extension agent to farmer ratio and encouraging other complimentary providers of services.
- Although CASI practices include sets of practices with demonstrable cost advantages and productivity dividends, the widely known enablers of agricultural technology adoption also remain relevant.
- Policy attention in support of CASI should remain focused on better access to markets, solid information delivery through strong agricultural extension and policy and infrastructure investments to produce favourable input and output price ratios.

Introduction

The need for conservation agriculture-based sustainable intensification (CASI) at this juncture is well established. The most promising options for increasing food production and achieving household food security involve some form of intensification—either intensify on available land, maintain or produce more food using limited amounts of family labour, or both. CASI includes the notion that smallholder agriculture can be a steward of the natural resource base while also sustaining productivity. However, this requires that these practices, technologies or interventions are more productive than current ones, address farmers' needs and are compatible with their circumstance. Even when these criteria are met, farmers have typically accepted certain trade-offs in the process of adopting CASI practices.

The literature on this issue, including that from the SIMLESA program, shows that resource scarcities (or more specifically, high opportunity costs of cash, land, labour and the like), have discouraged adoption and diffusion of the most promising CASI practices. Resources used to purchase inputs and labour for CASI practices may be alternatively directed towards more immediate needs. Delayed returns on investment have similarly posed a major challenge for CASI adoption.

Trade-offs have often resulted from agricultural market conditions. Markets that provide incentives for investment in CASI require information, grading facilities and other market infrastructure. However, these markets may exclude certain groups, including some of the most at-risk members of the smallholder population. Environmentally benign production methods have not always guaranteed high production or profits. For example, building soil carbon stocks and soil fertility may require several seasons of new practices before crop yields improve. Strategies, or adoption pathways, that help farmers bear (not avoid) these costs, including early incentives (e.g. labour savings), can help ensure that farmers benefit from CASI. Policies that subsidise inputs in the short term may also crowd out investments in private fertiliser distribution.

This chapter demonstrates the plurality of pathways that can lead households to rapidly and sustainably intensify. We identify three key pathways that smallholder agriculture can follow when adopting CASI practices:

1. subsistence and food security
2. markets and incentives
3. institutions and policies.

The first pathway involves securing sustainable household food security from diversified and household-level production. Household-level production for food security has been recognised as a strategy in market-constrained and relatively land-abundant situations. The second route involves greater participation in input and output markets. The promise of higher incomes from vibrant food markets can provide strong incentives for technology adoption and CASI. New market outlets can make the sale of staple crops such as maize and legumes a viable source of income for those who have access to these well-functioning markets. The third pathway involves an enabling policy and institutional environment including finance and information. The macro-economic conditions in which farmers operate will determine whether they have access to inputs and services that support adoption of CASI practices.

The three pathways above are not mutually exclusive (Figure 23.1). The predominant pathway used by individual farmers or communities of farmers in a country or region will depend on the needs and circumstances of the community. A number of steps can be taken to reduce trade-offs, or the potential losses that often accompany the different CASI pathways. These include building better information systems, developing contract-based value chains and grading and post-harvest processes.

First, we describe the data collected by the SIMLESA program, which are used in this analysis. This is followed by three main sections that outline and explain each of the pathways and their trade-offs. The concluding section outlines the key lessons that have been learned from the body of evidence generated in SIMLESA and similar literature.

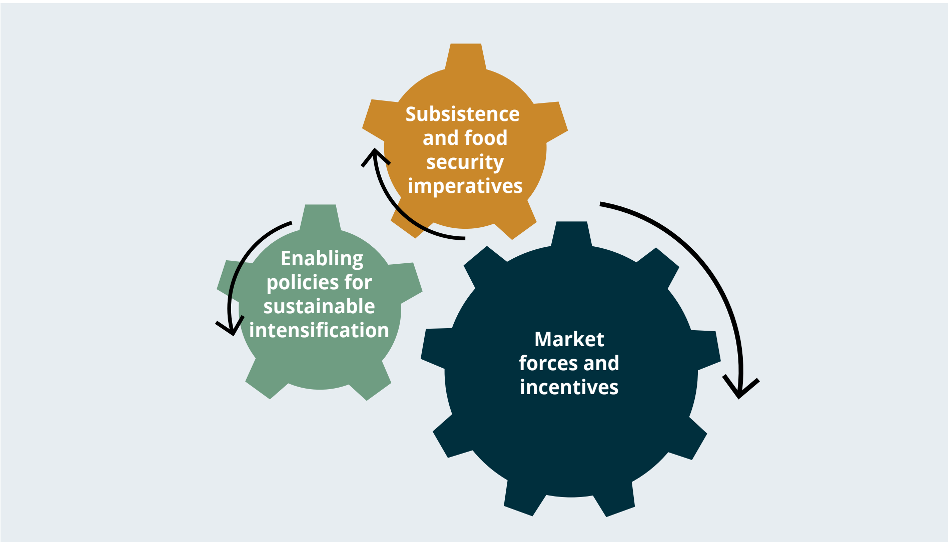

Figure 23.1 **Three related pathways to sustainable intensification**

Data used in this chapter

Broadly, the research results reported in this chapter are based on household and plot-level data gathered under the SIMLESA program, as well as a collaborative project named the Adoption Pathways Project[1]. The data were collected to understand drivers and enabling environments for the adoption of CASI practices and their impacts on farmers' livelihoods. The broad aim of these data was to generate information on farmers' resource conditions, community characteristics, gender relations, value chains and policies. This information was then used to support farmers, extension agencies, non-governmental organisations and public agencies including ministries of agriculture and agribusinesses along the value chains to inform investment in CASI technologies.

1 The Adoption Pathways Project, formally known as Identifying socioeconomic constraints to, and incentives for, faster technology adoption: Pathways to sustainable intensification in eastern and southern Africa, was meant to complement the work of the SIMLESA program and focus on generating information to support researchers, decisionmakers, farmers and development partners in making high-quality decisions that improve food security by providing appropriate panel datasets, knowledge base, tools and methods that can be used for better targeting of technologies, accelerating adoption and to understand the dynamics of socioeconomic development because of technology and policy interventions within maize farming systems in eastern and southern Africa. The project ended in June 2016. The data from this project are now available in Open Access at http://data.cimmyt.org/dvn/dv/cimmytdatadvn/faces/StudyListingPage.xhtml?mode=1&collectionId=119.

Subsistence and food security

Own-farm production has offered one of the most important strategies for ensuring food security in rural areas. Empirical studies associating food security with intensity of adoption of improved varieties have demonstrated the relationship between household production levels and food security (Kassie, Jaleta & Matei 2014). Food security and nutrition depended on household-level production and crop diversification among SIMLESA households. Kassie et al. (2016) further demonstrated a link between the mix of crops under production and household diets. They showed increases of 27%, 29%, 50% and 7% in kcal, protein, iron and diet diversity, respectively, when crop diversification was adopted jointly with improved maize varieties (Kassie et al. 2016) (Figure 23.2). Dietary diversity also increased when modern seeds and maize–legume diversification occurred simultaneously (Hailemariam et al. 2013). This suggests that, for many rural households, access to agricultural and labour markets is not the primary means of procuring food, especially when households have limited access to food markets. The results demonstrate the benefits of smallholder diversification in the face of subsistence production and weak markets. Households that rely on their own farms for food and nutrition security can reduce the risk of crop failure by sustainably intensifying production. Production of a diversified crop portfolio should be encouraged under these conditions, given the limited opportunities for specialisation and constrained access to diversified diets through local food markets. The requirements of this pathway towards CASI should, therefore, be critical information for agricultural extension and the development of other policies.

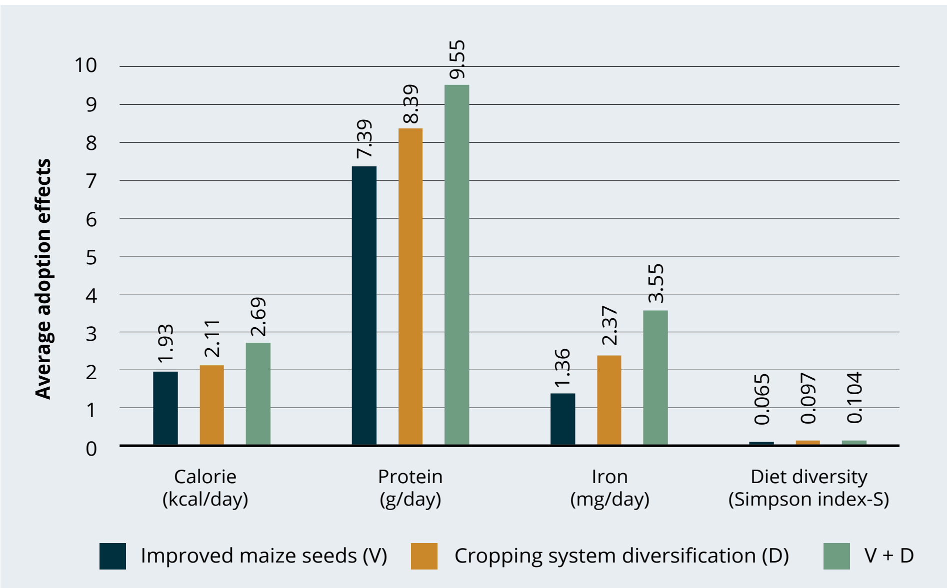

Figure 23.2 Impacts of CASI practices on nutrition

Source: Kassie et al. 2016

When farm production generates sufficient food and profits for an adequate food supply, the opportunity cost of investing labour towards own food production can be low, depending on food prices in local markets. However, the cost increases when labour is in high demand. Peak labour-demand periods for farmers can coincide with household food shortages and create a trade-off between immediate needs and medium- to long-term investment on their own farms. Most of the costs of production must be incurred up-front, from savings, credit or other non-crop income. The decision to outsource labour can minimise costs when the value of a household members' labour is high, food stocks from previous harvests have been drawn down and labour investments are immediately necessary to maintain on-farm operations.

Labour markets had a mixed effect on adoption of CASI practices among SIMLESA households. Households with salaried off-farm incomes had a higher probability of adopting soil and water conservation practices in Kenya. Yet the probability of manure use was lower in households with a salary earner, suggesting that, in some cases, the comparative advantage of off-farm income outweighed on-farm agricultural investment (Kassie et al. 2015). Similarly, Marenya, Menale et al. (2017) found that farmers who had off-farm wages or income or off-farm self-employment were less likely to adopt minimum tillage and mulching practices in Ethiopia. Yet in Tanzania, those who were self-employed off-farm were less likely to practise minimum tillage. Marenya, Menale et al. (2017) concluded that the negative correlation between access to nonfarm income and adoption of CASI practices may suggest 'high opportunity cost of labour' used on-farm. This means that farmers are better off in some cases allocating their labour to economic activities outside their farm. To offset this, Marenya, Menale et al. (2017) suggested that significant increases in on-farm crop yields and incomes are needed to attract more family labour to their own-farm production activities.

The high discount rate occasioned by short-term survival needs is the most cited cost of CASI (Diagana 1999). Rural households faced a trade-off between immediate survival and long-term benefits of CASI (e.g. soil quality) when households used the entirety of existing labour and financial tools to support immediate needs or when market failures were common. Most SIMLESA farmers who had an immediate and urgent need for food production did not invest in CASI technologies. Households did not reallocate resources that supported these strategies towards investment in intensification. Rather, they tended to use other short-term livelihood strategies to fulfil immediate needs.

Scholars have suggested that these costs and trade-offs have hampered and explained low CASI technology adoption levels, even when the benefits of adoption were significant (Marenya, Smith & Nkonya 2012; Reardon et al. 2001). One way to enable farmers to adopt CASI practices is to support immediate needs (decrease discount rates) and reduce financial hurdles. For example, Schmidt et al. (2017) showed that investments in own-farm soil erosion control in Ethiopia would largely be unprofitable given the prevailing shadow wages (i.e. alternative wage opportunities) and subsistence needs to sell labour for wage income. They suggest that sustainable land management investments must be paired with other input and infrastructure investments, as well as subsidies for initial labour costs, in order to incentivise adoption and long-term sustainable land management maintenance.

Markets and incentives

In areas with good infrastructure and inclusive market access, opportunities for the commercialisation of food crops can be high. Diversification into relatively high-value, nutrient-dense legumes can support high returns on production and incentivise CASI. However, the agricultural output markets assessed under SIMLESA operated with multiple market failures. Despite recent trends towards structured, quality-driven staple food grain markets in Africa (Vandeplas & Minten 2015), data collected under SIMLESA show that, in Ethiopia and Kenya, maize and legume grain markets were mostly informal with little or no integration, and no access to financial or insurance markets (Marenya, Bekele & Odendo 2016). Moreover, these markets were localised, and most transactions are made at or within the vicinity of the local village. In Ethiopia and Kenya, the local village or town was the primary area of operation for 94% and 72% of maize traders (Table 23.1).

Table 23.1 **The main location of maize traders' operations and sales**

	Operations and sales (%)	
Location	**Ethiopia**	**Kenya**
Local market, village and town	94	72.1
District/woreda	5.8	–
Zone	0.2	–
Division	–	10.9
Subcountry	–	9.3
Country	–	7.8

Source: Marenya, Bekele & Odendo 2016

Further, there were few transactions based on contracts in either country. Nearly all traders had no contract-based purchases from farmers in Ethiopia (99.6%) and 91% in Kenya (Table 23.2). Commitment failure is common in the absence of contracts (Palaskas & Harriss-White 1993; Gebre-Madhin 2001). These commitment failures may be explained by missing market information, inadequate regulation and lack of legal framework for contract enforcement. In other words, these markets are largely informal, rather than structured institutions with the capacity to facilitate anonymous exchange (Gebre-Madhin 2001, Kydd & Doward 2004). Kydd & Doward (2004) concluded that these qualities can hinder the development of modern value chains and the benefits of sustainable intensification.

Table 23.2 **Prevalence of contracts in purchase or sale transactions by traders**

	Ethiopia (%)	Kenya (%)
Do you have supply contracts with farmers?		
No contract	99.6	90.6
Have supply contract	0.4	9.4
Do you have buyer contracts to purchase from you?		
No contract	96.0	87.7
Have buyer contract	4.0	12.3

Source: Marenya, Bekele & Odendo 2016

The trade-off between costs of market access (e.g. transportation costs) and market revenues can determine the benefits of this agricultural intensification pathway and drive adoption of CASI practices. Some evidence has shown that SIMLESA households who were located close to markets were more likely to be net sellers of maize (Marenya, Kassie et al. 2017). CASI adoption patterns have been explained by household proximity to peri-urban markets, where farmers were more likely to implement CASI practices such as maize–legume diversification. For example, Kassie et al. (2015) found that households located closer to markets had a higher chance of adopting maize–legume crop mixes and manure in Ethiopia, improved varieties in Malawi and minimum tillage in Tanzania. As household distance from main markets increased, the chances that they implemented practices like minimum tillage, soil conservation and fertilisers decreased (Marenya, Menale et al. 2017).

Marenya, Bekele & Odendo (2016) suggested that expanding market access beyond local spot markets has potential to substantially increase financial incentives for CASI. Second, availability of support services such as transportation, post-harvest handling and grading will likely increase value addition along the value chain, opening up greater income enhancement opportunities beyond primary production. Third, price information systems based on widely accepted quality definitions can also substantially increase financial incentives for CASI. These can provide incentive signals for quality-based pricing and therefore production and value capture by farmers, providing financial incentives for CASI.

Institutions and policies

The potential benefits of CASI are clearly apparent, but also depend on the policy environment. Major policy reorientation across much of eastern and southern Africa has been necessary for the benefits of CASI practices to outweigh certain costs. In rural settings, where own production tends to be the major source of food, subsistence needs form an important consideration. Specific policies that support CASI can address constraints to food security. Policies can help address the high costs of investments in natural resources by supporting rural financial services. Policies that prioritise adaptive and on-farm research or fund adaptive research and agricultural extension can also help farmers to bear some of the adaptive and information gathering costs of CASI. Policies that promote investment in agricultural input and output value chains also have potential to greatly enhance rural livelihoods. In this section, we report results from a policy simulation exercise that sheds light on some principles to guide extension and programs that support investment in agricultural inputs and enhance market access. The policies that were simulated include investments in agricultural extension, input subsidies, credit provision and rural infrastructure. They can function to offset initial investment costs, since consumption smoothing through credit has been important in determining adoption outcomes.

Extension institutions

In the agricultural economies of eastern and southern Africa, extension services remain one of the most critical public investments and rural services. Recent interest in reforming agricultural extension services has given new impetus to revamping these services, which suffered neglect during the years of the structural adjustment programs of the 1980s (Rivera & Alex 2004; Pye-Smith 2012).

These declines were partly due to unsustainable expansion during the 1980s decade and the need for public sector contraction as part of the structural adjustment reforms. At the peak of investments in extension in the pre-adjustment years, the developing country average of the extension agent to farmer ratio was 1:300 and that declined to 1:1,500–3,000 by 2012 (Pye-Smith 2012).

Reflecting the new impetus for extension, the Ethiopian government has recently been investing considerably in agricultural extension, specifically the number of frontline extension staff. Davis et al. (2010) showed that, in Ethiopia, these efforts contributed to one of the most favourable extension agent to farmer ratios of 16:10,000 (at the time of publishing). This is certainly impressive, compared to 4:10,000 in Tanzania, 3:10,000 in Nigeria, 6:10,000 in Indonesia and 2:10,000 in India (Davis et al. 2010). Compare this with the recommendation in Pye-Smith (2012), that a good ratio concentration of extension agents would be about one extension agent for every 300 farmers, or 33 agents per 10,000 farmers, suggesting that Ethiopia was halfway towards this target.

Input subsidies

The return of fertiliser subsidies in eastern and southern Africa in recent years comes after a period of their absence in the wake of the structural adjustment programs of the 1980s and 1990s. At their peak in the 1960s and 1970s, the main reasoning for subsidies was based on evidence from the Asian green revolution showing that subsidies were crucial in supporting the widespread adoption of improved seeds and fertilisers. The evidence showed that carefully targeted subsidies can allow liquidity-constrained households to overcome short-term financing gaps that trap many farmers in vicious cycles of low productivity. By lowering the overall costs of inputs, farmers may be able to afford fertiliser and other CASI practices. Subsidies could relieve financial, liquidity, profitability or infrastructure-induced cost constraints.

Consequently, public expenditures on subsidies has been considerable in countries that chose to implement them. For example, Malawi spent about 72% of its agricultural budget in 2008–09 on agricultural input subsidies (Dorward & Chirwa 2010). Such a policy of increasing government investment on subsidies has frequently led to a number of challenges, including high fiscal costs and crowding out investment in other areas of agricultural development. The effect of subsidy policies will depend on a number of conditions being met, which ensure that market-smart programs do not undermine the private agribusiness sector (Smale, Byerlee & Jayne 2011).

There has been noticeable progress in market access and agribusiness activity in eastern and southern Africa since the end of the 1990s (Jayne, Chapoto & Shiferaw 2011). Nevertheless, outstanding issues remain that prevent these sectors from attaining their full potential. Some of these are inadequate infrastructure and weak input (output) supply chains leading to effectively high (low) and prices for inputs (outputs). These impediments have hampered technology adoption because they made otherwise beneficial technologies (e.g. hybrid–fertiliser combinations, herbicide-based conservation methods) inaccessible or expensive (Marenya, Mentale et al. 2017). Poor infrastructure leads to market isolation and lack of integration with national or regional markets, implying that any increased production can easily lower producer prices (due to the limited market horizons), erode profitability and undermine technology use. Due to poor infrastructure, fertiliser/grain price ratios in Sub-Saharan Africa have been found to be two times those found in Latin America or Asia (Yamano & Arai 2010).

Policy simulation exercise

In this section, we report on a policy simulation exercise to illustrate the possible policy pathways towards the adoption of CASI practices. We use minimum tillage combined with mulching as two important conservation agriculture-based practices that were researched under SIMLESA. The simulations are carried out based on the regression and simulation procedures reported in Marenya, Menale et al. (2017). We simulated two main policy aspects involving extension and fertiliser subsidies (Table 23.3). These were combined with indicators of market access and fertiliser–maize price ratios.

Table 23.3 Policy simulation variables

	Ethiopia	Kenya	Malawi	Tanzania	Average
Extension personnel per 10,000 farmers	**16.0**	**10.0**	**6.2**	**4.0**	**9.0**
Years	2010	2012	2008	2010	
Source	Davis et al. (2010)	Government of Kenya (2012)	Pablo et al. (2008)	Davis et al. (2010)	Authors' computations from indicated sources
Input subsidy expenditure as a percentage of public agriculture spending (%)	**10.4**	**19.0**	**58.9**	**46.0**	**33.6**
Years	2009–11	2009–11	2009-11	2009–11	
Source	Jayne & Rashid (2013)	Jayne & Rashid (2013)	Jayne & Rashid (2013)	Jayne & Rashid (2013)	Authors' computations from indicated sources
Farm gate maize prices (US$/kg)	**0.158**	**0.230**	**0.170**	**0.189**	**0.187**
Year	2010	2010	2010	2010	
Source	Authors' computations	Authors' computations	Authors' computations	Authors' computations	Authors' computations
Farm gate fertiliser prices (US$/kg)	**0.455**	**0.807**	**0.392**	**0.344**	**0.500**
Year	2010	2010	2010	2010	
Source	Authors' computations	Authors' computations	Authors' computations	Authors' computations	Authors' computations
Fertiliser–maize price ratios	**2.9**	**3.5**	**2.3**	**1.8**	**2.7**
Year	2010	2010	2010	2010	
Source	Authors' computations	Authors' computations	Authors' computations	Authors' computations	Authors' computations

Extension simulations

The extension agent to farmer ratio had a significant impact on the predicted probability of adopting minimum tillage combined with mulch as one element of conservation agriculture-based sustainable intensification (CASI) across all countries (Table 23.4). In Kenya, the probability of adoption increased from 3.9% to 6.5% by increasing the extension agent to 10,000 farmers ratio from 10 to 16. Similarly, the probability of adoption increased from about 34% to about 50% in Malawi and from 10% to 21% in Tanzania when the extension agent to 10,000 farmers ratio increased from 6 to 16 in Malawi and from 4 to 16 in Tanzania.

Subsidy expenditures had a significant impact on the probability of adoption when the extension agent to farmer ratio was reduced (by setting it at the lowest level, observed in Tanzania) and the input subsidy expenditure as a percentage of public agriculture spending was increased to Malawi's level of 58.9%. Despite the 75% reduction in the extension agent to farmer ratio in Ethiopia, the probability of adoption increased by about 4% (from 26% to 30%), due to the increase in subsidy expenditure. Increasing the extension agent to farmer ratio to compensate for reductions in subsidy expenditure led to a marginal increase in the probability of adoption in Kenya. For Tanzania and Malawi, the probability of adoption declined by between 2% (Tanzania) and 14% (Malawi).

Table 23.4 Extension simulations: predicted probability of CASI adoption by sample

Panel I:	**Effect of increasing EFR: for each country set EFR at Ethiopian level**				
EFR level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
At respective country means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Ethiopian mean (C)	0.214*** (0.019)	N/A	0.065*** (0.013)	0.498*** (0.067)	0.214*** (0.057)
Chi-square tests					
A = B	NA	8.60**	7.09**	6.0**	4.61**
A = C	5.47***	N/A	4.47**	5.91**	4.10**
Panel II:	**Effect of low EFR and high SER: For each country set EFR at Tanzania's level and SER at Malawi's level**				
EFR/SER level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective country means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Tanzania's EFR and Malawi's SER (B)	0.213*** (0.023)	0.301*** (0.037)	0.092*** (0.029)	0.308*** (0.014)	0.142*** (0.019)
Chi-square tests					
A = B	3.85*	1.31	3.60*	6.50*	5.62*

Note: CASI = conservation agriculture-based sustainable intensification

Table 23.4 Extension simulations: predicted probability of CASI adoption by sample (continued)

Panel III: Effect of high EFR with low SER: For each country set EFR and SER at Ethiopia's level					
EFR/SER level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective country means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Ethiopia's EFR and Ethiopia's SER (B)	0.129*** (0.015)	N/A	0.048*** (0.006)	0.201*** (0.047)	0.080*** (0.015)
Chi-square tests					
A = B	7.22**	1.31		3.61* 7.89*	2.35
Panel IV: Effect of high extension with complete absence of credit: for each country set credit constraint at 1 and EFR at Ethiopia's level					
EFR/Credit constraint level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective country means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
No credit available and EFR at Ethiopia's level (B)	0.192*** (0.019)	0.179*** (0.022)	0.056*** (0.011)	0.469*** (0.067)	0.184*** (0.051)
Chi-square tests					
A = B	1.75	12.16***	2.33	4.04*	2.73*
Observations	11,188	3,861	2,851	2,937	1,539

Notes: EFR = extension agent to farmer ratio; SER = input subsidy expenditure as a percentage of public agriculture spending; CASI = conservation agriculture-based sustainable intensification; *, ** and *** indicates statistical significance at 1.5 and 10% levels respectively.

The compensatory effect of a high extension ratio and lack of credit is demonstrated when the extension agent to farmer ratio was increased but credit was assumed to be unavailable. This was achieved by setting the extension agent to farmer ratio at the highest level (Ethiopia), and making the credit constraint binding for all farmers. The results show that in all cases (except Ethiopia), the magnitudes of increase ranged from 16% in Kenya, 13% in Malawi and 8% in Tanzania. The probability of adoption in Ethiopia fell from 26% to 18% when 100% of household credit was constrained (from 56%) and the extension agent to farmer ratio was unchanged.

Subsidy simulations

Setting subsidy expenditure as a ratio of all agricultural expenditure at the Malawian level (which was observed as the highest) increased the probability of adoption by more than 100% in Ethiopia and Kenya and about 40% in Tanzania (Table 23.5). Lowering subsidy expenditure and increasing credit (by treating every household as if they all had credit) lowered the probability of adoption in all cases (including the pooled sample) except in Ethiopia. Eliminating credit availability and increasing and setting subsidy expenditure at its highest (Malawian) level increased adoption across all countries except in Malawi, where elimination of credit had no corresponding subsidy expenditure increase.

Table 23.5 Subsidy simulations: predicted probability of CASI adoption by sample

Panel I: Effect of increasing SER: for each country set SER at Malawi's level					
SER level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
At respective sample means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At whole sample mean (B)	N/A	0.401*** (0.060)	0.065*** (0.013)	0.197*** (0.045)	0.067*** (0.013)
At Malawian mean (C)	0.319*** (0.67)	0.572*** (0.126)	0.140*** (0.057)	NA	0.143** (0.019)
Chi-square tests					
A = B	N/A	5.90**	4.80**	9.27***	9.91***
A = C	5.12**	6.38**	3.11*	NA	5.62**
Elasticities of adoption with SER					
A to B	NA	0.248	0.868	0.971	1.199
A to C	1.194	0.261	1.233	NA	1.585
Panel II: Effect of low subsidy with full credit availability: for each country set SER at Ethiopia's level and credit constraint at 0					
SER/credit constraint level	**Pooled**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective sample means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Ethiopia's SER and no credit constraint (B)	0.109*** (0.024)	0.285*** (0.010)	0.033*** (0.006)	0.119*** (0.062)	0.031*** (0.017)
Chi-square tests					
A = B	6.15**	19.3***	2.54	11.83***	17.93***
Panel III: Effect of high subsidy with no credit available: for each country set credit constraint at 1 and SER =at Malawi's level					
SER/credit constraint level	**Pooled**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective sample means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Malawi's SER and no credit available (B)	0.292*** (0.064)	0.547*** (0.126)	0.124*** (0.052)	0.312*** (0.010)	0.120*** (0.017)
Chi-square tests					
A = B	3.80*	5.34*	2.61	20.96***	1.63
Observations	11,188	3,861	2,851	2,937	1,539

Notes: EFR = extension agent to farmer ratio; SER = input subsidy expenditure as a percentage of public agriculture spending; CASI = conservation agriculture-based sustainable intensification; *, ** and *** indicates statistical significance at 1.5 and 10% levels respectively.

Fertiliser–maize price ratio simulations

A high fertiliser–maize price ratio can indicate either that fertiliser prices are too high relative to maize or that maize prices are too low relative to fertiliser. When fertiliser is seen as a critical component for conservation agriculture success, an increase in the fertiliser–maize price ratio resulting from high fertiliser prices can decrease the probability of adoption (Table 23.6). The profitability of fertiliser and maize production can decrease when the ratio is high (because of very low maize prices relative to those of fertiliser, all else equal), and undermine the rationale for CASI. Lowering the fertiliser–maize price ratio increased the probability of adoption in all cases. When the fertiliser–maize price ratio was set at the whole sample mean, increasing the values for Malawi and Tanzania, then the probability of adoption reduced in both cases from 34% and 10% to 32% and 8%, respectively.

Table 23.6 Fertiliser–maize price ratio simulations: predicted probability of CASI adoption by sample

Panel I:	**Effect of increasing FMPR: for each country set FMPR at Tanzania's level**				
FMPR level	**Whole sample**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
At respective sample means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At whole sample mean (B)	NA	0.268*** (0.010)	0.051*** (0.007)	0.315*** (0.015)	0.076*** (0.009)
At Tanzanian mean (C)	0.207** (0.021)	0.316*** (0.031)	0.067*** (0.016)	0.367*** (0.016)	NA
Chi-square tests					
A = B	NA	4.04**	3.54*	4.28**	4.38*
A = C	3.65*	3.76**	2.89*	4.04**	NA
Elasticities of adoption with FMPR					
A to B	NA	–0.562	–1.346	–0.391	–0.465
A to C	–0.696	–0.593	–1.478	–0.395	NA
Panel II:	**Effect of high FMPR with high EFR: for each country set FMPR at Kenya's level and EFR at Ethiopia's level**				
FMPR/EFR level	**Pooled**	**Ethiopia**	**Kenya**	**Malawi**	**Tanzania**
SER and EFR set at respective sample means (A)	0.168*** (0.004)	0.258*** (0.008)	0.039*** (0.004)	0.338*** (0.009)	0.099*** (0.008)
At Kenya's FMPR and Ethiopia's EFR (B)	0.181*** (0.029)	0.171*** (0.017)	0.065*** (0.013)	0.424*** (0.091)	0.145*** (0.063)
Chi-square tests					
A = B	0.21	22.94***	4.47*	0.93	0.51

Notes: EFR = extension agent to farmer ratio; FMPR = fertiliser–maize price ratio; CASI = conservation agriculture-based sustainable intensification; *, ** and *** indicates statistical significance at 1.5 and 10% levels respectively.

Conclusion

Constraints arising from limited markets and weak policy support have amounted to a number of trade-offs associated with adoption of CASI practices. Many agrarian households in the developing world have navigated decisions between immediate survival needs and long-term sustainability and productivity. The implications of the policy simulation results are threefold.

First, the power of input subsidies in predicting adoption suggests that lowering costs of inputs is central in encouraging adoption of CASI practices. Since the cost of investment can be a major barrier to adoption, diverse options for lowering input/output price ratios should be put on the policy table, including subsidies that effectively reduce the prices of inputs.

Second, investing in agricultural extension systems by increasing the number of personnel (increasing the extension agent to farmer ratio) and expanding the reach of publicly funded extension systems among complementary providers is a crucial element for successful CASI and would support both the subsistence-led and market-led pathways.

Third, although sustainable intensification practices include sets of practices that are resource-conserving with demonstrable cost advantages and CASI dividends, the same factors known to facilitate or impede agricultural technologies generally will remain relevant for CASI practices as well. Policy attention in support of CASI should remain focused on better access to markets, solid information delivery through strong agricultural extension and creating policy and physical infrastructure to produce favourable input and output price ratios.

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24 The role of digital knowledge sharing for scaling

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Key points

- The participatory development of SIMLESA text messaging allowed the SIMLESA team to develop information that was relevant and actionable by poorly resourced farmers.
- The use of mobile phones was an efficient and effective tool for scaling the SIMLESA project information beyond the areas where the project was actively interacting with farmers.
- Both male and female farmers benefited from the information they received over their mobile phones.
- Due to the impact of the SIMLESA approach, there are now institutions willing to cover the cost of maintaining, expanding and delivering the service.
- Capacity building on the Internet of Things and information and communication technology within the national system should be considered a government priority.

Introduction

The SIMLESA project developed and disseminated agricultural technologies with the aim of adoption by 500,000 farmers in 10 years. Achieving this goal required strategies that extended beyond traditional diffusion methods and utilised novel information and communication technologies. The use of information and communication technology, particularly mobile phones, was piloted in Mozambique in 2013. In 2015, this was spread to other SIMLESA countries. In this chapter, we discuss the process, impacts, lessons and the successful use of information and communication technology to foster adoption under SIMLESA.

Access to information is a key determinant of agriculture technology adoption in developing countries. This is widely recognised, based on evidence that timely access to agriculture and market information enables farmers to make better decisions and improves farming practices, access to markets and financial services (Anderson 2008) and opportunities to participate in the markets (Anderson 2008; Akera, Gosh & Burrell 2016). Extension and advisory services are considered principal mechanisms of establishing links with farmers and providing them with information to support knowledge acquisition and technology transfer and adoption (Maffioli et al. 2013). SIMLESA developed partnerships with major local agricultural and rural development organisations through innovation platforms. However, these services did not have the capacity to reach SIMLESA targets because they were understaffed and had limited funds. With extension agent to farmer ratios of 1:18,000 to 1:25,000, the publicly funded agriculture extension and advisory services in SIMLESA countries were limited in their effectiveness, relevance and coverage. Therefore, the SIMLESA scaling out and diffusion framework required an innovative approach that would go beyond traditional models and include opportunities to disseminate the technologies to a large number of farmers.

Given that more than half of Africa's 1 billion population were using mobile phones, the potential of the African mobile network for the delivery of actionable agricultural information was great. The use of mobile phones was already being implemented in India and western Africa (World Bank 2017). To better assess the potential of mobile phones as a tool for transferring agriculture information, a pilot study was conducted in Mozambique. The initial results confirmed the opportunity to use mobile phones as pathways for information delivery, but also to offer the kind of information farmers valued most, making the system relevant and timely and giving it greater reach. Therefore, mobile phones were treated as a critical tool for sending farmers relevant information under SIMLESA.

Pilot survey and model development

In 2013, a short survey was implemented in Mozambique to better understand mobile phone use and what kind of information farmers would like to receive. The survey also showed increasing mobile phone subscriptions in rural areas, with an increase of almost 49% since the 2010 baseline study. Moreover, the telecommunication companies were expanding their services to the rural areas, increasing the likelihood that more people would access mobile phones. These trends in Mozambique were similar to those of other SIMLESA countries.

The study also identified the main type of information that farmers were willing to receive and the frequency that would produce the intended outcome. Farmers wanted to receive information about weather, markets, availability and price of inputs, agronomic practices and networking events in their region. Based on the farmers' needs, we developed a model for information acquisition and quality management in consultation with farmers and stakeholders (Figure 24.1).

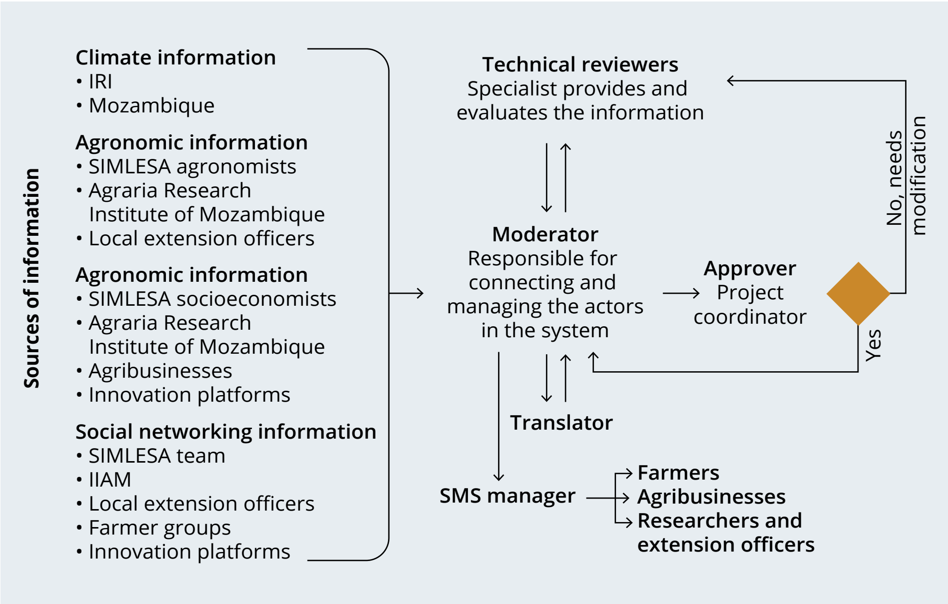

Figure 24.1 **Model for the delivery of information to farmers and agribusinesses by mobile phone**

Notes: IRI=International Research Institute for Climate and Society; IIAM = Instituto de Investigação Agronómica de Moçambique.

The model has five main components:

1. Source of information—organisation, people and systems that provide information that is relevant and useful for farmers.
2. Moderator—person who transforms the information to a format that is easily understood by farmers.
3. Technical reviewer—specialist in the areas, usually objective leaders who had the role of evaluating the scientific and technical content of the message, providing corrections where necessary.
4. Approver—usually the project coordinator, who would approval the messages to be disseminated through the cropping season.
5. SMS manager—responsible for managing the web-based platform and sending the information to the stakeholders.

It was necessary to ensure the quality of the data, particularly the weather and market information, in order to build trust and reliance in the system, and also to make the system specific to each location. This required a mechanism for collecting information in each location.

Content development

A two-day workshop was conducted with the farmers, agrodealers, traders, extension agents and agriculture development organisations working in the target regions. The objective of the workshop was to discuss the relevance of the approach, the model to be implemented, the roles of each actor, the type of information and a timeline for message delivery. A key aspect was the participatory approach of content development. This process included farmers, extension agents and agrodealers, who discussed the type of information and the content they needed. This allowed for the development of message content that was relevant to each of the actors, and ensured adoption of the system. During these content development workshops, it became clear that that many of the actors in the chain required the same information (Table 24.1).

Extension agents also required the same information, but needed it before it was sent to the farmers. This would support them during their meetings with farmers. When farmers face problems, the first person they reach out to is their extension agent, who would therefore need the same information as the farmer.

The output of the participatory content development workshop was a spreadsheet with the SMS content, the period when it was to be sent and the frequency of messaging. This was introduced in the web-based platform.

Table 24.1 Type of information required by users

Information	Farmers	Agrodealers	Traders
Price of inputs	Yes One month before the planting period	Yes	No
Amount of inputs	Yes One month before the planting	Yes At least three months before the cropping season	No
Price of produce	Yes Before planting	No	Yes After harvesting
Amount of produce available/needed	Yes	No	Yes Before harvesting

Implementation of mobile phone system

Farmers' entry

The implementation of mobile phone in SIMLESA countries was phased. In 2013, it was implemented in Mozambique. It was spread to other countries in the second phase of SIMLESA. The implementation started with the establishment of a farmer database in the web platform.

The data collection tool collected information on farmers such as region and village and, whenever possible, this was georeferenced to support the monitoring and evaluation process. However, during implementation, it became clear that other information, such as gender, age, farm area and main crops, would also be relevant. This could be used for monitoring and also to estimate production in each region, which would provide accurate product information for traders.

Systems management

Systems management involved two components: hardware (technical aspects) and software (managerial aspect) of the system. The SMS platform was a web-based system with a server domain outside the SIMLESA countries. Two issues were raised:

1. one-way information flow
2. capacity to reach all mobile phone companies in the SIMLESA countries.

Through the systems, farmer could receive information but were not able to provide feedback or ask for clarification or additional information. This was a great limitation because it was difficult to track farmers' responses in real time. To overcome this, some countries put in place a mobile phone line where farmers could send messages. The answer to the question was afterwards sent to all farmers in the system. Moreover, some major mobile companies were not reached through the server, making it difficult to reach all the farmers in the database.

Each country identified different stakeholders to engage in the system and modes of operations that best suited the country capacity. For example, in Mozambique, the system was managed by an information technology specialist and a moderator. Only they could add farmers to the database and send messages. In Tanzania, the system was open to all systems operators, who could all send messages. These models each had advantages and disadvantages. In Mozambique, it relied only on two operators, making it easier to ensure quality assurance but putting pressure on the operators. When all operators had access to the system, it was more difficult to ensure quality and there was increased risk of losing control of the messages being delivered, but there were more people to share the workload.

Stakeholder engagement

The model adopted by the project enabled each country to adapt and adjust it to meet their needs. In each country, a different model of engagement and different roles for each stakeholder were established (Table 24.2).

Table 24.2 Stakeholder engagement

Role	Ethiopia	Kenya	Malawi	Mozambique	Tanzania
Source of information				NARS SIMLESA team	
Moderator	NARS	NARS		Scaling partner	Scaling partner
Technical reviewer		Objective leader	Objective leader	Objective leader	Objective Leaders
Approver	SIMLESA country leader	SIMLESA country leader	SIMLESA country leader	SIMLESA country leader	SIMLESA country leader
SMS administrator	NARS	NARS		Scaling partner	SIMLESA

Note: NARS = national agricultural research systems

Each country adjusted to a model that best fit its own needs and ensured reliability and sustainability of the system. The role of scaling partners varied in each country.

One of the main challenges was the engagement of traders to effectively establish market linkages and enable market access. Although traders recognised that the system could help them to plan and establish trustworthy relationships with farmers, they also understood that revealing prices in advance reduced their negotiation power with farmers. The system gave traders an estimate of products available and their main location, but farmers did not have access to the price the trader is willing to pay. Farmers only had access to the average price in the region. They could use this information to negotiate with traders.

Impacts

The system reached 1,071 farmers in Tanzania and 6,035 farmers in Mozambique. The farmers received a variety of information throughout the cropping season and used this to enhance their production systems. In 2014, farmers in Mozambique showed that the mobile phone played an important role in providing agriculture information. Of 100 farmers interviewed, 49% had a mobile phone and 63% of farmers who received a message with agriculture information shared that with people in their network, sending an average of 89 messages throughout the cropping season.

The system also improved the relationships in the chain and provided information to all stakeholders, increasing access to inputs and linkages to traders. However, market relations were still weak and needed further improvement as traders were still not willing to share their prices.

Figure 24.2 shows how sources of information have changed in Mozambique and provides evidence that mobile phones and information and communication technology can support existing extension services. Since the start of mobile phone usage, the ways of sending and sharing information changed. Mobile phones played an increasing role in individual decision-making but were also being used in social networks, strengthening and supporting more people.

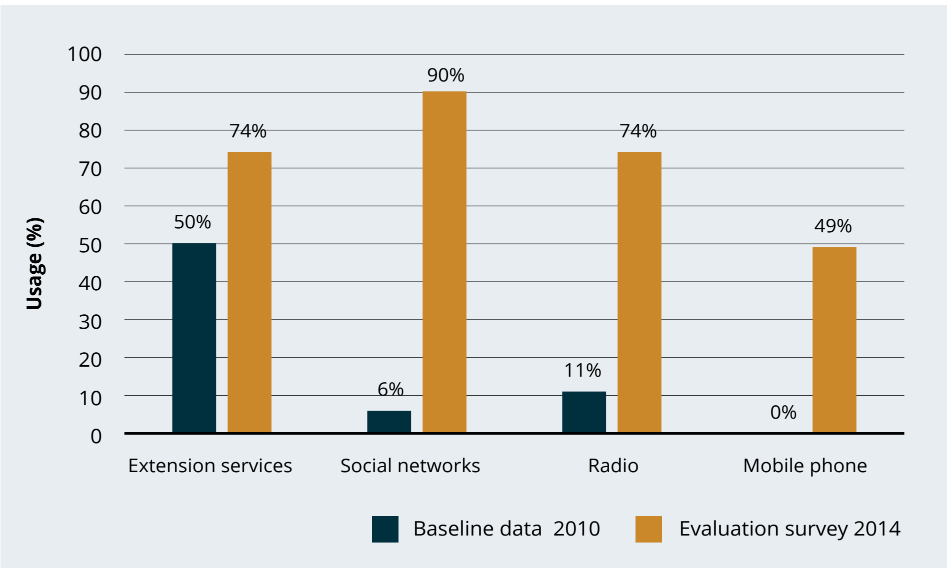

Figure 24.2 **Main sources of information among participating farmers**

Lessons learned

The use of mobile phones was a breakthrough for information dissemination in the different regions. The system enabled information to be sent to a more diverse and spread out population, making it possible to reach thousands of farmers in a very short period of time. The system supported existing extension services, reached more people, provided opportunities to get timely feedback from farmers and significantly reduced the cost of extension services in the target regions. However, to be effective, farmers needed to be able to use the system to increase their market opportunities. This was only possible if traders were willing to be more transparent and share timely information with farmers.

At the moment, all the costs to host the servers are supported by the project, but due to its effectiveness institutions are willing to pay for the service. In Mozambique, the SMS administrator has established contracts to deliver information for programs working in agricultural development. To further strengthen the system and increase its sustainability, administrators and moderators need to provide information to farmers, traders and policymakers and encourage them to use the system on a daily basis.

The success of the system is also linked to the fact that it was very flexible and simple to manage, and allowed for interaction and participation by the main stakeholders in the chain. It was also necessary to engage telecommunications companies in each of the countries and jointly develop a platform so that the dependence on international server hosts was reduced and the systems could be entirely managed by the countries.

As the role of the mobile phone is increasingly being recognised in these countries, more organisations are using similar tools. This creates the risk of conflicting or duplicated information being sent to farmers.

Future plans

The success of the mobile phone system shows that there is a potential to continue using it, but also to develop more systems. Research and development institutions face the challenges of getting accurate data.

The experience of the project shows that there is potential to develop interactive mobile phone applications that features information on weather, fertiliser recommendations, weeding and pest management recommendations and market information, among others. These features would include the capacity to take pictures in the field and send them in, triggering a response to the problem faced by the farmer.

Using mobile phones, farmers could collect georeference data and upload it, using the same model as the Open Data Kit but with a simpler method of data collection. The system could also be used to develop educational videos in local languages, upload them and provide a link to farmers.

Additionally, this experience showed that it is necessary to continually engage stakeholders and policymakers to increase the usage of the system. A promising strategy for ongoing engagement is the development of a national Knowledge Management System Framework for Agriculture Development.

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25 Linking sectors for impact: the science of scaling out

Michael Misiko, Gérard Bruno, George Mburathi, John Dixon & Mulugetta Mekuria

Key points

- Effective scaling of research results to substantial numbers of benefiting farm households is essential to generate value for money, or national return to investment in agricultural research.
- Three approaches to scaling were incorporated in the SIMLESA program: initial scaling around research hubs during Phase 1, systematic testing of selected scaling models and pathways during Phase 2, and strengthening of regional spillovers to three countries in the region through both phases.
- The impacts from SIMLESA scaling included quantitative benefits to adopting farm households and qualitative benefits to national capacity and the institutional and policy environment along pathways to impact.
- Agricultural innovation platforms based on research hubs linked the field and local levels with the policy level and added to the effectiveness of public extension and private sector input and service delivery for conservation agriculture-based sustainable intensification (CASI).
- The effectiveness of linking agriculture-related sectors and refocusing public and private organisations and investment on CASI has been demonstrated by SIMLESA in selected countries in the region.

Introduction

The objective of this chapter is to illustrate quantitative and qualitative nature of scaling by analysing results of a competitive grant scheme and agricultural innovation platforms. By focusing on the SIMLESA project, we illustrate why science is critical in achieving efficiency in scaling conservation agriculture-based sustainable intensification (CASI) portfolios. Quantitative expansion in the SIMLESA competitive grant scheme included a catalytic budget of A$700,000, partnerships of more than 90 organisations in more than 60 districts of five countries, reaching over 2 million households, targeting to influence adoption among more than 400,000 households. This expansion also included the furtherance of 58 agricultural innovation platforms, which are a unique impact pathway. With the right niche focus, policy, transformational investments, national coordination and mentoring, agricultural innovation platforms generated equitable spillovers, co-benefits and impact at scale. Underlying these numeric gains was qualitative expansion, in skills, coordination leadership, communication, strategic partnerships, policy processes, institutionalisation and innovation. Innovation and cost reduction resulted from research-led investments and resourceful partnerships guided by higher goals, such as the United Nations Sustainable Development Goals and national policies.

The word ‘scaling’ is often used in combination with ‘up’ or ‘out’ to signify covering many beneficiaries by some ‘package’ of interventions (IIRR 2000; Uvin & Miller 1994; Proctor 2003). It mostly refers to increasing the numbers. In this chapter, it means achieving wide agricultural impact at affordable cost. It is a process with several stages. Some of the stages can be measured during a single agricultural project. However, the totality of ‘scale’ cannot be demarcated within a few years. Holistic scale (which is key for increased impact) is a function of the exposure of a population, combination of several initiatives’ effectiveness (quality of implementation and efficacy of interventions employed), efficiency (cost per beneficiary), sustainability (benefits, continuity, ownership), and equity (equitably reaching the hardest to reach, usually the poor, women and youth). A large project such as SIMLESA can act as a catalytic component, especially among many partnering initiatives. Improved coverage under a single initiative can cause impact to increase. However, impact is a function of many variables such as program quality (including innovation), affordability (efficiency) and quantity. Impact is moderated by social, economic, temporal, ecological or physical variability. True impact at scale is therefore more possible through a network of programs with multiple agricultural research and development interventions that are socially inclusive, and that respond to a broad range of societal, spatial, communal, historical and individual needs.

Scaling in SIMLESA

The SIMLESA project was implemented mainly in Ethiopia, Kenya, Malawi, Mozambique and Tanzania. Between 2010 and 2014, SIMLESA Phase I undertook participatory testing, agronomic and economic evaluation and validation of several CASI options in numerous sites. During this phase, tens of agricultural innovation platforms were established, with the underlying aim of catalysing equitable impact. In 2014, a scaling phase was launched to strengthen the agricultural innovation platforms' achievements, and aid SIMLESA's overall adoption target of 650,000 households by 2023. A competitive grant scheme was designed to bring on board new partnerships for broader capacity in scaling. The SIMLESA competitive grant scheme had three main objectives:

1. scale SIMLESA research portfolios through producer-oriented programs
2. pilot an innovation-based knowledge value chain, based on demand–supply partnerships among international, private and public research and development institutions
3. draw lessons from the experience of funded projects that reduce the margins of technology transfer in SIMLESA countries.

SIMLESA and the science of scaling

Scientific research principles and evidence are essential in shaping scaling (World Bank 2012). Scaling science is critical in planning for and guiding program impact (Waddington 1993). As illustrated in Figure 25.1, SIMLESA innovatively applied essentials of scaling science to guide impact at scale.

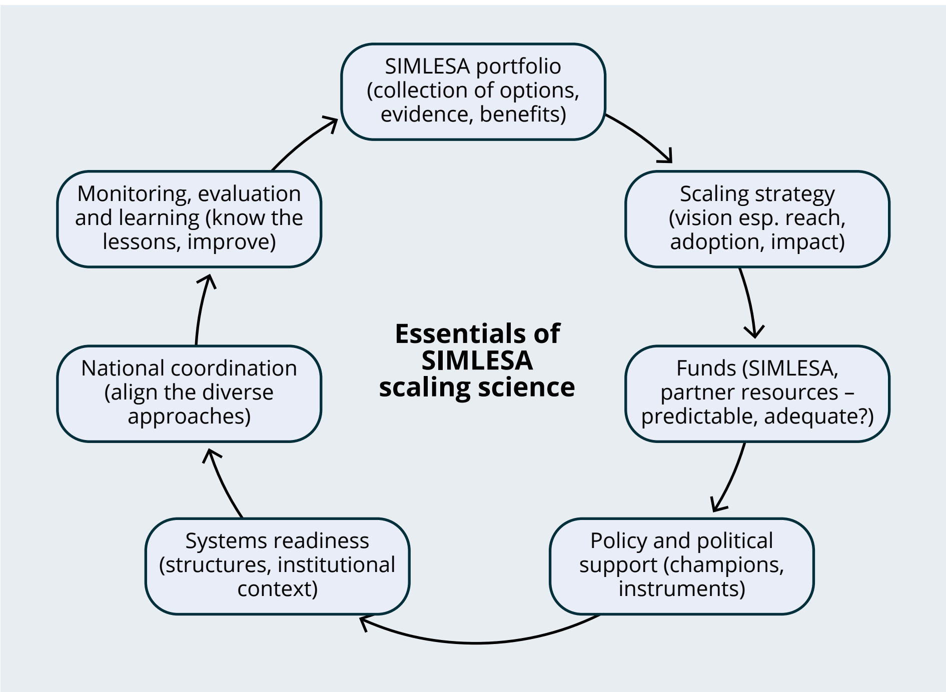

Figure 25.1 Components of SIMLESA scaling science

The success theory of SIMLESA was that, supported by scaling science, the program would catalyse wider reach and stimulate multiple benefits for equitable impact at scale. Beside planning and guiding impact, scaling science was critical in the measurement of results, outcomes and impact. SIMLESA measured these in terms of both quantitative and qualitative expansion.

Quantitative expansion

Quantitative scaling denotes quantities—inputs and achievements that can be measured and written down numerically (Table 25.1). 'Number of farmers reached' is the most sought target.

Table 25.1 Partner estimates of reach vs application (or tryouts by end 2018)

Country	Partners	Partner estimations			No. of districts	No. of partners	No. of portfo-lios
		No. reached	No. applying	%			
Ethiopia (Public extension at Zonal level)	East Shewa Zone	72,660	21,798	30	3	4	4
	East Wollega Zone	74,180	22,254	30	3	4	4
	West Shewa Zone	53,690	16,107	30	3	4	4
	Hadiya Zone	53,140	15,942	30	3	4	4
	West Arsi Zone	73,150	21,945	30	3	4	4
	Sidama Zone	48,980	14,694	30	3	4	4
	West Gojjam Zone	48,840	14,652	30	3	4	4
Kenya	University (Egerton)	30,000	7,500	25	4	7	4
	Seed company (Freshco)	30,000	24,000	80	4	4	4
	Faith-based (NCCK)	30,000	9,000	30	4	7	4
	Television (Mediae)	2,000,000	300,000	15	>20	5	4
Malawi	Radio (Farm Radio Trust)	100,000	15,000	15	3	4	4
	Seed company (MUSECO)	10,000	5,000	50	-	-	4
	Farmers organisation (NASFAM)	30,000	7,500	25	4	7	4
Mozam-bique	Business non-government organisation (Agrimerc ODS)	50,000	15,000	30	5	7	4
	Information and communication technology-based (ISPM)	100,000	15,000	15	>10	4	4
	Farmers organisation (UCAMA)	30,000	9,000	30	4	5	4
Tanzania	Farmers organisation (MVIWATA)	50,961	15,288	30	4	7	4
	Non-government organisation (RECODA)	24,000	12,000	50	3	6	4
	Seed company (SATEC)	30,000	24,000	80	3	5	4
Totals		**2,939,601**	**585,680**	**34**			

Notes: Reach = farmers being covered and verifiably receiving SIMLESA portfolios. This is different to diffusion (Walker & Alwang 2015). Applying (also referred to as tryouts) = farmers using the options scaled out. Adoption and impact will be fully measured in 2023 (see definitions in Walker et al. 2014). However, outcomes can be reported in 2019. NCCK = National Council of Churches Kenya; MUSECO = Multi-Seed Company Limited; NASFAM = The National Smallholder Farmers' Association of Malawi; ISPM - Instituto Superior Politécnico de Manica; ODS = Sustainable development goals; UCAMA = União Províncial de Camponeses de Manica; MVIWATA = Mtandao wa Vikundi vya Wakulima Tanzania; RECODA = Research, Community and Organisational Development Organisation; SATEC = Suba Agro Trading and Engineering Co.Ltd.

A comprehensive set of criteria and indicators of quantitative expansion are given in Table 25.2.

Table 25.2 Criteria and indicators for quantitative expansion (directly attributable to SIMLESA)

	Criteria	Indicator
Short term	Reach	Number of women and men beneficiaries verifiably receiving research portfolios, sites covered
	Try outs (application)	Number of women and men beneficiaries verifiably utilising, taking up or trying information
	Innovation management	Proportion of contracted projects (% of total applicants) Number of projects terminated after start of competitive grant scheme Per cent of projects that have achieved target goals Rate of realised against planned time for project execution
Medium term	Value for dollar	Total cost of SIMLESA competitive grant scheme initiative relative to number of beneficiaries, number and value of benefits
	Institutional change	Partnership ventures during the period of the competitive grant scheme Matching funds allocated to SIMLESA competitive grant scheme initiative Capacity changes related to competitive grant scheme initiative
Long term	Additionality and sustainability of resources	Increase of partner scaling budget in over a defined period—because of fundraising SIMLESA competitive grant scheme success
	Impact or effectiveness attributed to scaling initiative financed by the SIMLESA competitive grant scheme	Factor productivity (crop yields, labour productivity) Rate of adoption of SIMLESA research options Incomes and social benefits derived—absolute and relative rates

Source: Misiko 2017—unpublished (also see International Service for National Agricultural Research 1998)

Table 25.2 illustrates that quantitative expansion means holistic measures of values (including counts or occurrences) expressed as figures. Numeric variables, including 'how many', 'how much' and 'how often', are necessary in measuring scaling. Quantitative expansion means more or new gains, in terms of absolute number and rate of households reached and adopting, and more and better diversity of incomes/benefits derived. Efficiency in scaling includes early successes such as reaching more people more rapidly, achieving a higher ratio of adoption per reach population, extending portfolios that are well tested, and applying partnerships that integrate complementary concepts that are necessary for inclusivity. In short, realising value for money with less investment.

Value for money

The ultimate value for the SIMLESA competitive grant scheme will be known after related International Maize and Wheat Improvement Center and partner administrative and staff costs are known, when adoption is established and benefits are valued. Among those benefits will be how many women and youth are increasing (the diversification of) their incomes and social welfare (e.g. reduced labour, time or energy use) as a direct result.

Initial value for money is seen to emanate from sheer reach and tryouts (i.e. initial farmer application of options) resulting from the SIMLESA competitive grant scheme. Partner scaling plans have 2,939,601 farmers being targeted with CASI options (Table 25.3). However, projections show only an average of 34% (585,680) are likely to try out one or different combinations of the sustainable intensification portfolios, with an estimated 15% (440,940) sustaining by 2023. This is based on known adoption rates among exposed farmers (Simtowe 2011; International Maize and Wheat Improvement Center 2014, 1993). Besides end users, partners are capacitating a network of 4,115 professionals including extension officers, agricultural innovation platform actors and farmer group officials.

The total SIMLESA competitive grant scheme was 2% of the entire SIMLESA budget and it ran for 18% of SIMLESA's duration. From a project perspective, the SIMLESA competitive grant scheme will be hugely successful if it contributes over 50% of SIMLESA's target of 650,000 adoptions of (single or different combinations of) its research options.

Qualitative expansion

By qualitative expansion, we refer to aspects of SIMLESA benefits that are non-numerical, and that will sustain quantitative benefits over time and across locations. Indicators of qualitative expansion include various forms of knowledge or benefits. One example is women having influential leadership in SIMLESA-supported agricultural innovation platforms, rather than merely increasing membership numbers. Other qualitative aspects are skills from program training in marketing and resulting agribusiness innovation. Identification and pursuit of innovation opportunities was a critical pathway to scaling CASI co-benefits, and a sustainable way to target spillovers and co-benefits. SIMLESA achieved enhanced excellence of institutional capacities (a collective mix of mutually supportive skill sets and coordinated leadership), especially through mentoring for national capacity in evidence-based scaling. It also achieved adaptive communication (including interactive feedback), strategic partnerships and policy processes. These are incremental aspects of the development process that can be treated as inputs, variables and outcomes that explain, enable and shape the quantitative impact of SIMLESA. They were essential for innovation in scaling for impact.

Innovation in SIMLESA-led scaling for impact

Innovation in SIMLESA came from the diversity of scaling approaches and partners. For instance, AgriMerc in Mozambique worked with marketing, SMS, radio, seed companies and other private sector actors to link farmers to better markets despite the poor road network. Although innovation was often a by-product, this was not accidental. SIMLESA had a carefully developed strategy and defining guiding principles that were applied by partners to facilitate innovation. Table 25.3 shows how selected partners applied these principles based on their scaling concepts.

Table 25.3 Summary of SIMLESA competitive grant scheme guiding principles as applied by selected partners

Guiding principle	Mediae	AgriMerc	Recoda	Farm Radio	ISPM	Egerton	NASFAM
Main scaling approach	iShamba, Shamba Shape Up	Agrodealer system, lead farmer, mobile platform	RIPAT recoda-tanzania.org/ripat	Participatory radio farmradiomw.org	SMS, radio, video	Participatory, farmer group networks, radio, print media	Club model, lead farmers
Motivation	TV info deals	Smallholder business	Participatory service	Radio/information and communication technology information deals, intermediaries		Data and policy drive	Farmer welfare, value chain
Policy linkages	Medium	High	Low	Low	High	High	High
Main capacity	Message delivery	Brokerage	Participatory	Message organisation	Content development	Testing and delivery	Delivery and advocacy
Scaling pathway	Via field, TV and mobile	Piloting, testing and replicating	Piloting, testing and replicating	Via field, radio and mobile	Via information and communication technology (SMS), radio and video	Participatory, media and local farmer networks	National network of farmer groups
Partnership nature	Transitory, based on knowledge needs and funding source	Wide, depend on national agricultural research systems and international knowledge market	Wide, depend on national agricultural research systems and international knowledge market	Transitory, based on knowledge needs and funding source	Long-term, stable and less dependent on external funding	Long-term, stable, national and external funding	Wide, stable, national agricultural research systems, national and international knowledge market
Key monitoring, evaluation and learning mechanism	Unique, designed for TV and information and communication technology feedback	Performance of agribusiness	Partner feedback systems	Learning by doing, radio feedback mechanism	Standard monitoring, evaluation and learning methodologies	Extension methodologies, standard monitoring, evaluation and learning	Farmer network evaluation
Orientation for purpose	Partnerships with knowledge partners	Market-related work	Partnership, especially with research	Depends on partners with knowledge portfolios	Collect and/or organise content	Research, participatory extension	Training a critical component

Source: Misiko 2017

Table 25.3 shows how innovation was catalysed (Hall, Mytelka & Oyeyinka 2006). It illustrates the need to organise partnerships based on converging interests. SIMLESA needs were well aligned with the visions of selected partners. Table 25.3 explains the SIMLESA handover of CASI portfolios from research to sustainable ownership (FAO 2002).

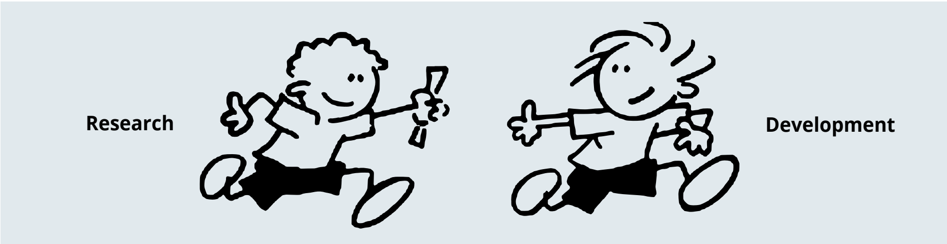

Figure 25.2 Research and development is a relay

Handover is a transition. Research organisations pass bundles of research portfolios to the next users, who deliver the products of the research to beneficiaries (Figure 25.2). This is a qualitative process.

SIMLESA competitive grant scheme

The full range of SIMLESA competitive grant scheme merits will not be wholly discerned in the short term. However, a program review revealed emerging merits and demerits of the current competitive grant scheme (Table 25.4).

Table 25.4 Merits and demerits of SIMLESA competitive grant scheme

Merits	Demerits
Role of research and science entrenched	Limited funding, pilot, not wider scaling
Efficacy through competition and cofinancing	Good proposals did not necessarily mean good opportunities for better scaling
Enhanced capacity among scaling partners	Short-term, limited documentation for fuller lessons
Simplification of research products for sharing	No institutionalisation of competitive grant scheme, lack of mentoring program
Target-oriented and demand-driven system, seamless relay of research options	Demanding and costly transactions, less time for scaling research
New type of research-scaling partnerships	Legal, financial, administrative and technical complications
Diversification of ideas = innovation, new scaling concepts such as iShamba	Competition means large organisations dwarfed less-known local actors, no equity
Scaling strategy key to guide basic institutional arrangements	Seed partners need to be purposively rather than competitively selected
SIMLESA competitive grant scheme was an arranged market concept based on merit/objectivity	Depends more on knowledge market rather than needs oriented
New research opportunities have emerged	Prone to delays. Limited grants, small scaling teams, exit of a team member disruptive
Suitable for targeting diversity of needs at national level	

Source: Misiko 2017

Principles of SIMLESA's scaling partnerships

Scale and higher goals

Table 25.3 shows partnerships based on diversity and complementarity. In Kenya for instance, scaling partnerships comprised media (Mediae Ltd, FM radio), seed producers (Freshco Seed Ltd), farmer networks (Egerton University), participatory extension (National Council of Churches of Kenya), public extension (county governments) and newspapers (Egerton), among others. The integration of diverse approaches ensured that CASI portfolios reached, and were utilised by marginalised men, disadvantaged women and low-resourced youth. These contributed to higher goals, United Nations Sustainable Development Goals and other national policy priorities. SIMLESA partnerships considered how to best achieve national scale and social inclusion.

Local ownership, equity and sustainability

SIMLESA investments in capacity mentoring resulted in agricultural innovation platforms that catalysed multiple benefits (Table 25.5).

Table 25.5 Number of agricultural innovation platforms established under SIMLESA

Country	Sites	Agricultural innovation platforms	Levels of agricultural innovation platform
Ethiopia	7	19	Woreda (District)/Community
Kenya	5	13	District/Community
Tanzania	5	10	District/Community
Malawi	6	6	District/Community
Mozambique	4	4	District/Community
Rwanda	4	4	Sector
Uganda	2	2	District
Total	**33**	**58**	

Case studies were conducted for six of the 58 agricultural innovation platforms. Findings show agricultural innovation platforms were ideal for generating spillovers and co-benefits, and in addressing equity.

Agricultural innovation platforms

Agricultural innovation platforms are an alliance of stakeholders formed to diagnose constraints, explore opportunities, analyse solutions and complement efforts along a value chain to generate mutual benefits.

Case studies show successful agricultural innovation platforms under SIMLESA or elsewhere benefited from research and were initiated by donor projects. Once established, members were taught techniques to identify business opportunities and trained in business management skills.

Once registered, members made regular contributions. Key milestones in the conservation agriculture-based sustainable agricultural innovation platforms were inclusivity and investments (especially direct support) from governments and donors, for example, in machinery, storage and transport. Inclusivity was directly related to how benefits were generated and equitably shared. Agricultural innovation platforms at Level 5 of progression (Figure 25.3) were not mere conservation agriculture-focused assistance-receiving committees, but rather service-oriented entities that resulted in multiple benefits and spillovers beyond their membership.

There were four key fundamentals that separated failure and success:

1. Policy instruments. In Rwanda, successful cooperative-based agricultural innovation platforms received a 40% price reduction on capital equipment.
2. Development investments. Beyond research, transformations were enabled through development investments. These were directly catalysed by policy instruments, and were specifically targeted to agribusiness/diversification.
3. Agricultural innovation platforms. Agribusiness was directly related to CASI. Agricultural innovation platforms that diversified—beyond field activities—generated more benefits, and evolved beyond 2–5 years of project support.
4. Coordination. All these factors were operationalised by appropriate coordination. SIMLESA invested heavily in mentoring for national capacity to coordinate.

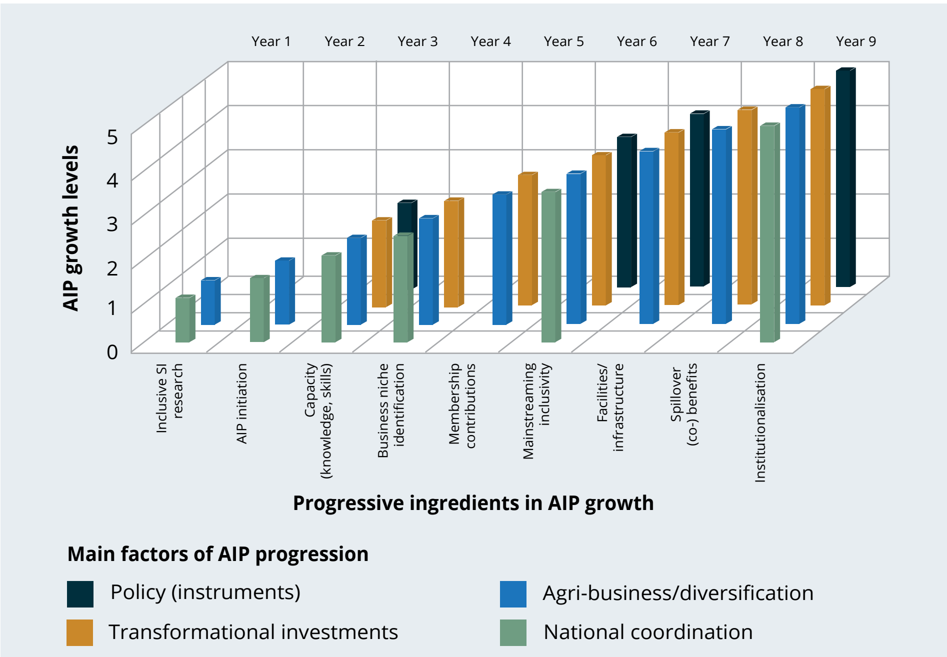

Figure 25.3 **Factors of agricultural innovation platform maturation and their ingredients of growth, along with extrapolated illustration of time and growth stages**

Notes: AIP = agricultural innovation platform; SI= sustainable intensification
Level 1: Foundation; group integration with project activities
Level 2: Committee; for scaling out, trainings
Level 3: Niche integration; project funding supplemented by aspects of agribusiness
Level 4: Growth; business, asset, etc.
Level 5: Maturity; diversification, transformational investments—focus on long-term benefits, co-benefits, spillovers

Figure 25.3 illustrates that over time, successful agricultural innovation platforms generate spillover co-benefits that provided evidence for institutionalisation. Conversely, institutionalisation ensured the sustainability of agricultural innovation platform concepts and their benefits. This is illustrated by SIMLESA case research in Rwanda (Misiko et al. 2016). Findings show that the Mudende Innovation Platform and the Cassava Innovation Platform had a combined network of 700 men and women. About seven years after being established through research funding, their core activities evolved into processing cassava (KIAI) and milk, and producing seed potato (and potato seed, Mudende). They evolved from research-supported agricultural innovation platforms by integrating community-based organisation, self-help and (mostly) cooperative principles. In 2016, the combined direct service (and infrastructure) network reach of KIAI and Mudende was more than 7,500 non-member households.

Mudende and KIAI avoided the pitfalls of typical cooperatives by integrating the agricultural innovation platform principles of wider partnerships, benefits equity, niche diversification and diverse membership. They:

- increased market access, mitigated transaction costs and leveraged better and stable (input and produce products) prices for marginalised smallholders
- improved nutrition among the vulnerable
- attracted infrastructure development (e.g. Mudende feeder road)
- attracted banking facilities and services
- provided affordable and secure produce transport
- facilitated equitable sharing of proceeds and influence/leadership
- aided responsible management of common pool natural resources, including land, water and new germplasm.

In Kenya, the Kieni agricultural innovation platform attracted insurance and poultry investments that benefited thousands more than the 35 members. The Rhotia agricultural innovation platform in Tanzania created a new international market channel for pigeonpea smallholders, lowered transaction costs and helped to commercialise an otherwise subsistence pattern of production.

Conclusion

Figure 25.4 illustrates how scaling in SIMLESA sought to be holistic and integrative.

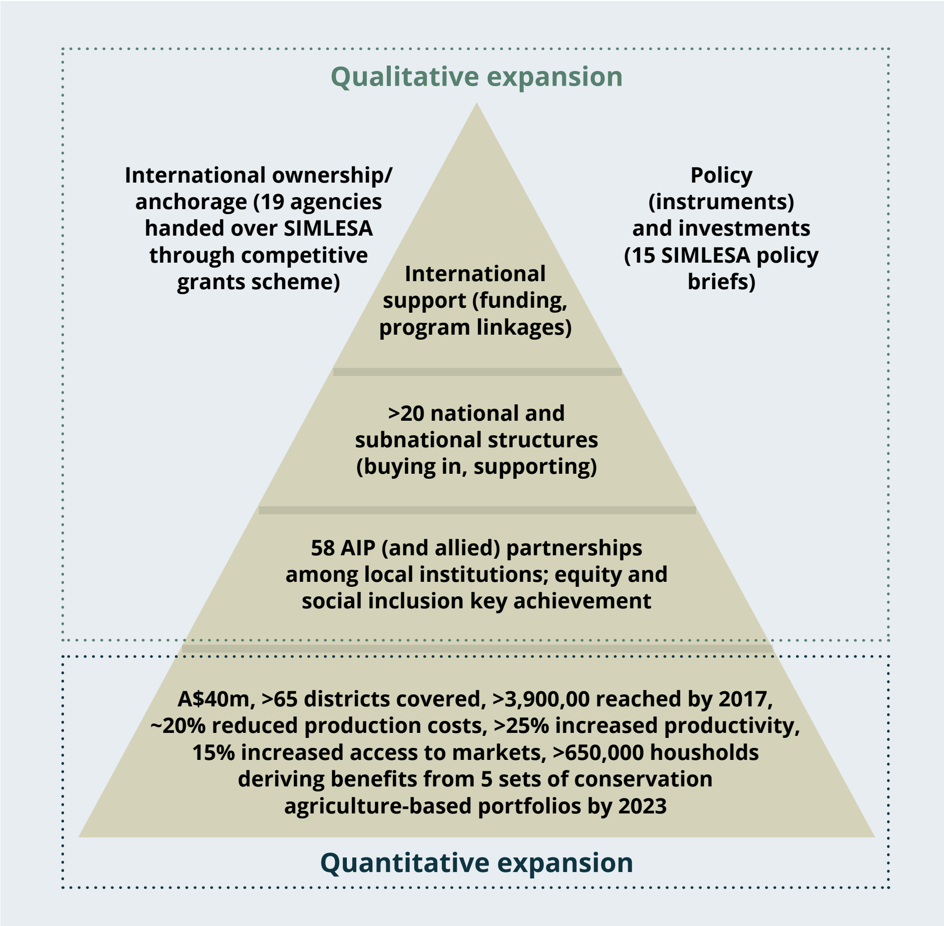

Figure 25.4 Summary of SIMLESA scaling

Figure 25.4 illustrates qualitative and quantitative expansion. These are necessary for generating impact. However, immense investments in scaling are necessary for impact at scale. Although recent debates show public–private partnerships are key, the role of governments in Ethiopia, Rwanda and Mozambique, along with donor support in agriculture (extension, research and reforms) have played greater roles in transformation. SIMLESA scaling focused on integrating marketing and value additions, which had better technical economies of scale compared to those arising from the indivisibility of agricultural inputs (e.g. draft animals, machinery, farm management skills) (Binswanger & Deininger 1993). Scaling was not merely about ensuring reach, but rather organising farmers (especially through agricultural innovation platforms) to have access to the necessary inputs, machinery and infrastructure to operate efficiently (Deininger et al. 2011).

The wisdom of SIMLESA was that it ensured that smallholders generated their own means to enhance farming through income diversification. In other words, scaling the means to impact was more transformational than mere scaling of research technologies. The focus on partnerships in competitive grant schemes and agricultural innovation platforms was informed by the African smallholder heterogeneity that complicates the wider use of research products. Impact among smallholders resulted from diversification of incomes.

The fuller impact of SIMLESA will be realised with increased direct investments that contribute to the fundamental transformation of the agriculture sector. Governments must play a critical role to ensure policy (instruments) enhances the ability of smallholders to adapt to the changing structure of the modern food and agriculture sector, while reducing the risk of social exclusion. The SIMLESA competitive grant scheme has generated ground for a new sort of policy instrument for information chain development, such as a national agricultural scaling innovation facility.

SIMLESA shows the need to focus on three areas:

1. improve access to capital, inputs, and markets through membership in cooperative-led agricultural innovation platforms (Von Pischke & Rouse 2004)
2. participate in collective livelihood schemes like export agro-processing, increase negotiation capacity and reduce agro-related transaction costs
3. tune rural farming to align with off-farm economic services and entrepreneurship.

These must be supported by investment in strategic skills in management and technology adaptation. With strategic skills and organisation, farmers can take advantage of cheap land leases to circumvent usual constraints, including small farms and lack of capital. Both the competitive grant scheme and agricultural innovation platform analyses show rural transformation is possible when skills gaps are closed. Without this, any research, development or other investments lead to a lack of spare capacity to utilise transformational investments.

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SECTION 5

BUILDING ON SIMLESA

26 SIMLESA: Outputs, outcomes, impacts and way forward

John Dixon & Mulugetta Mekuria

Looking at #SIMLESA's evidence, we can say that #conservation agriculture works for our farmers.

Josefa Leonel Correia Sacko, Commissioner, Rural Economy and Agriculture of the African Union, https://t.co/iLHhnp0K19

Key points

- The SIMLESA program established the confidence of agricultural leaders across eastern and southern Africa in conservation agriculture-based sustainable intensification (CASI) as a pathway to food security and rural development, and influenced the design of a number of major research-for-development initiatives.
- The program demonstrated improved productivity, resilience and resource management through CASI in more than 30 research hubs with relevance across southern and central Queensland and the maize mixed farming systems of eight eastern and southern Africa countries.
- The livelihoods and food and nutrition security of more than 480,000 farm households spanning low- and high-potential environments of eight eastern and southern Africa countries improved with the adoption of CASI methods.
- Impact-oriented integrated innovative interdisciplinary systems approaches to soil health, field agronomy, market access, computer modelling and policy engagement provided effective research results.
- More than 50 innovation platforms, designed to complement the interdisciplinary research sites, coordinated farm, research, extension, value chain and other business activities and generated co-learning, feedback to research and evidence for local scaling of CASI practices.
- Scaling grants targeted selected public and private organisations and scaled up adoption and impact processes manyfold, from tens of thousands to hundreds of thousands of adopting households.
- The SIMLESA program contributed to widespread capacity building of farming women and men, small- and medium-seed enterprises and the National Agricultural Research and Extension Services.
- Effective pathways to impact were identified and scaling models tested to enable the National Agricultural Research and Extension Services to scale out and scale up CASI innovations and expand climate-smart agricultural research-for-development across eastern and southern Africa.

Introduction

The previous chapters of this book offer a rich set of highlights of the activities and results of a unique regional—indeed interregional—program of research and capacity building centred on agricultural transformation through conservation agriculture-based sustainable intensification (CASI). The contents of the book indicate the breadth and diversity of the research outputs[2] generated by the SIMLESA program in relation to the intensification, diversification and resilience of the maize mixed farming system. This system is the future 'engine of growth' in Africa, which has a farm population of 107 million, cultivated area of 40 Mha and a livestock population of 36 million tropical livestock units in 2015 (eds Dixon et al. 2019), and dominates farming, food production and rural development across eastern and southern Africa. The SIMLESA program design recognised that rainfed mixed crop–livestock farming is common in both Australia and eastern and southern Africa, and that both continents confront many similar agricultural challenges, for example, infertile soils, land degradation, variable rainfall and long distances to markets. (ACIAR has supported 30 years of agricultural research partnerships in the region.) SIMLESA was focused on CASI, a relatively new theme for African research, to ensure environmental sustainability along with intensification and build on Australian experience with conservation agriculture. It is no surprise that the strengthening of the agricultural science bridge between Africa and Australia is a major outcome of SIMLESA, building on the program research partnerships, study tours and graduate scholarships.

Research by the National Agricultural Research System in five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) and Australia constituted the backbone of SIMLESA. This five-country core was supplemented by the managed spillovers of SIMLESA research results to three other countries (Uganda, Rwanda and Botswana). In addition, there were two-way science exchanges on CASI with Zimbabwe (in particular, on appropriate mechanisation and crop–livestock integration). Training activities were initiated in South Sudan but circumstances did not permit their continuation. Inspired by SIMLESA, USAID established a similar CASI program in Zambia.

Soon after SIMLESA commenced, ACIAR launched complementary research in the region on appropriate mechanisation for CASI, crop–livestock integration, water management, agroforestry and socioeconomic constraints to adoption of CASI innovations. The Bill and Melinda Gates Foundation considered investing directly in SIMLESA, but ultimately the N4Africa program was established on legume development, which complemented SIMLESA. USAID also drew upon the SIMLESA program design and experience for the formulation of the Africa Rising program. The SIMLESA design and experience informed the formulation by ACIAR of the Sustainable and Resilient Farming Systems Intensification project in South Asia and the Sustainable Intensification and Diversification project in Cambodia. Thus, another outcome of SIMLESA was the improved design of CASI research-for-development initiatives in Africa, South Asia and South-East Asia.

2 The conventional project and program definitions of outputs, outcomes (effects of output use by next users, for example increased competency and organisational effectiveness after training) and impacts (effects on final target beneficiaries, ecosystems or social groups).

Highlights of SIMLESA outputs are described in the book and organised in five parts:

- **Section 1:** setting the scene (rationale, sustainable intensification and agricultural transformation, development diversity, climate variability and uncertainty and agricultural innovation)
- **Section 2:** regional research-for-development (CASI, climate-informed management, mechanisation, gender, crop varieties, livestock, markets and value chains and South African–supported training)
- **Section 3:** country research-for-development (highlights of research from nine countries, co-learning between Africa and Australia, and synthesis of lessons from countries)
- **Section 4:** scaling (adoption pathways, capacity building, policies and institutions, intersectoral linkages)
- **Section 5:** future vision (key outcomes and way forward).

While the outline might appear comprehensive, readers should be aware that the 88 authors of these 26 chapters have described only a small proportion of the knowledge outputs and development outcomes generated by the SIMLESA program across nine countries of the region and Australia. This impressive sampling of research outputs does not completely represent the SIMLESA legacy, but points the way to potential future outcomes and impacts from the program. Some of these are foreshadowed in this chapter.

Paradigm shifts

When SIMLESA began, improved food security was the priority of a majority of research leaders in the region and research efforts tended to be dominated by commodity-based approaches associated with improved varieties, inorganic fertiliser and improved markets. As noted in the introduction to this book, food crop yields were stagnant, annual variability was high and rural hunger was prevalent. SIMLESA has contributed to a paradigm shift towards a systems approach to sustainable intensification based on conservation agriculture, with the triple-bottom-line of increased productivity and incomes, strengthened resilience (and reduced risk or variability) and reduced soil degradation. This paradigm shift was fostered by effective ownership of SIMLESA by participating countries, which ensured that research was focused on national priorities. Given their seniority, national members of the program steering committee were often active advocates of the promising field research results. The annual national and regional program meetings exposed policymakers to the adaptations and performance of CASI in SIMLESA countries. As a consequence, national SIMLESA teams received the necessary support for their research. Moreover, CASI offered effective triple-bottom-line outcomes of increased productivity, system resilience and sustainable resource management, which had been noticeably missing from earlier research efforts.

After four years of operation, the performance of SIMLESA was widely recognised in the region. At a high-level forum in October 2015, organised by the Association for Strengthening Agricultural Research in Eastern and Central Africa, five ministers of agriculture signed a communiqué endorsing CASI in agriculture and committing to supporting the adoption of SIMLESA research results.

This policy-level recognition led to an invitation to present SIMLESA results at the Africa-wide CAADP platform meeting in Gabon in April 2018. During SIMLESA's concluding year of operations, high-level policy support for its role and results was reaffirmed in May 2019 at a high-level ministerial forum organised by ASARECA-SIMLESA, at which a ministerial joint communiqué on CASI to support and scale up CASI was endorsed by 14 ministers of agriculture from eastern and southern Africa (see Appendix). Few research initiatives achieve such policy influence and outcomes so quickly.

By reaching out and influencing other projects, national agencies, private companies and regional platforms, SIMLESA demonstrated noteworthy responsibility and maturity. The program stepped beyond a project mindset, and focused on activities and outputs towards a responsible program approach, demonstrating and networking on the effectiveness of farming systems research and CASI as viable alternatives to the commodity and disciplinary approaches that were the norm a decade before.

The paradigm shift towards systems-oriented CASI was reinforced by specific policy analyses of the SIMLESA regionwide household survey panel database, which generated a series of critical findings. For example, the synergy between different technological components of CASI was clearly demonstrated, which has major significance for extension policy. Policy simulations estimated the impact of changes in public investment in extension or subsidies on the adoption of CASI. The open-access 5,000-household survey database from three panel rounds in 508 villages in five countries is a major and unique resource for the region and enables further outcomes in the form of valuable policy analyses to examine other policy and institutional options (Nyagumbo et al. 2020).

Policymakers can also draw lessons from the operational effectiveness of and outcomes from 58 innovation platforms. These evolved into multistakeholder forums for co-learning and adaptation of CASI innovations by farmers, extension, research, local business and civil society, as well as coordinating local demonstrations, input supply and marketing. Such social capital can also underpin local scaling of the SIMLESA results, and provide insights for investment in impact pathways and the planning of wider scaling efforts.

Putting knowledge to work

Some SIMLESA contributions to science are highlighted in this book, and more are comprehensively reported in about 100 reports, publications and program syntheses, organised by country and research theme, including more than 50 journal articles on CASI (29% of articles), technology adoption (24%) and research methods (20%) (Keating 2017). The focus on one broad farming system type in the region (maize mixed farming system) facilitated the interpretation of on-station and on-farm trial results and allowed for meaningful cross-country comparisons. These were enhanced by the systematic location of 33 maize–legume cropping system research sites in contrasting agroecological environments in each African country. Spatial analyses identified a number of agroecological and climate analogues between the main five SIMLESA countries in eastern and southern Africa and Australia (specifically Queensland). The productive partnership between Australian universities, African national agricultural research systems and the Consortium of International Agricultural Research Centers contributed greatly to research productivity, as did the national ownership and investments, and the capacity building activities.

A fundamental research outcome is the confidence in CASI established by the triple-bottom-line benefits (productivity, resilience, improved soils) in the maize mixed farming system, as Keating, Gahakwa & Rukuni (2018) observed, 'under farmer's circumstances at a scale previously never achieved—that is over 5,000 treatment observations developed across five countries and multiple agroecologies within country'. SIMLESA complemented the on-farm research trials with on-station experiments in all countries and agroecologies. The combination of the basic principles of conservation agriculture (minimum soil disturbance, residue retention and rotation) with complementary sustainable intensification practices (e.g. appropriate varieties, modest fertiliser applications and improved weed management) increased average maize yields by 5–38% and legume yields by 5–15% (SIMLESA 2019). Because of savings in labour requirements for ground preparation and weeding, labour productivity approximately doubled with significant savings for farming women.

The program has shown that positive environmental outcomes are possible with a multidisciplinary approach to better agronomic and natural resource management practices in a context of appropriate socioeconomic incentives and institutions. With these, African farming systems can truly enter a sustainable intensification pathway. CASI significantly improved soil health (for example, reduced bulk density and indications of increased soil carbon even in the short term). Also, maize–legume intercrops under CASI increased cropping system ecoefficiencies in Mozambique and Ethiopia, including increased water use efficiency and 34–65% reduction in soil erosion. Significantly, household surveys showed that the use of CASI practices doubled the probability of adoption of crop diversification and soil and water conservation practices. Therefore, CASI could be viewed as an entry point to wider farm and landscape developments.

In 2012, early SIMLESA experience led the program to adopt a flexible and stepwise approach to CASI smart sequences, with the intensity and sequence of practices dependent on the agroecological and socioeconomic circumstances of the farm. For example, the high ratio of livestock numbers to crop area in Ethiopia favoured zero tillage (for savings of labour and draught animals) and rotation (for soil health, human nutrition and crop sales), but farmers preferred feeding crop residues to livestock over leaving them on the soil surface. Conversely, the low population density in Malawi and lower demand for animal feed favoured the retention of crop residues in the field. The flexibility of CASI, as applied by SIMLESA, embraced agroforestry in Rwanda and improved forage production and livestock feeding in Ethiopia and Tanzania.

The program has established the complementarity of conservation agriculture principles and selected sustainable intensification practices, including improved varieties and modest inorganic fertiliser use. The on-farm evaluation and release and promotion of 40 improved maize cultivars and 64 legume varieties with significant yield potential is a major CASI-based contribution. Some of the germplasm entered the breeding program in Queensland but has not progressed to the release stage. An accompanying outcome is the increased effectiveness of coordinated germplasm improvement and seed multiplication and distribution by farmers, breeders, seed companies and farmer groups working in concert. Farming systems modelling was essential to estimate synergies between enterprises (for example, maize and legumes) and trade-offs between practices (for example, crop residue retention on the soil surface vs feeding to cattle). These activities built an understanding of the power of modelling in farming systems analysis. Efforts to build capacity on APSIM have been initiated and a number of postgraduate students have used the model for their research.

System resilience has a number of implications for sustainable rural development, not least the household food security and transient poverty arising from climate and market volatility and uncertainty. Farm household system resilience, household aversion to risk and the riskiness of technologies interact and influence the propensity of smallholder adoption. In recent years these issues have been largely ignored by most African national agricultural research systems. The program generated valuable new knowledge on risk premiums of CASI practices through econometric analysis of the household survey data and crop model simulation, which can be utilised by weather-indexed insurance programs, agricultural finance programs and agricultural extension programs. In fact, simulations based on 30-year weather series were critical for estimating the nature and level of risk stemming from climate variability. These analyses generated a greater awareness of the importance of risk and resilience for smallholders and are central to considerations of climate-smart agriculture.

Scaling and rural development

The above outputs have already led to significant farm-level economic, environmental and social impacts that indicate the potential for transformation of agricultural and rural development in eastern and southern Africa. A primary outcome of SIMLESA activities is the ability of more than half a million farmers to manage CASI practices in a way that augments crop production and income and conserves soil. By 2019, an estimated 484,000 farmers had adopted and benefited from CASI practices (SIMLESA 2019), compared with a program target of at least 650,000 farmers by 2023. The impact of adoption on household livelihoods is impressive. Based on household surveys in Ethiopia, net maize incomes expanded by 6–35% from the adoption of conservation agriculture practices and 26–137% from the adoption of the richer set of CASI practices.

Increased social capital is another farm household-level outcome, achieved through program formation of 58 operational innovation platforms. There are encouraging indications of additional household impacts arising from the innovation platforms. In due course, SIMLESA established the knowledge base, social capital and agricultural institutions to improve access to inputs, services and markets, gender empowerment, co-learning between farmers and other groups and possibly greater willingness to take risks associated with intensification, diversification and commercialisation.

The scaling activities were incorporated in SIMLESA for two reasons:

- to provide feedback to research on second-generation research issues as technologies are adopted by farmers
- to research the best scaling models for CASI under various African institutional and policy environments.

The innovation platforms are a key component of adoption and impact pathways, complementing the field operations of agricultural extension, agribusinesses and non-government organisations. SIMLESA has emphasised the importance of research, extension, agribusiness and policymakers working together to formulate practical scaling strategies for CASI. In the process of testing alternative scaling models, SIMLESA managed a competitive grant scheme to test the contributions of business, non-government organisations and media to scaling. The assessment of these alternatives is critical information for informing policymakers on optional mechanisms for scaling, which has the potential to boost scaling effectiveness and smallholder impacts.

Capacity for sustainable rural development

Strengthened capacity in eastern and southern Africa (of individuals, organisations and institutions) for CASI and diversification of agriculture is one of the major outputs of the program. This is touched on throughout this book and emphasised in the midterm and interim final reviews of the program.

From its inception, SIMLESA prioritised research competency building through on-the-job training, informal mentoring and graduate education. Training, predominantly postgraduate, was one of the planks of the Africa–Australia bridge. In fact, the program supported or arranged for 65 fellowships for masters or PhD degrees in Australia or Africa, which represents a major boost to agricultural science capacity in eastern and southern Africa. In order to ensure high-quality standardised field research, the program provided substantial short-course training of National Agricultural Research System agronomists in relation to CASI and on-farm research procedures. ACIAR, the Crawford Fund and CSIRO provided short-course training on impact pathways, innovation platforms, leadership and research report writing. The Republic of South Africa also provided a range of scholarships for masters degrees and introduced new concepts and skills through short courses on innovation systems and gender analysis. National researchers were mentored in a wide range of skills, and observers often remarked on the growth of confidence, analytical insights and presentation skills of the national program scientists. Many thousands of research-hub farmers also learned a tremendous amount about soils, inputs, CASI and marketing through interactions with scientists and the other farmers. Sister research projects also built complementary skill sets in economic analysis, mechanisation and business development. The strengthened competencies have increased the quality and efficiency of the national agricultural research systems and, to some degree, agricultural policymakers, development agencies and agribusinesses, and improved the prospects for the fine-tuning and adoption of CASI.

Building on strengthened competencies of staff, SIMLESA contributed further to the operational capacity of eight national agricultural research systems, many public agricultural development organisations and at least 40 agribusinesses. National agricultural research systems were empowered to find solutions to multidisciplinary problems in the development of CASI, especially in complex contexts such as soil health, crop–livestock integration and climate change. Similarly, the capacity of commercial firms to build and support input/output supply chains was strengthened, notably in relation to improved seed multiplication and sale. This was augmented by the business development services of a sister project on mechanisation. Thus, policymakers and governments will be better equipped to create enabling environments for the adoption and adaptation of CASI innovations by smallholder farmers.

There is a third level of capacity building related to social capital and agricultural institutions (in the sense of the 'rules of the game', which influence individual and organisational cooperative or competitive behaviour). There is a growing understanding of the ways in which social capital and institutions influence incentives and behaviour. By pioneering 58 innovation platforms in the African program countries, SIMLESA has demonstrated the power of social capital in relation to actor cooperation, co-learning, ongoing innovation and community monitoring of environmental and social outcomes that can be replicated by other farmers' groups, women's groups or cooperatives.

By way of a synthesis, Table 26.1 aggregates SIMLESA outputs into broad clusters and summarises likely outcomes from the application of the outputs until 2024 (five years after the end of the program) and anticipates probable impacts approaching 2030 (up to 10 years after the end of the program). The outcomes depend on continued commitment and follow-up investment by national governments.

Table 26.1 Selected SIMLESA output clusters, likely outcomes and probable impacts by theme

Program themes	Output clusters generated during the program	Likely outcomes from use of outputs (up to 2024)	Anticipated impacts (up to 2030)
Agricultural development paradigms	Influence on systems and CASI-oriented content of other programs and projects in Africa and Asia	Growing recognition of the relevance and effectiveness of systems and CASI approaches to agricultural development	More effective regional and national agricultural and rural development programs
Farming systems research methods (including agronomy, crop improvement, livestock forage, socioeconomics)	Demonstrated multidisciplinary team management in eight countries, demonstrated crop modelling, major open-access databases and analyses, notably the 5,000 household panel surveys and agronomy trial data	Strengthened multi- and interdisciplinary research in national agricultural research systems, wider use of crop modelling, further analysis of SIMLESA agronomy and economic data, integrated analysis of crop management, mechanisation and livestock feed management results	More effective and adoptable innovations for farming systems intensification and resilience, through routine use of farming systems research multidisciplinary teams and farming systems modelling, a knowledge base on maize mixed farming system informing eastern and southern Africa research priorities and policymaking
CASI	Proven CASI-based maize–legume practices supported by soil health, mechanisation and value chains in high/low potential agroecologies in 5+ countries, pilot adopted by 480,000+ farmers	Regional policy support and national investment in CASI smart sequences for sustainable rural development, significant farmer adaptation and innovation of CASI practices	Sustainable intensification trajectories for major eastern and southern Africa farming systems through application of CASI smart sequences, enriched with legumes, livestock, agroforestry and mechanisation
Resilience/risk reduction	Demonstrated estimates of risk premiums by practices from surveys and crop climate simulations	Greater awareness of risk management in sustainable intensification, promotion of crop and livestock insurance	Improved risk management options available to smallholders, routine risk assessment, most likely by farming system simulations
Innovation platforms	58 operational innovation platforms linking local actors, fostering co-learning and innovation, and strengthening market access	Awareness of the role of social capital and multistakeholder forums, support for the existing innovation platforms, and replication	Increased smallholder benefits from access to and adaptation of CASI innovations and markets, improved storage
Capacity building	Increased competencies of farmers, research, extension and businesspersons, and postgraduate training for 65 researchers	Improved research and scaling quality and efficiency, and more productive and adoptable innovations	Improved smallholder livelihoods and environmental benefits from the increased research capacity of national agricultural research systems
Scaling and spillovers of CASI and related innovations	Cross-border spillovers to three countries, identified impact pathways, scaling strategies and pilot scaling leading to adoption of CASI by 480,000+ smallholders in five countries	National and agribusiness investment in adoption and impact pathways for CASI, adoption by more than 650,000 smallholders, continued exchanges across regional platform	Widespread adoption and sustainable economic, environmental and social benefits contributing to the United Nations Sustainable Development Goals

Note: CASI = conservation agriculture-based sustainable intensification

Of course, SIMLESA could not embrace all aspects of farming systems in its first decade. However, the program linked directly to complementary research projects on critical themes such as adoption pathways, mechanisation and crop–livestock integration; and communicated with other projects in Africa on relevant research on agroforestry and sustainable intensification (e.g. the USAID-supported Africa Rising) and in Asia on sustainable and resilient farming systems intensification.

Ways forward and building on SIMLESA outputs

The immediate opportunity, even an expectation, is that national governments will invest in scaling CASI-smart sequences, building on the results and capacity generated by SIMLESA, in line with the intent and spirit of the communiqué endorsed by eight ministers of agriculture from the region in May 2019. The immediate target would be the adoption of CASI by at least 650,000 smallholders by 2023. Naturally, there are opportunities to strengthen institutions piloted by SIMLESA, such as the innovation platforms and working links with agribusiness seed, machinery and media companies and non-government organisations. It would be advantageous to monitor adoption and farmer adaptation of CASI and extend the lessons to national agricultural research systems and national policymakers.

The relevance, strength and magnitude of SIMLESA outputs and outcomes for CASI in eastern and southern Africa countries is obvious, and opens many opportunities for research and development in the short term and in the medium to long term. There would be good pay-offs from pursuing a deeper analysis of the existing socioeconomic and agronomy databases. Research on the integration of mechanisation, perennials and livestock into selected program research hubs and/or innovation platforms would be valuable. While CASI clearly benefits farming women, additional research on adapting and scaling CASI in the context of gender empowerment would be very useful.

Climate change has become a top policy and research priority for countries of eastern and southern Africa. Agricultural leaders focus on the adaptation to climate change, especially the increased variability of precipitation. In the medium term, changes in annual precipitation, shifts in seasonal rainfall patterns and increases in temperature are common concerns. It will be important to identify win–win solutions for adaptation to climate change and mitigation of emissions of greenhouse gases. In Africa, a large proportion of the continental emissions are agriculture-related, and the conversion of land to cultivation continues (see Kenya's Climate Smart Agriculture Strategy 2017–2026, Tanzania's Climate Smart Agriculture Program 2015–2026, and Africa Climate Smart Alliance convened by The New Partnership for Africa's Development and the Common Market for Eastern and Southern Africa). However, it is important to recognise that non-climate-related constraints to smallholder intensification and diversification and food and nutrition security have not evaporated; in fact, they interact with and compound the climate change challenges.

Because SIMLESA focused on risk reduction (in the context of variable climate) alongside CASI (across a spectrum of agroecologies), the CASI results are directly relevant to the challenge of climate variability and climate change. Moreover, the augmented capacity built by SIMLESA in research, development and businesses for multidisciplinary research and scaling development is a huge advantage for tackling 'wicked' (complex and uncertain) problems such as climate change and its interactions with other agricultural constraints. The goals of intensification, food and nutrition security and climate-smart agriculture (including climate change adaptation and mitigation) are intimately intertwined with those of CASI (Figure 26.1).

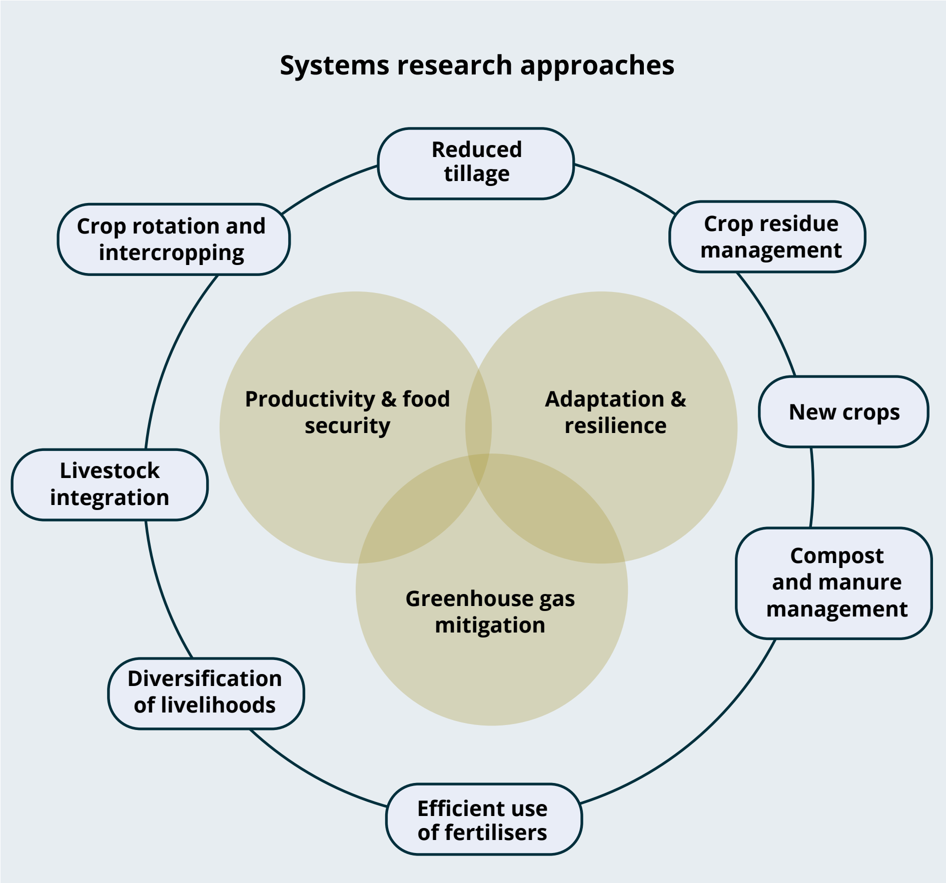

Figure 26.1 Key CASI focus areas mapped to three climate-smart agriculture pillars

Source: Adapted from Keating 2018

The complementarity between climate-smart agriculture and CASI is clear. Climate-smart agriculture is viewed as an approach towards the goals of agricultural productivity/food security, adaptation/resilience and mitigation, rather than a recipe of technologies. Generally, climate-smart agriculture practices are not novel. Rather, they are well researched soil, water, nutrient, crop and residue, tree and livestock practices, often with newer complementary institutional or insurance mechanisms. All of the issues of concern to researchers and policymakers looking into CASI pathways are in scope in a climate-smart agriculture approach. However, climate-smart agriculture is highly context dependent (as with systems-oriented CASI). Thus, the Climate Smart Village approach seeks to place climate-smart agriculture in a community-based participatory learning context, focused on local co-learning about feasible options rather than spilling-in technologies from outside (there are similarities with SIMLESA's innovation platforms). Trade-offs and synergies across climate-smart agriculture are common—a single practice or portfolio of practices/services will generate a mix of costs and benefits that could contribute to the three climate-smart agriculture goals. The evidence is mounting that markets and institutions in the broadest sense are critical obstacles to progress (as with CASI goals).

Addressing the climate change challenge requires integrative and transformative farming systems research. Given the richness of the knowledge bases on resource management, agronomy, livestock and socioeconomic aspects of farm households, it has been argued that transformation requires an emphasis on the benefits and trade-offs of alternative policy and institutional innovations (in particular, social capital contexts) for the climate-smart sustainable intensification of agriculture. It is important to focus policy and institutional options on integrated farming systems (for example, crop–livestock farming systems, interfaces of production systems with local institutions and markets, and coordinated provision of agricultural services and inputs) towards CASI to boost livelihoods and resilience while navigating the complex challenges of climate change. Farming system modelling and policy simulation will be useful tools, especially if differentiated by types of farming systems and households. It is essential to clarify pathways to impact and scaling strategies for any technological or institutional innovation prior to major investments in research. Naturally, there would be advantages in building on some of the scientific relationships established between eastern and southern African countries and Australia.

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Appendix

Joint Communique: ASARECA COUNCIL OF PATRON MINISTERS SUMMIT: Repositioning ASARECA for Accelerated African Agricultural Transformation, May 2019

CIMMYT International Maize and Wheat Improvement Center

Australian Government
Australian Centre for International Agricultural Research

ASARECA Transforming Agriculture for Improved Livelihoods

Joint Communiqué

Joint communiqué by Ministers of Agriculture of The Republic of Burundi, The Republic of the Congo, The Democratic Republic of Congo, The State of Eritrea, The Federal Democratic Republic of Ethiopia, The Republic of Kenya, The Republic of Madagascar, The Republic of Rwanda, The Republic of South Sudan, The Republic of the Sudan, The United Republic of Tanzania, The Republic of Uganda, The Republic if Malawi and The Republic of Mozambique of the high level Ministerial Panel on Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) implemented by CIMMYT and national partners in Uganda, Ethiopia, Kenya, Malawi, Mozambique, Rwanda and Tanzania at the ASARECA Council of Patron Ministers Summit.

We, the Ministers responsible for Agricultural Research from the aforementioned countries gathered in Kampala, Uganda, on this 3rd day of May 2019;

Aware

- **that** in Eastern, Central and Southern Africa, the challenge of feeding a growing population projected to double by 2050 has to be met,
- **that** despite a degrading resource base coupled with global climatic and economic changes, where smallholder agriculture remains the centerpiece of our countries' economies,
- **that** confronting this challenge while protecting the natural resource base involves finding innovative and sustainable ways to produce more food with less resources.

Cognizant of the need to use our land resources in ways that will ensure its health and sustainable access to future generations, **Here note that:**

- conservation agriculture-based sustainable intensification (CASI) practices, including practicing minimum tillage, maintaining permanent soil cover and mulches and implementation of crop diversification practices (such as cereal legume intercropping and rotations), as tested through the sustainable intensification of maize-legume cropping systems in eastern and southern Africa (SIMLESA) program and similar multidisciplinary research efforts show promise in boosting and stabilizing productivity and safeguarding the resource base in the face of climate change.
- Mainstreaming CASI calls for institutionalization efforts that support scaling and networking, integration into agricultural research and extension systems and fostering value chains development. CASI also benefits from appropriate mechanization

which would reduce drudgery especially for women farmers and laborers; as well as attracting youth talent into agriculture.

Do therefore recommend the following policy actions to our Governments and call for concerted action from a range of multiple stakeholders in Africa including: multi-disciplinary researchers, Think Tanks, extension agencies, National and Regional Parliaments and Local Governments, private businesses, non-governmental organisations, regulatory agencies, farmers and their community organisations, trade organisations and others:

Mainstream and Institutionalize Conservation Agriculture-based Sustainable Intensification (CASI) farming practices through:

Enhanced investments in scaling priority technologies through

- *Advisory and extension institutions.* Ministries of Agriculture should facilitate re-skilling extension personnel in CASI and the operations of farmer innovation platforms and collective institutions
- *Broad-based Farmer Education through CASI demonstration and learning sites.* By mobilising public and private partnerships to fund national networks of long term CASI learning sites.

Regional CASI networks of

- *Ongoing adaptive and multi-disciplinary research, training at multiple levels and knowledge systems.* This should be done in collaboration with other relevant ministries and agencies (such as Education, Science and Technology, Environment and Natural resources) as well as sub-regional research organisations such as ASARECA, CCARDESA and CORAF.

Enable rural market development by:

Encouraging innovations that improve rural value chains and enable adoption of CASI.

- Supporting agribusinesses willing to invest in rural innovation and market development as part of their business model, e.g. through funds that enable such innovators to access start-up capital where needed.
- Promoting collective institutions to enable farmer integration into markets

Support the development of smallholder machinery value chains through:

Collaborative efforts for networks of machinery development, testing and adaptation

- Local-level training for entrepreneurs in decentralized custom hire businesses and service centers
- Support market innovations that enable low-cost farmer learning and experimentation

To conclude, **we re-affirm** that with multi-sector support, smallholder farmers can trial, select and adopt CASI practices suited to their varying conditions to build resilient farms needed to feed the growing populations in Africa. Using CASI as a framework, it is possible to instigate critical paradigm shifts in smallholder farming systems and underlying agronomy, encourage institutional and market innovations to support farmers adopt CASI.

The potential of CASI to conserve soils, improve yields and have positive environmental impacts can enhance farm resilience to the effects of climate change. Therefore, CASI should be promoted as a regional initiative and as a major contributor to achieving the Malabo Commitment on resilience of farming systems in Africa.

We also affirm that political and material support at both national and regional levels are required to build strong partnerships in regional AR4D flagship programs for scaling of agricultural technologies and innovations. These regional collective actions are critical opportunities to create the free flow of new ideas, research results, technologies and innovations to generate the much needed spillovers across institutions and countries. Such positive spillovers are central to achieving impact of agricultural innovations faster and at national and regional scale.

IN AGREEMENT HEREOF, the undersigned representatives being duly authorized by their respective Governments have signed the present Joint Communique

DONE AT KAMPALA, this___**3rd** ___ day of __**May**__Year __**2019**_____

FOR:

THE REPUBLIC OF BURUNDI

....

MINISTER OF ENVIRONMENT, AGRICULTURE AND LIVESTOCK

REPUBLIC OF THE CONGO

....

MINISTER OF SCIENTIFIC RESEARCH AND TECHNOLOGICAL INNOVATIONS