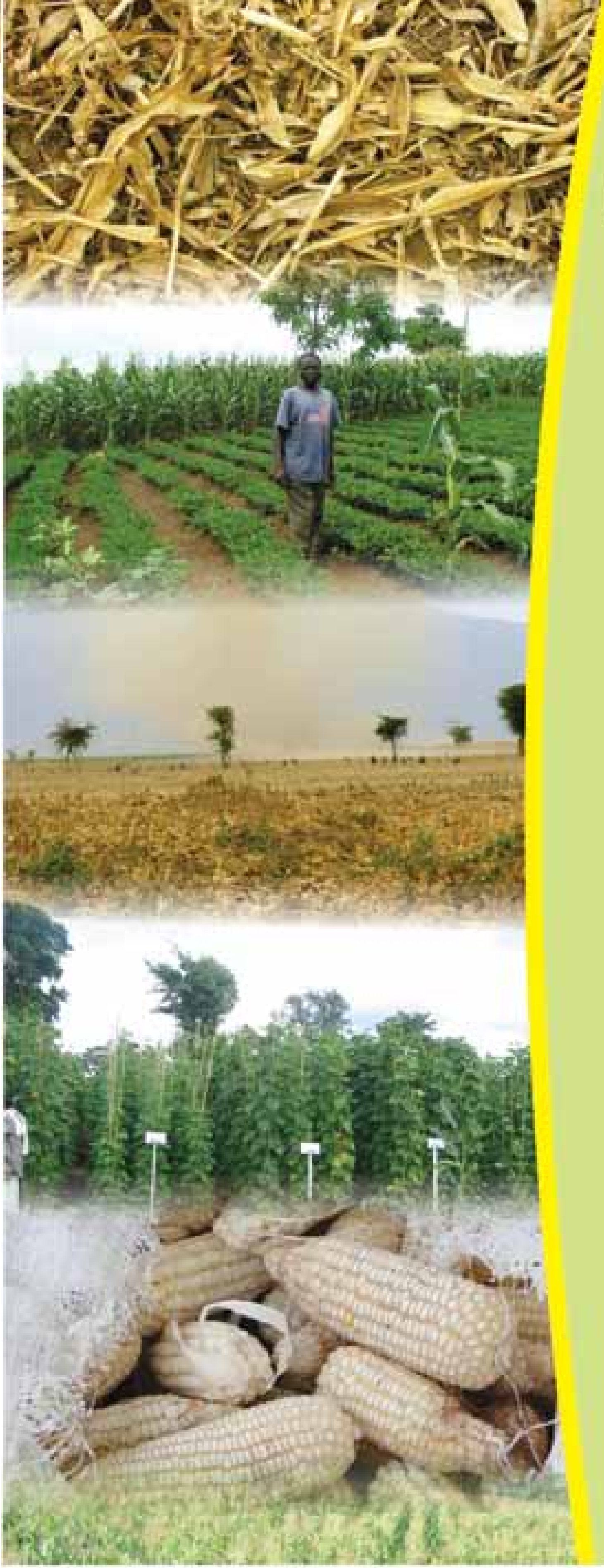

ASARECA

Transforming Agriculture for Improved Livelihoods

Agricultural knowledge and technology transfer and spillovers:

Study to inform SIMLESA

Volume 1

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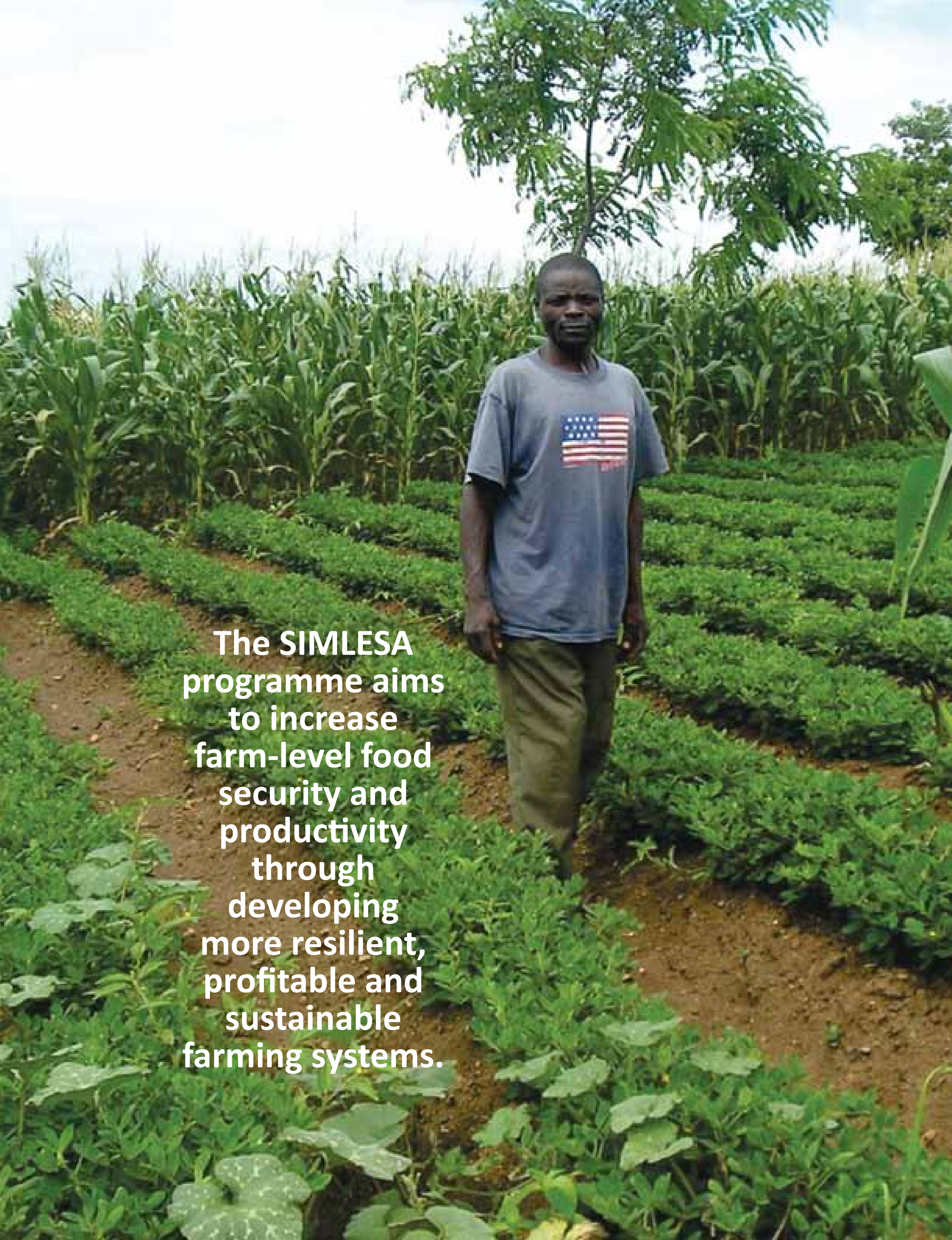

The SIMLESA programme aims to increase farm-level food security and productivity through developing more resilient, profitable and sustainable farming systems.

Facilitating scaling out and spillovers of agricultural technologies and knowledge: Study to inform SIMLESA

Volume 1: Main report

Association for Strengthening Agricultural Research in
Eastern and Central Africa
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Contents

Foreword

Agricultural productivity and growth is without question widely acknowledged as the cornerstone to any meaningful reduction of hunger and poverty, as well as the means to attain economic growth for countries in sub-Saharan African. In most countries in sub-Saharan Africa, about 70% of the population and nearly 90% of the poor work in agriculture where they depend on increased agricultural productivity for food security and to lift them out of poverty.

Despite this, agricultural productivity in sub-Saharan Africa has lagged behind that of other regions of the world both in terms of total and per capita food production. For example, in the last decade Africa's share of world food production was only 3.9% while the shares for Asia, North America and Europe were 47.7%, 14.8% and 12.2% respectively. Coupled with the high population growth, the low productivity has contributed to increased food insecurity in the region. The recent rise in food prices witnessed around 2008–2009 caused much suffering to the millions of food insecure households in the region.

In efforts to redress this problem, various initiatives were started over the past several decades, some by national governments. Others were started by regional and international agricultural research and development (ARD) organisations with considerable support from various development partners. At the continental level, the Comprehensive Africa Agriculture Development Programme (CAADP) prepared by the African Union/New Partnership for Africa's Development (AU/NEPAD) in 2003 is one example of a broad strategy designed to promote interventions that best respond to this challenge. Other regional interventions by national governments include the Eastern Africa Agricultural Productivity Programme (EAAPP) and the West African Agricultural Productivity Programme (WAAPP) designed around commodity-based regional centres of excellence with support from World Bank funding.

In 2010 the International Maize and Wheat Improvement Center (CIMMYT) with support from the Australian Centre for International Agricultural Research (ACIAR) started a programme on sustainable intensification of maize–legume cropping systems (SIMLESA) covering five countries in Eastern and Southern Africa. The aim was to increase household and regional food security and incomes. SIMLESA is a regional collaborative programme implemented by national agricultural research systems (NARS) in Ethiopia, Kenya, Malawi Mozambique and Tanzania in collaboration with international and regional institutions. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is among the regional collaborating institutions. Other partners include, University of Queensland through the Queensland Alliance for Agriculture and Food Innovation, the Queensland Department of Employment, Economic Development and Innovation (QDEEDI) and Murdoch University in Australia; and CIMMYT, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Agricultural Research Council (ARC), South Africa. The role of ASARECA in SIMLESA is to provide technical backstopping to NARS in monitoring and evaluation (M&E) frameworks and gender mainstreaming, and in technology and knowledge transfers and spillovers. The study that culminated in this publication was part of ASARECA technical backstopping inputs to SIMLESA.

About ASARECA

ASARECA is a not-for-profit sub-regional organisation comprising 11 countries: Burundi, the Democratic Republic of Congo (DRC), Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, South Sudan, Sudan, Tanzania and Uganda. Its mission is: To enhance regional collective action in agricultural research for development, extension and agricultural training and education to promote economic growth, fight poverty, eradicate hunger and enhance sustainable use of resources in Eastern and Central Africa.

ASARECA brings together scientists and other partners to generate, share and promote knowledge and innovations to solve common problems in agriculture in member countries and contribute to productivity and growth of the sector. Its partners include farmers, national, regional and international research, extension, and training organisations, public and private sector actors, non-governmental organisations (NGOs) and development agencies.

Dr Fina Opio
Executive Director, ASARECA

Preface

The Sustainable Intensification of Maize–Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) programme aims to increase farm-level food security and productivity through developing more resilient, profitable and sustainable farming systems. It is a multi-stakeholder collaborative programme covering five countries—Ethiopia, Kenya, Malawi, Mozambique and Tanzania. The programme focuses on validation and delivery of technological and institutional innovations that can significantly change the livelihoods of millions of smallholder farmers in Eastern and Southern Africa (ESA).

The SIMLESA strategy emphasises leveraging science and technology by using existing scientific evidence to enhance evaluation, adaptation and delivery of profitable options to smallholders. However, for SIMLESA to achieve its overall objective of spreading the impacts of its outputs widely within the five participating countries and beyond, integration of mechanisms that facilitate effective knowledge and technology transfers or 'spillovers' is critical.

It is against this background that the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), as a regional collaborator responsible for providing technical backstopping in knowledge transfers and spillovers, commissioned this study in 2012. The study sought to establish possible strategies to effectively transfer information and knowledge to end users, and to facilitate scaling out and spillovers of SIMLESA technologies. It also sought to generate an inventory of available maize and legume technologies and conservation agriculture practices that could be scaled out to communities within participating countries and to facilitate spillover across relevant countries. Furthermore, the study sought to identify extension approaches and knowledge products currently being used in SIMLESA. Using geographic information systems (GIS), the study sought to establish current areas of spread of the SIMLESA technologies and practices and to determine potential areas where the technologies can be further spread within the ESA sub-region.

The output of the study is presented in two volumes. Volume 1 is the main report. It comprises an executive summary, and three parts. Part 1 describes the various methodologies used by the study team to generate the findings; and Part 2 reports the results of the inventory of SIMLESA technologies, knowledge products and extension approaches used in the five countries. The locations that reported use of SIMLESA technologies were determined using outputs generated with GIS. Part 3 reports the findings relating to conditions for facilitating scaling out and spillovers of SIMLESA technologies and includes the conclusions and recommendations. Part 3 includes a short section that provides additional thoughts on the application of GIS in this type of work. Volume 2 contains all the annexes referred to in Volume 1.

I thank the study team: Rachel Percy (from the IDL group), Team Leader/Research Uptake Specialist; Barry Pound, Agronomist/Research–Extension Linkages Specialist; Alan Mills, GIS Specialist; Alexander Phiri, Agro-economist/Farming Systems Specialist; and support staff—Daria Dubovitskaya (Dasha) and Alastair Stewart—who worked under the auspices of Triple Line from the UK for conducting the study. I express my gratitude to the many stakeholders who directly and indirectly contributed to the output that led to this publication.

Lydia Kimenye, PhD
Programme Manager, Knowledge Management & Upscaling, ASARECA

The SIMLESA strategy emphasises leveraging science and technology by using existing scientific evidence to enhance evaluation, adaptation and delivery of profitable options to smallholders.

Executive summary

Background and methodology

The Sustainable Intensification of Maize–Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) is a multi-stakeholder collaborative research programme. It is managed by the International Maize and Wheat Improvement Center (CIMMYT) and implemented by the national agricultural research systems (NARS) in Ethiopia, Kenya, Malawi, Mozambique and Tanzania, with support from other partners. SIMLESA started implementing activities in 2010 and will run through to 2013. SIMLESA is supported through grants provided by the Australian Centre for International Agricultural Research (ACIAR).

The project has five objectives. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is responsible for providing support to Objective 4, which includes knowledge and technology transfer and strategies for facilitating spillovers.

A consulting firm from UK, Triple Line, was appointed by ASARECA to investigate the transfer of knowledge and technology for maize–legume cropping systems with the aim of providing strategies and lessons for facilitating scaling out and spillovers. A team of four consultants plus support staff carried out the work from January to May 2012.

The team used a five-phase process to achieve its objectives: 1) an inception phase; 2) desk review of the literature on scaling out and spillover in which 50 documents were reviewed in detail; 3) fieldwork in four of the five SIMLESA countries (Ethiopia, Kenya, Malawi and Tanzania) and gathering secondary data from Mozambique; 4) a data analysis phase; and 5) a reporting and validation phase. Geographic information system (GIS) mapping and modelling were important components of the study.

Findings from desk review

The desk review analysed over 50 documents from the project region and beyond. The focus was on past experiences in transferring maize–legume technologies and knowledge. Policy and regulatory, institutional, agro-ecological and socio-economic factors influencing scaling out and spillover were identified.

Six key factors that either hinder or enhance scaling out and spillover were identified: 1) increased and sustained agricultural investment by African governments enhances scaling out and opportunities for spillover; 2) actions by regional agencies developing regional policies and approaches that enhance harmonisation; 3) monitoring and evaluation of technology and knowledge transfer ensures availability of adequate baseline data and allows for lesson learning on the impact of scaling out and spillover initiatives; 4) the ongoing regional harmonisation of seed polices, regulations and testing procedures is gradually enhancing spillover; 5) gender targeting is essential; currently, scaling out and spillover are hindered by insufficient attention being paid to women specifically in agricultural research and extension programmes; and 6) increased involvement of the private sector in the agriculture sector (for example, through innovation platforms and sale of seed nationally and regionally) can enhance scaling out and spillover.

Findings on technologies and knowledge products

The study examined the following SIMLESA conservation agriculture (CA) practices: minimum tillage, soil cover with crop residues, maize–legume intercropping, maize–legume rotations, use of herbicides, and pit planting. The key finding was that these practices successfully address soil degradation and declining soil fertility under increasingly erratic rainfall conditions. CA also reduces input and labour costs, and evidence exists that higher yields could be realised from intercropping than from sole cropping of maize and beans.

Proven varieties examined in the study were hybrid and open-pollinated maize varieties, and the following legumes: pigeon pea, Phaseolus bean, groundnut, soyabean and cowpea. The study provided an inventory of pre-released and proven maize and legume varieties, detailing the variety, agro-ecology and problems addressed. The main problems being addressed were drought intolerance and low yields. Findings concerning gender issues were limited, and criteria that women may be more interested in (poundability, grain type, taste and colour for maize) were not raised as problem areas. The maize varieties were suited to similar agro-ecologies in Eastern and Southern Africa.

The key advantages of legumes are: they fix nitrogen; provide a relatively cheap source of protein; double up as cash crops; and fit well in maize farming systems either in intercropping or crop rotation. Information gathered in the study regarding agro-ecologies suited for each variety can inform scaling out and spillover to similar agro-ecologies elsewhere.

Each country in the study has several extension providers. The extent to which each operates depends on the political and policy context of each country. Across all countries governments remain the key providers of extension services. Other providers include commodity or technology networks, farmer organizations, non-governmental organisations (NGOs), the private sector and politicians. Commonly, these providers work with or through government extension systems.

Extension approaches widely used across the SIMLESA countries include extension staff visiting farmers and farmer groups; crop trials and demonstrations; field days; agricultural shows; farmer field schools; and informal farmer-to-farmer extension. Field days and demonstrations were seen as the most effective approach. International, national and field level knowledge products were identified. Knowledge products being used at field level included posters, flyers, brochures, information stands, radio broadcasts and use of mobile telephony to access market information.

Findings on factors influencing scaling out and spillover

The study analysed SIMLESA and its functions in relation to an analytical framework based on innovation systems. The project plays a bridging role: SIMLESA ensures technologies produced by public, private and civil society are made available to value chain players through scaling out approaches, knowledge products, organisations and structures.

The team explored factors that constrain and enable scaling out and spillover of technologies and knowledge products through discussions with a wide range of stakeholders in each of the four countries visited. As with the desk review several factors (policy and regulatory, institutional, agro-ecological and socio-economic factors) were identified, first, in relation to scaling out in-country and, second, with regard to spillover to other countries.

Findings on factors influencing scaling out and spillover were discussed in depth with stakeholders from SIMLESA countries and beyond during a validation workshop held in Nairobi towards the end of the study. Workshop participants refined the findings and identified the most critical constraints and enabling factors. Policy and regulatory factors identified as critical to scaling out were low overall investment in agriculture in recent decades and insecure land tenure (constraining), and political will and seed harmonisation (enabling).

Key institutional factors identified as constraining scaling out were low government capacity; emphasis on production rather than the whole value chain; and limited access to affordable credit. Institutional factors enabling scaling out were the establishment of multi-stakeholder platforms; pluralistic and strong extension; and increased numbers and strength of farmer organisations.

Several agro-ecological factors were also identified as critical to scaling out. These were: competing demand for crop residues and farmers being accustomed to conventional practices (constraining), and CA being a suitable response to land degradation and leading to soil fertility over time (enabling). Socio-economic factors identified as critical to scaling out were poor infrastructure and farmer mindset on minimum tillage and free grazing (constraining), and the decrease in labour requirements resulting from CA and reliable markets that can drive value chains (enabling).

From the constraining factors identified, six were listed as overall 'killer' constraints: low investment in agriculture over recent decades; emphasis on production rather than on the full value chain; mindset of farmers; competing and conflicting demands on crop residues; limited access to credit; its availability and affordability; and limited availability of quality seed.

Three overall enabling factors were agreed upon (all relating to conservation agriculture): CA improves productivity of degraded lands and reduces labour requirements; effective markets to motivate adoption of CA; and effective extension services to drive CA.

Regarding spillover specifically, many of the above factors related to scaling out are also pertinent to spillover. Findings specific to spillover were fewer than those related to scaling out.

Constraining factors validated in the workshop were all either policy and regulatory or institutional. Policy and regulatory factors included: seed harmonisation is still in its early stages; limited capacity to monitor movement of germplasm between countries; and complicated import and export regulations. Constraining institutional factors were the low capacity of new seed companies and general low capacity to produce sufficient foundation seed; lack of suitable equipment for CA such as jab planters; insufficient funding all round for exchange visits; and, within SIMLESA, limited linkages between SIMLESA and the African Conservation Tillage Network (ACT), and limited shared learning between CA and variety testing components of the project.

Factors that enable spillover were identified in all four categories: policy and regulatory, institutional, agro-ecological and socio-economic. Policy and regulatory factors were the renewed government commitment to and investment in agriculture across Africa; liberalisation and greater scope for the private sector; and seed policy harmonisation and related germplasm exchange networks. Institutional factors were the existence and activities of ACT and of regional networks and bodies, and the range of SIMLESA activities. Agro-ecological factors were that CA is versatile and widely applicable and that the agro-ecology in the wider region is suited to spillover of the maize-legume technologies. Enabling socio-economic factors were informal trade; sharing of seed across borders; and evidence of the reduced labour demands under CA are an incentive for its uptake in other countries.

Recommendations

Recommendations agreed upon in the validation workshop fell into two categories: those for SIMLESA and higher-level recommendations for country governments. This executive summary draws out some of the key recommendations in each category.

There were three key recommendations for SIMLESA. First, SIMLESA should further develop and maintain institutional linkages and coordination with other national, regional and international bodies concerned with CA and maize–legume scaling out and spillover. Informal linkages could be made formal; SIMLESA annual country meetings could include a session open to external stakeholders; the project could link up with existing national level (maize and other) working groups; and economies of scale could be identified and exploited where various projects and programmes have similar objectives.

Second, SIMLESA knowledge and expertise in innovation platforms should be enhanced. The project should: involve more stakeholders in its innovation platforms; identify and link up with other organisations running innovation platforms; and for sustainability and cost effectiveness, seek to mainstream its innovation platforms in existing government initiatives.

Third, greater emphasis should be placed on monitoring, documenting and learning lessons on the uptake and adaptation of SIMLESA technologies and the effectiveness of knowledge products. Reports on exchange visits, trials and demonstrations should be shared on the SIMLESA website.

Two recommendations concerned spillover countries: 1) they should advise ASARECA of their key organisations involved in agricultural innovation; and 2) before embarking on scaling out maize–legume and CA technologies, spillover countries should get strong support from these national bodies.

Four areas were recommended for country governments. The first was how to enhance harmonisation of seed policies and regulations. SIMLESA could lobby the chief executive officers of national agricultural research institutes (NARIs) to in turn influence national legislative bodies to enact the laws needed for seed harmonisation.

The second was to improve the enabling environment for private sector bodies to engage in multiplication and sale of new varieties. This may mean revisiting the common need for seed companies to pay royalties for foundation seed, and ensuring that good-quality assurance measures are applied to private sector companies.

The third area concerned CA. The workshop recommended that lobbying governments to promote CA as a mainstream activity and securing long-term government commitment to CA would lead to more and sustained uptake of the practice.

The fourth area was on innovation platforms. A study should be conducted to inventory the existing national platforms for maize and legumes, and how they could enhance spillover.

Acronyms

AATF	African Agricultural Technology Foundation
ACIAR	Australian Centre for International Agricultural Research
ACT	African Conservation Tillage Network
AGRA	Alliance for a Green Revolution in Africa
ARC	Agricultural Research Council
ARD	Agricultural research and development
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASWAp	Agriculture sector-wide approach
CAADP	Comprehensive Africa Agriculture Development Programme
CA	Conservation agriculture
CA-SARD	Conservation Agriculture for Sustainable Agriculture and Rural Development
CGIAR	Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
COMESA	Common Market for Eastern and Southern Africa
DFID	Department for International Development, UK
DTMI	Drought-Tolerant Maize Initiative
EAAPP	Eastern Africa Agricultural Productivity Programme
EAC	East African Community
EPRDF	Ethiopian People's Revolutionary Democratic Front
FANR	Natural Resources Directorate
FIPS	Farm Inputs Promotions Africa Ltd
FISP	Farm Input Subsidy Programme
GDP	Gross domestic product
GIS	Geographic information system
GLS	Grey leaf spot
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communication technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Services
M&E	Monitoring and evaluation
MSV	Maize streak virus
NAADS	National Agricultural Advisory Services, Uganda
NARS	National agricultural research system
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organisation
OPV	Open-pollinated variety
PASS	Programme for Africa's Seed Systems, AGRA
PPP	Public–private partnership

PVS	Participatory varietal selection
REC	Regional economic community
RIU	Research Into Use
SACCOS	Savings and credit cooperative societies
SADC	Southern African Development Community
SADC-FANR	Southern African Development Community-Food, Agriculture and Natural Resources Directorate
SARI	Selian Agricultural Research Institute
SARNET	Southern Africa Root and Tuber Network
SG	Sasakawa-Global 2000
SIMLESA	Sustainable Intensification of Maize–Legume cropping systems for food security in Eastern and Southern Africa
SPAM	Spatial production allocation model
SRTM	Shuttle Radar Topographic Mission
TOSCI	Tanzania Official Seed Certification Institute
USAID	United States Agency for International Development
WAAPP	West African Agricultural Productivity Programme
WADEC	Women in Agricultural Development and Environmental Conservation
QDEEDI	Queensland Department of Employment, Economic Development and Innovation

Acknowledgements

This publication reports the results of a study conducted by a team of consultants put together by Triple Line consulting company from UK, which had been contracted by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). Special thanks go to the study team: Rachel Percy for her inputs as team leader and research uptake specialist; Barry Pound who provided inputs related to crop agronomy and was the specialist in research–extension linkages; Alan Mills for his inputs in the specialised area of geographic information systems (GIS); Alexander Phiri, for the work in agro-economics and farming systems; and Daria Dubovitskaya (Dasha) and Alastair Stewart for administrative support to the rest of the team.

The report would not have been possible without the support of several individuals and organisations.

Many thanks to the five SIMLESA national coordinators and their teams for the efforts they made to support the study. In particular, for the way in which they took time to discuss the project with the study team and provide advice on key stakeholders beyond SIMLESA project staff whom the consultants should meet. The assistance the coordinators provided the team in terms of setting up meetings and field visits, and providing supporting documentation is also appreciated. Thanks also go to the International Maize and Wheat Improvement Center (CIMMYT) SIMLESA programme coordinator and objective leaders for meeting with the study team. Special thanks also to all other stakeholders including researchers, farmer groups, seed company staff, staff of various ministries of agriculture across the countries visited, and non-governmental organisation (NGO) staff for creating time to meet and interact with the study team.

Though the team was unable to visit Mozambique, many thanks go to the country coordinator for the wide range of materials he provided in relation to SIMLESA in that country. Much appreciation goes to everyone who gave up their time to join in and actively contribute to the stakeholder validation workshop held in Nairobi from 3 to 4 May 2012.

Last, but not least, many thanks to various ASARECA staff for supporting the implementation of this study. To the Programme Manager, Knowledge Management and Upscaling (KMUS), and her team who provided the study team with timely, helpful and constructive advice at key milestones during the study and to the Procurement and Contracting Officer, for ably facilitating the contracting process for the study.

The funds for the study came from the Australian Centre for International Agricultural Research (ACIAR) and were channelled through CIMMYT, which manages and coordinates the SIMLESA programme.

Part 1

Methodology and desk review

Recommendations

SIMLESA should:

1. Further develop and maintain institutional linkages and coordination with other national, regional and international bodies concerned with CA and maize–legume scaling out and spillover.

2. Enhance SIMLESA knowledge and expertise in innovation platforms.

3. Place greater emphasis on monitoring, documenting and learning lessons on the uptake and adaptation of SIMLESA technologies and the effectiveness of knowledge products.

1 Introduction

1.1 Background

The Sustainable Intensification of Maize–Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) is a multi-stakeholder collaborative research programme managed by the International Maize and Wheat Improvement Center (CIMMYT) and implemented by national agricultural research systems (NARS) in Ethiopia, Kenya, Malawi, Mozambique and Tanzania, with backstopping inputs from other partners. SIMLESA started in 2010 and is due to run through to 2013. The programme focuses on leveraging science and technology to develop and deliver technological and institutional innovations in maize–legume production systems. These innovations are expected to make significant measurable positive changes in the livelihoods of all categories of smallholder farmers. SIMLESA is supported through grants provided by the Australian Centre for International Agricultural Research (ACIAR). The project has five objectives. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is responsible for Objective 4, which focuses on three areas: gender mainstreaming; monitoring and evaluation; and knowledge transfers, and technology spillovers. ASARECA contracted a consulting firm, Triple Line, to conduct a study in the third area of objective 4. This study relates to activity 4.1.3 in the SIMLESA project proposal.

1.2 Objectives of the study

The overall objective of the study was to analyse knowledge transfers and technology spillover focusing on past experiences to come up with lessons, strategies and mechanisms for facilitating scaling out and spillovers. The specific objectives were to:

- Conduct an inventory and document the available maize–legume cropping system technologies, practices and knowledge products that can be scaled out in-country and are transferable from project countries to other relevant countries. This included mapping where the technologies and practices are currently being applied and where else they can be up-scaled.

- Analyse past experiences in scaling out and facilitating spillovers to identify bottlenecks, enabling policy, institutional and biophysical conditions for smooth exchange and spillovers of technologies. This analysis included identifying what works and why, and providing illustrative successful case studies.

- Recommend strategies and mechanisms that can be tested on pilot cases and/or adapted to promote exchange of knowledge and to facilitate technology spillovers.

1.3 Team composition

As agreed between Triple Line and ASARECA, a team of four consultants and two support staff was contracted to carry out this study between 19 January and 11 May 2012. The team comprised:

Rachel Percy[1] , team leader/research uptake specialist
Barry Pound, agronomist/research–extension linkages specialist
Alan Mills, geographic information systems (GIS) specialist
Alexander Phiri, agro-economist/farming systems specialist
Support staff, Daria Dubovitskaya (Dasha) and Alastair Stewart

1.4 Definitions

1.4.1 Technology

The general definition of technology is given in the ASARECA Glossary of Terms (Annex 1 in Volume 2), which was provided with the Terms of Reference (ToRs) for this study. A technology is:

> Any one or combinations of tools, equipment, genetic material and breeds, farming and herding practices, gathering practices, laboratory techniques, models, etc., and the knowledge and skills needed to use them.

In the SIMLESA project, a technology may be simply a new variety, a maize–legume production system, a practice, or a combination of practices such as conservation agriculture (CA). In some cases an innovation such as a package or combination of technologies will also be classed as a technology. An important part of technology definition is the reference to knowledge and skills needed.

1.4.2 Scaling out and spillover

This study examines scaling out and spillover of technologies and knowledge. Scaling out is the spread of a technology and/or knowledge within a country. Spillover refers to spreading of the technology and knowledge across countries, that is, across borders.

A distinction can be made between spillover between the five countries covered by the SIMLESA project (internal spillover) and the spread of SIMLESA technologies and knowledge to new (non-SIMLESA) countries based on demand from those countries (external spillover).

1.5 Country contexts

1.5.1 Kenya

Kenya's economy experienced domestic and external shocks in 2011, dampening growth prospects and reducing gains from higher economic growth and recovery in 2010. High global food prices have contributed to the domestic food crisis, and agricultural policies are also to blame. Despite these shocks, the growth momentum remains strong underpinned by structural reforms, a new constitution and a dynamic private sector.

The Kenya Constitution (2011) is one of the long-term issues that the coalition government committed itself to when it was sworn in on 17 April 2008. This will enable the government to address other long-term issues, including judicial, electoral and land reforms.

[1] Dr Rachel Percy is an employee of the IDL group.

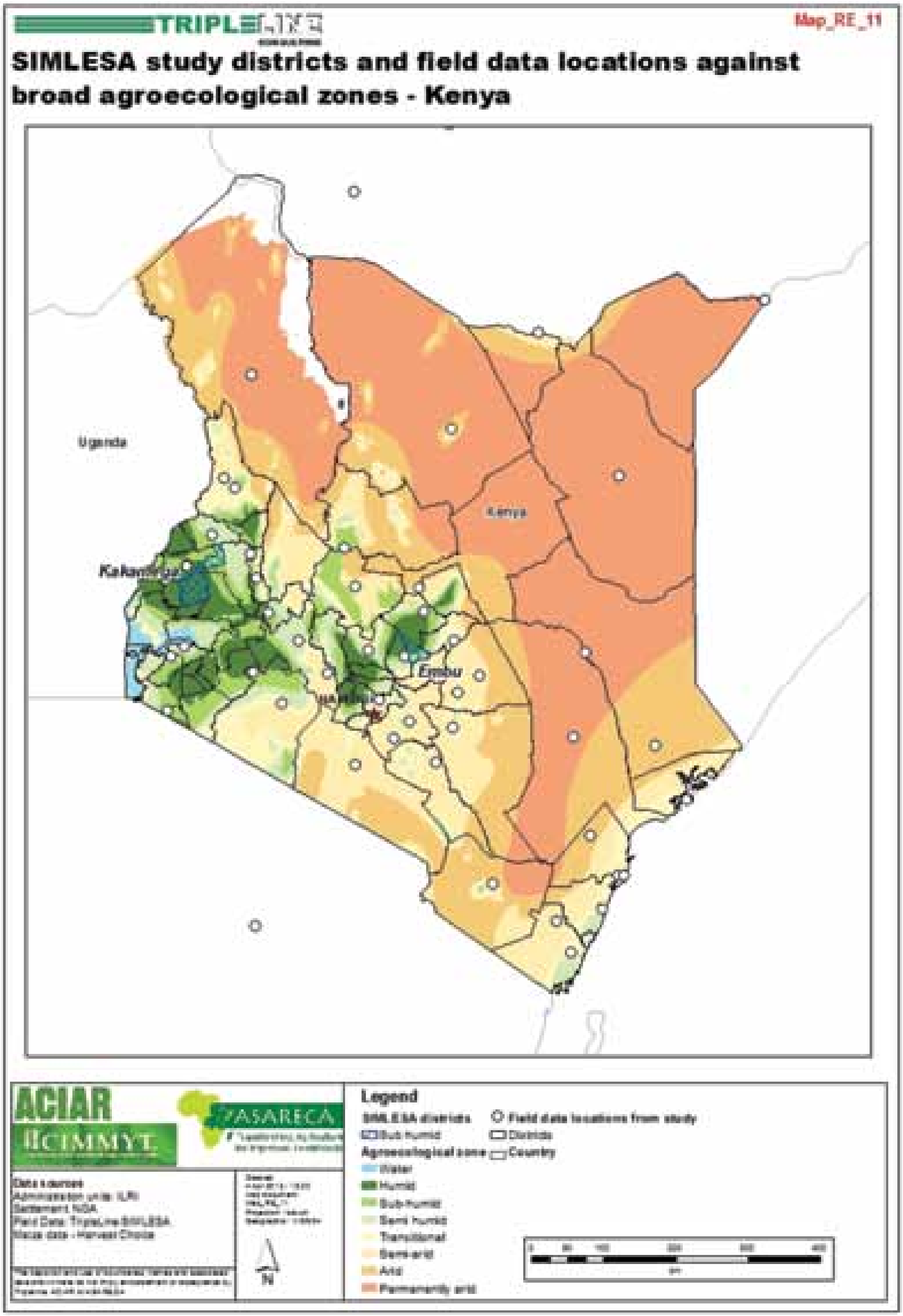


Figure 1.1: SIMLESA districts and agro-ecological zones of Kenya.

Large parts of Kenya have been affected by drought, leaving 3.7 million people in need of food and other aid. The affected population is nearly 10% of Kenya's population (estimated at 40 million), increasing poverty levels and compounding development challenges. Figure 1.1 shows the SIMLESA districts and broad agro-ecological zones in Kenya.

1.5.2 Ethiopia

Ethiopia, with a population of about 82 million, is the second-most populous country in sub-Saharan Africa. In recent years, Ethiopia has been one of the fastest growing economies in Africa. However, the recent surge of inflation depicts the country's vulnerable macroeconomic condition. While Ethiopia's economy is expected to continue to grow at a healthy pace, its macro situation will remain under stress in the foreseeable future.

The current ruling party, the Ethiopian People's Revolutionary Democratic Front (EPRDF), has governed Ethiopia since 1991. Although the formal Ethiopian state structure has been transformed from a highly centralised system to a federal and increasingly decentralised one, several challenges remain. The national elections in 2005 and 2010 and the largely uncontested local elections in April 2008 illustrated the fragility of the democratic transition, the dominance of the EPRDF, and the weakened state of the opposition. The government is already devoting a very high share of its budget to pro-poor programmes and investments. Over the past two decades, significant progress has been recorded in key human development indicators: primary school enrolment has quadrupled; child mortality has been cut by half; and the number of people with access to clean water has more than doubled.

Ethiopia is one of the few countries in sub-Saharan Africa to achieve the Comprehensive Africa Agriculture Development Programme (CAADP) target of 10% of the gross domestic product (GDP) spending on agriculture. Ethiopia is also much less dependent on foreign aid for its agricultural development than most other countries in the region, and has made strenuous efforts to make research more relevant and to expand its agricultural extension system to reach more farmers. Over 40% of GDP comes from farming and some 80% of people are involved in farming. The country has a very varied agro-ecology with several endemic crops, such as teff and enset. Figure 1.2 shows the SIMLESA study districts and broad agro-ecological zones of Ethiopia.

1.5.3 Tanzania

The drivers of growth in Tanzania over the last decade have been mining, construction, communications and the financial sector. Manufacturing, transport and tourism have also posted solid growth rates. Agriculture is the primary economic activity for about 80% of Tanzanian households. The high degree of dependency on this sector renders the economy particularly vulnerable to adverse weather conditions and unfavourable prices in international primary commodity markets. The government is investing a growing share of its budget on agriculture and is encouraging broader commitment to agribusiness development.

The United Republic of Tanzania is among the most politically stable nations in sub-Saharan Africa. The ruling party Chama Cha Mapinduzi has dominated domestic politics since independence. Tanzania is a member of the East African Community (EAC) and of the Southern African Development Community (SADC).

The private sector ranks poor infrastructure, especially insufficient power supply, as the main constraint to growth. Expensive transport and poor roads, particularly in rural areas, block market access and value addition of agricultural products that are needed to increase incomes of smallholders. Unlocking Tanzania's growth potential depends on well-designed and implemented public investment programmes for energy, transport and water. Agricultural productivity is also below its potential; problems include low adoption of improved technologies, high transport costs and lack of adequate market competition.

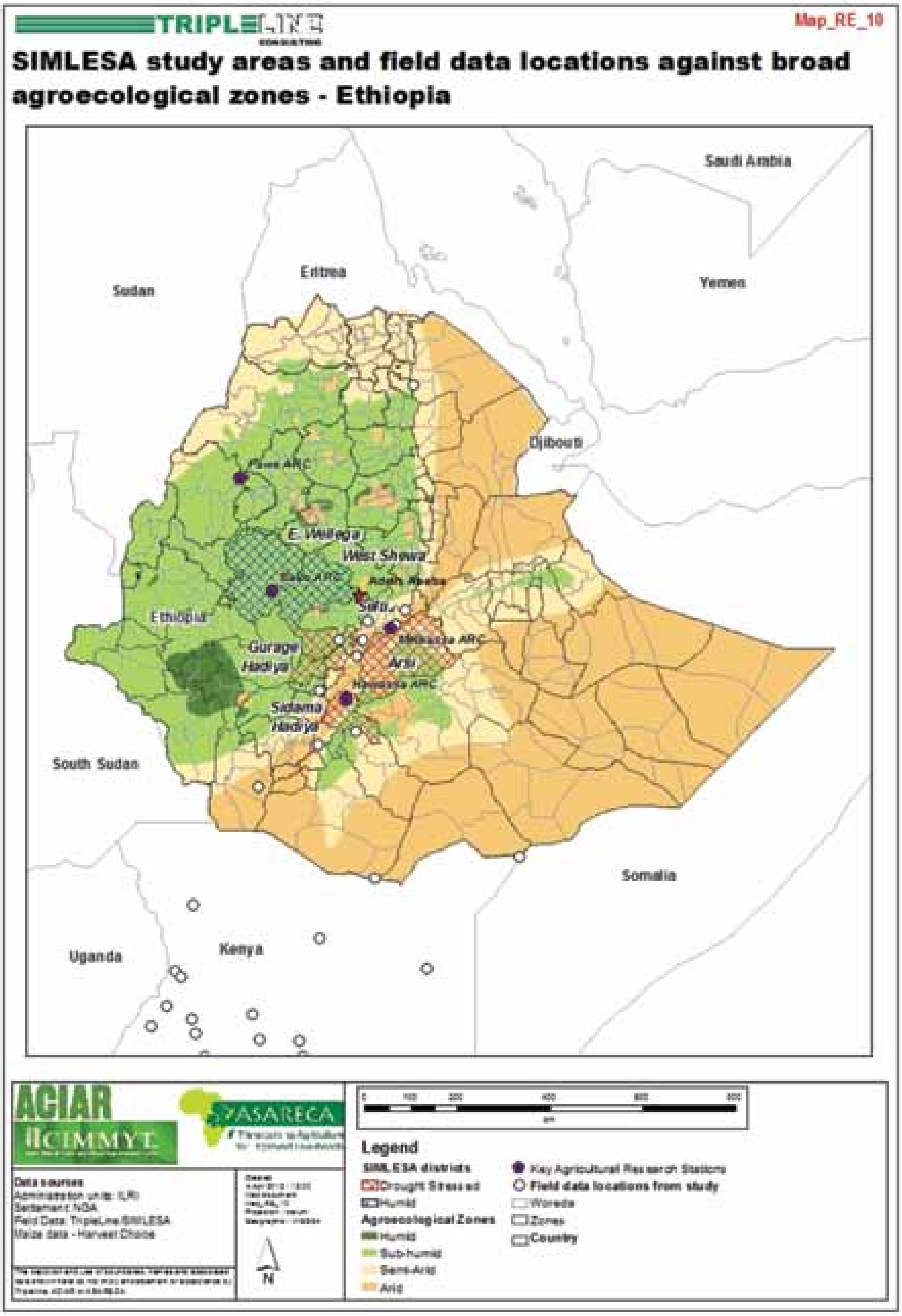


Figure 1.2: SIMLESA districts and key agricultural research stations on agro-ecological zones in Ethiopia.

1.5.4 Malawi

Malawi continues to enjoy uninterrupted solid growth for the fifth year in a row backed by sound economic policies and a supportive donor environment. This growth was supported by several bumper tobacco harvests (USD 472 million in the 2007–2008 season), good weather and availability of fertiliser and seeds through the government's Farm Input Subsidy Programme (FISP). Despite encouraging growth, Malawi continues to face numerous supply-side constraints such as persistent energy constraints and lack of foreign exchange. The economy remains vulnerable to terms of trade, weather and other exogenous shocks.

Malawi has a multiparty system of government that was introduced in 1994; presidential and parliamentary elections are held every five years. The late President Bingu wa Mutharika prioritised agriculture and food security, education, transport, energy generation, rural development, irrigation and water development, youth development and anti-corruption.

Although agriculture contributes 35% of GDP compared with 46% from services and 19% from industry, the sector accounts for more than 80% of Malawi's export earnings and supports 85% of the population. Smallholders contribute over 80% of Malawi's agricultural production. However, due to resource constraints these farmers are more likely to be net buyers than sellers of food. Most farming production systems are dominated by maize, the country's staple food crop. The country's export trade is dominated by tobacco, tea, cotton, coffee, and sugar, but the number of farmers pursuing commercial crop production is still limited, constrained by low productivity.

1.5.5 Mozambique

Mozambique, one of the poorest countries in the world at independence, has emerged from decades of armed conflict to become one of Africa's best-performing economies. This has resulted in more than three million people being lifted out of poverty over the same period. However, poverty reduction has stagnated and growth has not resulted in job creation. In addition, the global food and fuel crises continue to cloud Mozambique's economic outlook. The riots of September 2010, a re-run of the 2008 price hike-related demonstrations, were another reminder of the country's vulnerability to external shocks. They underscore Mozambique's chronic dependence on food imports and the need to stimulate agricultural productivity and rural development in general, given that approximately 70% of the population lives in rural areas.

Sustaining the country's impressive performance over the last two decades will require further investments to expand the country's infrastructure networks, including roads, railways, energy, water and ports. Other major challenges include the need to step up job creation, accelerate and sustain economic growth in an inclusive manner, foster a competitive and diversified productive and export-based economy, and boost production and productivity in labour-intensive sectors with special focus on agriculture.

1.6 Report structure

This report has six chapters. Chapter 2 provides the methodology. A summary of the desk review is provided in Chapter 3, with the full desk review being provided in a separate volume of annexes. Chapter 4 provides the findings of available proven technologies and knowledge products. Chapter 5 provides findings on factors either preventing or enabling the scaling out and spillover of technologies, practices and knowledge within the context of the analytical framework. Chapter 6 provides reflections on gender, the private sector and the process and potential of geo-referencing information systems; conclusions and recommendations for the SIMLESA project itself and at the national policy and institutional levels. Volume 2 contains the annexes.

Mozambique, one of the poorest countries in the world at independence, has emerged from decades of armed conflict to become one of Africa's best-performing economies.

2 Methodology

This section summarises key features of the methodology used for each phase. As use of geo-referencing information systems (GIS) was an integral and important component of this study, detailed information on its use and limitations is provided.

2.1 Phase 1: Inception

The inception phase involved developing the workplan for the study and agreeing on it with the client. It also involved developing the conceptual framework, analytical framework, survey tool and methodology for each phase. Terms of reference for country visits were developed (see Volume 2) and arrangements for visits started in consultation with the SIMLESA country coordinators. Please refer to Volume 2 for details of the methodology including the workplan and original survey tool.

2.2 Phase 2: Desk review

Team members identified potential sources of secondary data, which included peer-reviewed journals and programme reports from international and regional agricultural institutions. In total, 83 documents were identified, of these 50 were reviewed in detail. These references were analysed and notes were made in a 'literature review database', enabling the review to be written by pulling together all references related to certain subject headings. The findings from the desk review identified key conditions for technology and knowledge transfer, and helped increase understanding among the team before the fieldwork stage, and analysis of the fieldwork data. The full desk review is available in Volume 2, and the key points are presented in Chapter 3 of Volume 1.

2.3 Phase 3: Fieldwork

Fieldwork took place between 11 February and 16 March 2012. Week-long visits were made to Kenya, Ethiopia, Tanzania and Malawi. Schedules for all field visits, including the itineraries and details of who the team met with are available in Volume 2.

The first country visit was to Kenya where the methodology was piloted. As a result of this piloting the survey tool was revised, as were the formats for data entry. The revised survey tool is in Volume 2.The team decided to use Microsoft Access rather than Excel for data entry, as this would allow for more refined data searches during the analysis phase. Three different forms were designed: one for general project information, one for all aspects concerning SIMLESA Objective 2 (conservation agriculture practices), and one for all aspects concerning SIMLESA Objective 3 (varieties). Findings on scaling out, spillover, the private sector, economic analysis and gender were mainstreamed into the Access formats for Objectives 2 and 3.

Budgetary and time constraints meant that the team could not visit Mozambique. However, the SIMLESA team there sent the Triple Line consultancy team useful information, which the team analysed.
The consultancy team either met with or corresponded with the SIMLESA country coordinator before or shortly after departure from each country. At this stage preliminary findings were shared, discussed

and validated. Areas where information was missing were identified and efforts were made to secure that information in due course.

The team met with SIMLESA objective leaders, government officials, extension staff, NGO staff, seed company staff, participating farmers and other relevant stakeholders in each country to get their perspectives on the technologies being promoted and on the factors enabling or constraining scaling out and spillover.

Field reports were prepared for team use only. These were shared with the respective country coordinators for review and comment. The team used these field reports to carry out an initial analysis of findings to submit to ASARECA as a PowerPoint presentation. The ASARECA Programme Manager for Knowledge Management & Upscaling, Lydia Kimenye, presented these findings during the 2nd SIMLESA annual partners' and programme steering committee review meeting on 20 March 2012.

2.4 Phase 4: Data analysis

Detailed data analysis took place from 19 March to 13 April 2012. At the start of this phase a draft report structure was shared with ASARECA and agreed upon. Data analysis and mapping of findings using GIS took place in parallel: maps were prepared in relation to key findings that could be spatially located.

2.5 Phase 5: Reporting and validation

The last phase of the study involved presenting the key findings at a stakeholder validation workshop organised by ASARECA in Nairobi from 3 to 4 May 2012. Participants included SIMLESA coordinators and country leaders for Objectives 2 and 3 from all five countries, the SIMLESA CIMMYT coordinator and Objective 2 leader, key stakeholders from Uganda, Rwanda and South Sudan, which are among the potential spillover countries, and representatives of ASARECA.

Following the stakeholder validation workshop the team revised the draft report in line with the outcomes of the validation workshop and detailed comments by ASARECA and Triple Line on the draft report.

2.6 GIS mapping and modelling

In this project GIS has been used in two ways: 1) to look at the spatial distribution of factors from the existing maize–legume cropping systems as picked up by field work and literature; and 2) to identify potential areas for spillover based on those factors using existing GIS data of sufficient quality covering all SIMLESA countries.

2.6.1 Mapping of existing factors

Method

For the existing factors, data retrieved from the field and literature desk review were entered in MS Access databases. For both sets of data those records with geographical references were extracted. These references sometimes related to specific locations (e.g. villages or agricultural regions), in others to administrative areas (e.g. districts, woreda, provinces and regions), non-administrative areas (e.g. rift valley) or entire countries. Mapping these data at country level was not particularly useful as it provides little detail on the spread of factors. Mention that a practice or knowledge product was used in a particular administrative area did not necessarily mean blanket coverage in the area.

Where geographical references were found, the latitude and longitude of the locations (or, in the case of administrative areas, the central point) were documented in the database. In many cases geographical references were not available; these were often where a strategic overview was being given, when a particular approach was being studied (e.g. the effectiveness of women's groups) or the technique or approach was seen as universally applicable.

The narrative text in the database, which was broadly reported from interviews or written references, precluded direct categorisation and quantification of factors. Pre-analysis was therefore necessary. A list was created of important parameters—techniques, biophysical characteristics, varieties and products—and the database entries were searched for evidence of each parameter including, where possible, whether the reference was shown to be enabling spillover or acting as a barrier.

Database queries could then be constructed in Access combining the geographical locations with the basic reference information (interviewee, major category of practice or product) and the parameters extracted as described above. The data were then exported from the database into a GIS-ready format and symbolised in mapping to show patterns. Multiple factors (e.g. CA practices or knowledge products) were in use at the same locations, which meant that mapping often had to group these together to show meaningful and clear distributions without obscuring important information.

Note that despite the design of the questionnaire asking for geographical locations, few specific locations were obtained in the interviews. Therefore the results are focused on a very limited set of points.

2.6.2 Other data sources

A summary of the major data sources is given in Table 2.1.

Besides literature review and field interview databases, other ancillary data were obtained through data searches online and through requests by the field team or by email. Their purpose was either to provide background information on the map, or to be used to analyse factors that might inform potential spillover areas. Topographical data sets were obtained containing coastlines, elevation from the US National Aeronautic and Space Agency (NASA) Shuttle Radar Topography Mission (SRTM), administrative districts from a wide variety of sources.

Cropping and market data were obtained from several institutes that have extensive GIS such as the International Livestock Research Institute (ILRI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); extensive data from the recently published, extremely useful Harvest Choice website, and the 2002 Maize Atlas of Africa. Of the ILRI data sets, most were national, in different formats and used different methodologies (e.g. land use and rainfall statistics) and it was difficult to get blanket coverage for a particular factor or to compare across countries. However, regional data sets on rainfall, altitude and soil types were available.

2.6.3 Modelling for spillover methods

The study used two approaches. One approach identified the existing known ranges of crops and combined them to find out where potential intercropping might be easiest to spillover or scale out. The underlying assumptions were that if these crops are currently grown in these areas then the biophysical parameters are already more suitable. Where a tradition of growing these crops already exists (separately or intercropped already), the communities might be better equipped and more likely to adopt techniques and new varieties associated with those crop types.

Table 2.1: Summary of major data sources

Data set	Source	Reference	Detail	Notes
Soils	FAO	http://www.fao.org/geonetwork/srv/en/metadata.show?id=29031&currTab=simple	Map of major soil types according to FAO classification scheme	Have simplified to the major groups (e.g. Vertisols) and identified acidity based on web searches
Altitude	SRTM (Shuttle Radar Topography Mission)	http://www2.jpl.nasa.gov/srtm/	Elevation raster data set, 90 m horizontal resolution 20 cm vertical resolution, vertical error +/- 16 m maximum	
Various: topographic, agro-ecological and settlement	International Livestock Research Institute	http://www.ilri.org/gis/	Administrative, agro-ecological, livestock, cropping data, soils and geology, settlements	Some of the data were useful but most related to project work which had limited geographical range or not relevant to maize–legume intercropping
Rainfall	CIMMYT	DP Hodson, E Martínez-Romero, JW White, JD Corbett, and M Bänziger. 2002. Africa Maize Research Atlas Version 3.0. http://www.cimmyt.org/en/services/geographic-information-systems/resources/maize-research-atlas	Average annual rainfall totals (mm)	While it is acknowledged that average rainfall amounts change significantly, this was seen as a useful surrogate for general rainfall regimes
Settlement	National Geospatial Intelligence Agency (NGIA)	Geonames server at http://earth-info.nga.mil/gns/html/	All place names kept by US government including administration, features and settlements	Used to identify place names locations in study
Place names	Getlatlon	Simon Willison, http://www.getlatlon.com/	Site to obtain latitude and longitudes of place names	Used to identify place name locations in study
SPAM crop distribution data	http://mapspam.info/	L You, Z Guo, J Koo, W Ojo, K Sebastian, MT Tenorio, S Wood, U Wood-Sichra. Spatial Production Allocation Model (SPAM) 2000 Version 3 Release 1. http://MapSPAM.info	Data derived from the Harvest Choice data sets	http://harvestchoice.org/

From the Harvest Choice website, in particular the SPAM (Spatial Production Allocation Model), a vast database has been created of many crops showing their distribution. Time precluded extensive use of all the data sets available but they included distributions of crops for low rainfed areas, high rainfed, irrigated areas, total production and harvested area estimates. Unfortunately, close examination of the data revealed that not all were complete (often whole countries excluded), or some data did not have quantitative amounts available for the supposed parameter being mapped (e.g. groundnut). Despite this, there is massive potential for the use of these data.

The approach used in this exercise was to take the mapped extent of harvested areas (ha) of two crops (one always maize) and intersect the two. Since the data were raster images of 10-km cells, the value in each feature related to the estimated harvested area within each 10-km cell; a measure of the intensity of production of that crop in each area. The data were prepared from raster to vector[2] format to aid the intersection, the zero areas were eliminated from the data sets and the two data sets intersected. This meant that all the attributes from each data set were combined, and by multiplying the area of each crop in each 10-km cell an indication of the amount of overlap (called an index in this case) was produced. The result is not a quantitative measure of the total area, but allows a hotspot map to be produced showing low to high intensity of overlap of crops in 10-km cells, which could prove useful in identifying areas where potential spillover techniques related to these crops would be more easily implemented.

The second approach allowed the use of data sets with biophysical data to obtain areas where certain growing regimes might exist, with the aim to be used to identify suitable potential spillover areas for combinations of crops.

The large number of varieties and parameters that can influence scaling up and spillover preclude detailed modelling of each given the timescales and regional scope of this project. However, it is clear that biophysically, many combinations of cropping suit ranges of altitude, rainfall and soil types. A simple model combining average rainfall regimes, altitude ranges and general soil type acidity was used (Figure 2.1), integrating the data in ArcGIS. Note the model below disregards some pre-processing steps such as converting raster (pixellated) data to vector formats and clipping the extent of the study to the SIMLESA focus and spillover countries.

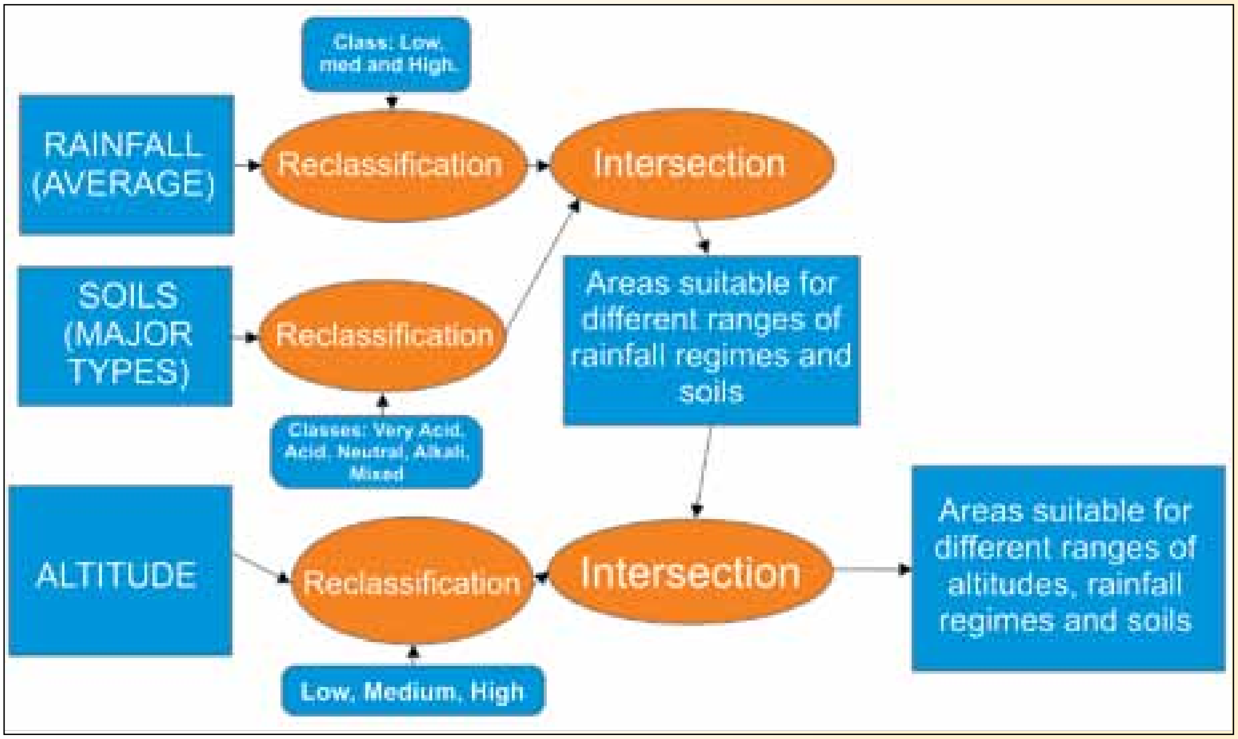


Figure 2.1: A simplified GIS model for identifying potentially suitable lands for varieties.

[2] Raster–GIS data represented by a (usually rectangular) grid of cells and a known origin location and scale or resolution where values stored relate to some parameter. Vectors are GIS data represented by a sequence of x,y Cartesian coordinates as points, lines or polygons and values are stored in an associated attribute table.

The reclassification was conducted given available data in the field database on regimes suitable for different varieties. For soils, research from the World Reference Base for Soil Resources (http://www.isric.nl/isric/webdocs/ docs/major_soils_of_the_world/set9/int_set9.pdf) allowed a rudimentary classification of acidity (see Table 2.2), although it should be appreciated that classifying major soil groups into broad pH categories will miss subtleties in soil types and local conditions.

In many cases a 'mixed' class was use to denote soils that could be of any pH dependent on parent material. For rainfall, the data were average annual rainfall derived from a model developed by CIMMYT (Hodson et al. 2002) and was the most complete rainfall data set obtained in the data search.

Table 2.2: Reclassification of major soil types into general acidity classes

Soil type	Acidity class
Acrisols	Acid
Aeronosols	Mixed
Andosols	Mixed
Cambisols	Acid
Ferralsoils	Acid
Fluvisols	Mixed
Gleysols	Mixed
Greyzems	None
Histosols	Very acid
Kastaznozems	Alkali
Luvisols	Mixed
Nitosols	Very acid
Phaeozems	Acid
Planosols	Very acid
Podzols	Very acid
Podzoluvisols	None
Rankers	None
Regosols	Mixed
Rendzinas	Alkali
Solonchaks	Alkali
Solonetz	Alkaline
Vertisols	Neutral
Xerosols	Acid
Yermosols	Mixed

Given the wide array of crop needs, often dependent on intensity and length of rainy seasons, it was difficult to pick a universally useful indicator of rainfall, so average overall annual rainfall was used and then partly arbitrary thresholds were set of 500 mm and 1000 mm and used to discriminate between low, medium and high rainfall regimes.

Altitude data are easier to model as the relation between crops and altitude is generally linear but again arbitrary thresholds were set to discriminate between 'low' (<750 m), 'medium' (up to 1500 m) and 'high' (>1500 m) altitude regimes.

These thresholds should not be interpreted as a definitive cut-off for suitability of cropping. Crops will often grow, but poorly in sub-optimal conditions, and also local factors (e.g. aspect) may enhance yields despite other factors being sub-optimal. This modelling does not include many other parameters that are important to cropping due to lack of data and the level of sophistication possible within the project timeframe and scope. These could be macro factors such as soil types (soil horizons might be more important than generalised pH), degree days, temperature regimes, or micro factors that include aspect, slope, shelter, microclimate, local soil and improvement methods.

Different parameters depend on each other and the interrelationships of some of these factors may mean that characterisation of one factor would help explain the implications of other factors. For example, the use of altitude as a parameter can be a surrogate for both temperature regimes and length of growing season.

Social and economic GIS data were not obtainable for the whole region, and many of the searches yielded data that would not be a sufficiently useful surrogate for those factors needed. For example, data on market access for dairy products in Kenya are available from the International Livestock Research Institute (ILRI). However, because the locations of production and usage are different from those for maize, and because the perishable nature of the dairy products, the data are not sufficiently similar to those for maize and legumes to be appropriate in this modelling. General population density and total mapping were also deemed not useful as a surrogate for market access as a much more complex model of supply and demand would need to be developed and tested before it could be combined with the agro-ecological data.

Figure 2.2 shows locations where, based on the literature reviewed, specific geographical references could be obtained. The reference to geographical locations in the literature review identified that there were concentrations of research and development in some areas (e.g. western Kenya and Malawi) and other maize-growing areas have fewer references (see Figure 2.2) such as in Tanzania. This may suggest a bias in outputs that favour conditions in these literature-rich areas.

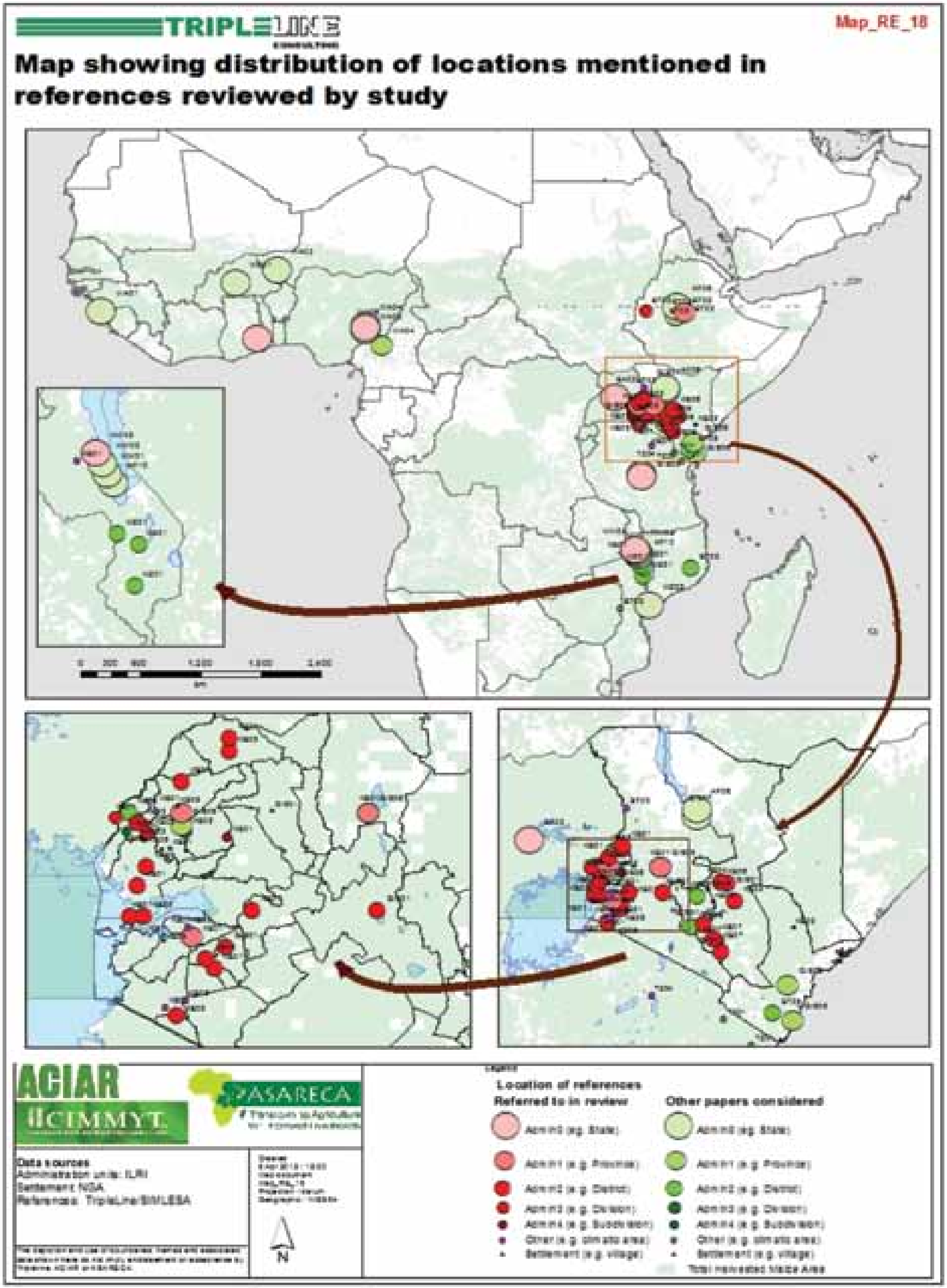
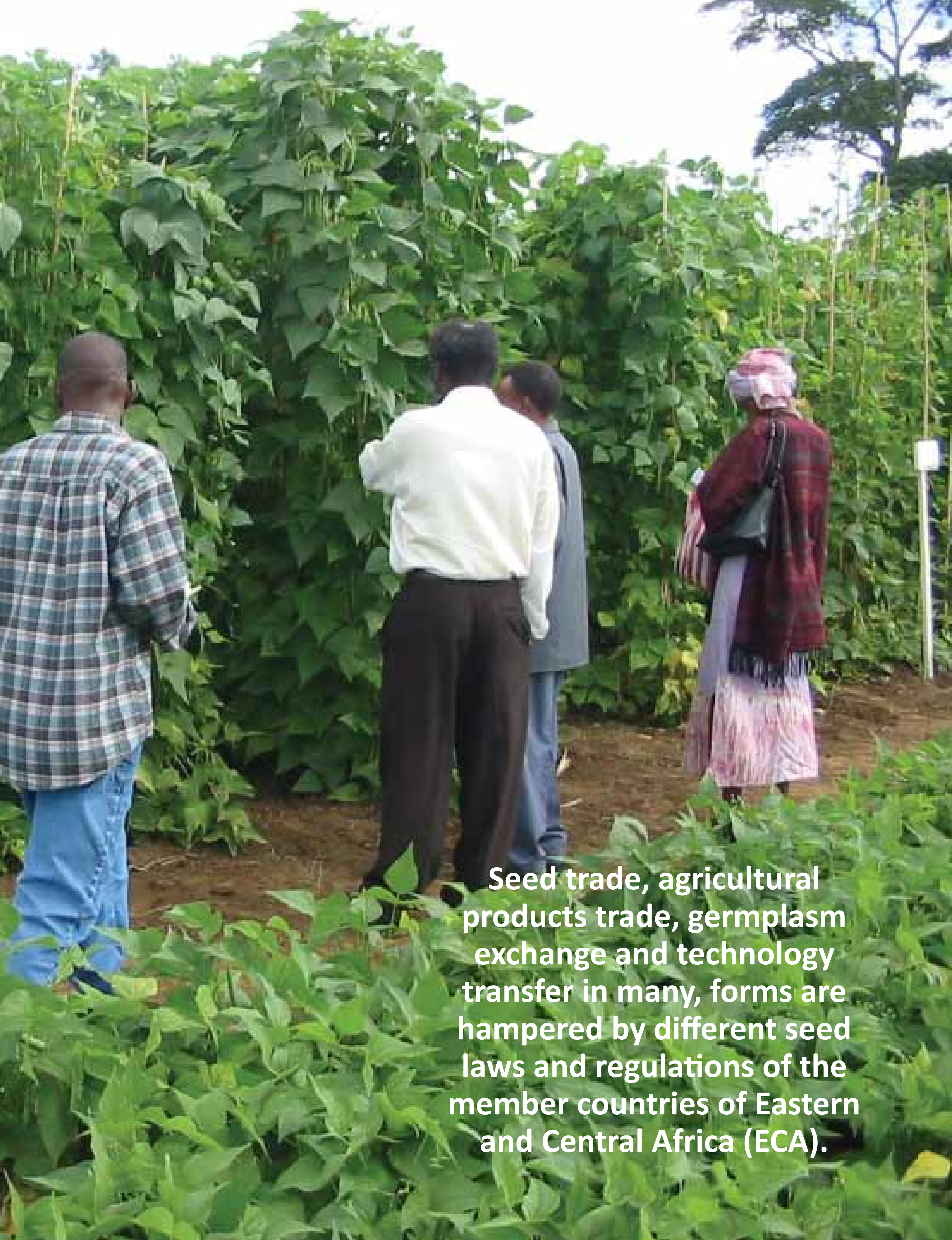


Figure 2.2: Locations mentioned in the literature reviewed where specific geographical references could be obtained.


Crop
Variety
Planting date
Spacing
Seedrate kg/acre



Seed trade, agricultural products trade, germplasm exchange and technology transfer in many, forms are hampered by different seed laws and regulations of the member countries of Eastern and Central Africa (ECA).

3 Summary of desk review

The literature review was critical for the preliminary gathering of information about available proven technologies and knowledge products, and for reviewing secondary information on past experiences and conditions that have enabled knowledge and technology transfer and spillover within the region and elsewhere. Findings from the desk review were used to inform the survey tool used during the fieldwork and to analyse the findings from the fieldwork.

3.1 Political conditions affecting technology and knowledge scaling out

3.1.1 Agricultural investment

The reduction in donor assistance for African agriculture during the 1990s has been attributed to frustration with the poor performance of donor-financed agricultural programmes, the perception that state interventions in agricultural markets were serving the interests of ruling elites, the low priority afforded to agriculture by African governments (Jayne et al. 2010) and the impact of structural adjustment programmes.

Recently, however, African governments have committed to increase public investment in agriculture to a minimum of 10% of their national budgets, through CAADP. By 2008, Burkina Faso, Ethiopia, Ghana, Guinea, Malawi, Mali, Niger and Senegal had exceeded this target. CAADP also has an agricultural growth target of 6% that 10 countries have exceeded: Angola, Burkina Faso, Eritrea, Ethiopia, the Gambia, Guinea-Bissau, Nigeria, Republic of the Congo, Senegal and Tanzania (NEPAD 2010). An issue facing agricultural research and extension is that any benefits of increased investment are likely to accrue in the long term, which contradicts many governments' needs for short-term impacts.

3.1.2 Seed policies and harmonisation

The high costs incurred to meet the different standards and regulations for genetic materials in different countries, and the relatively low demand for improved seed varieties make it difficult for local and international seed companies to make the investments required to provide the quantity, quality and variety of seed needed to support an expanding agricultural base (Minde et al. 2006). Seed trade, agricultural products trade, germplasm exchange and technology transfer in many, forms are hampered by different seed laws and regulations of the member countries of Eastern and Central Africa (ECA). The harmonisation of seed policies among Kenya, Tanzania and Uganda, and now being adopted by other countries, is expected to accelerate trade not only in the ASARECA countries but also throughout the Common Market for Eastern and Southern Africa (COMESA) region (Kirkby et al. 2011). Harmonising policies and regulations will encourage the flow of seed across national boundaries, leading to increased availability and choice of seeds for farmers.

In Kenya, the passing of the Biosafety Bill has contributed to an enabling environment for transgenics to be introduced into the country (Brooks et al. 2009). Ethiopia's Plan for accelerated and sustained development to end poverty and Malawi's Farm Input Subsidy Programme have led to smallholder farmers increased access to improved seed, fertiliser, small-scale water-harvesting systems, market liberalisation and export promotion (Sanchez et al. 2009).

3.1.3 Political will

The Sasakawa Global 2000 high-input maize technologies project in Ethiopia, Malawi and Mozambique was more successful in Ethiopia for several reasons. One reason was due to the country's president taking a personal interest in the high-profile scheme, leading to the formation of a new extension programme (see Case study 1).

Another example of how political will enables change is from Zimbabwe. In 2010 the Zimbabwe Government allocated a budget for the next three years specifically for CA: the practice is now included in the annual National Crop and Livestock Assessment; a module on CA has been launched in colleges delivering the diploma in agriculture; and the government's extension department (AGRITEX) has set up CA demonstrations across the country. The implementation of CA within the mainstream agricultural development and extension services will have important positive consequences for upscaling CA practices (Thiombiana 2009).

Case study 1: Farmer training centres and demonstration farms in Ethiopia

The Ethiopian Government has already established the largest agricultural extension system in sub-Saharan Africa, which is the third largest agricultural extension system in the world after China and India. Currently, Ethiopia has about 45,000 development agents, and the government plans to increase this number to over 60,000 field extension workers. Ethiopia is pursuing an innovative extension model of cost-sharing with local farmers. First, to establish a farmer training centre at the local government (kebele) level, local farmers have to agree to donate 1–2.5 ha of community land near the kebele headquarters to establish a farmer training centre, including a demonstration farm. Then, the national government will help finance and develop the FTC by constructing a small classroom-office building, simple housing for development agents (currently there are three development agents assigned to each farmer training centre) and other capital improvements such as livestock buildings. Again, the farmers jointly finance these building costs by donating their labour for free to construct the farmer training centre buildings. The current strategy being pursued by some innovative development agents is to develop their demonstration farms not only as demonstration units, but also to use them as revenue-generating units to help cover the operational costs of each farmer training centre.

Source: Swanson et al. (2010).

3.1.4 Land tenure

Farmers without ownership rights to the land they are using lack the incentive to invest in the long-term productivity of the land. Land and soil conservation techniques used in CA require permanent practice and deliver long-term benefits (Thiombiana 2009); mulching is viable only when property rights over residual crop biomass are observed and tenure is secure (Erenstein 2003). Such technologies may not appeal to smallholder farmers who are uncertain of using the same land in the future, so new technologies need to provide instant results if they are to be successfully scaled out to landless farmers.

3.1.5 Consistency of policy

CA is a long-term land-use philosophy rather than a technology. It requires support over a minimum of 10 years and a widely spread, cohesive effort as illustrated for Zimbabwe (see Section 3.1.3). This means that both donors and government need to have a consistent approach that includes CA, and for continuity to be assured even when fashions change and there is temptation to go down the high input, quick-fix route.

3.2 Institutional conditions affecting technology and knowledge scaling out

3.2.1 Extension services

Extension services have evolved over recent decades from a linear scientist to extension worker to farmer model through participatory bottom–up approaches, approaches that support teaching–learning processes among farming men and women (Swanson and Rajalahti 2010) and public–private partnerships in extension delivery. Extension approaches vary according to a nation's development goal: achieving national food security, improving rural livelihoods, or improving natural resource management.

According to Swanson and Rajalahti (2010:11):

> During the second half of the 20th century the primary agricultural development goal of most developing countries was food security. Due in large part to the Green Revolution and public extension's focus on technology transfer, many nations actually achieved national food security by the end of the 20th century. As a result government support for both agricultural research and extension institutions began to decline, with a direct long-term impact on agricultural productivity growth.

Governments and donors alike are emphasising innovative, market-driven extension approaches. These are consistent with the agricultural innovation system's framework, which is the basis for this study's analytical framework. Under this extension approach, the growing market for, usually, high-value products, controls specific innovations that can be successfully taken up by different farming households.

In relation to this many NGOs, and donors such as the UK Department for International Development (DFID), the International Fund for Agricultural Development (IFAD), the Dutch Agency SNV and the SIMLESA project itself, seek to establish innovation platforms. These platforms bring together key players from across a particular value chain.

While in the past there was a strong focus on public sector extension provision, these days extension provision is far more pluralistic, with various combinations of government, NGO and private sector participation. Many governments and donors are interested in supporting such pluralistic services and are exploring various ways in which public–private partnerships can be established for effective extension and agricultural innovation.

Uganda's National Agricultural Advisory Services (NAADS) is an example of an attempt, at a national level, to shift to private sector provision of extension services, funded largely by public (government/donor) sources. Although NAADS has departed somewhat from its original vision, evaluations of the first phase of its operation indicated that it had substantial positive impacts on the availability and quality of advisory services provided to farmers (IFPRI 2007, ITAD 2008).

Farmers have different information needs depending on the stage of technology introduction; these needs range from weather forecasts, inputs, improved cultivation practices, pest and disease management, and prices (Aker 2010). Negatu et al. (1999) found that recommendations from extension agencies are often inconsistent with farmers' objectives and decision criteria, leading to slow or non adoption. Extension services must therefore identify the information needs and preferences of the target farmers before attempting to promote new practices.

Effectiveness of extension services is also dependent on extension staff; much of the literature cites problems with motivation and accountability. Effectiveness is also influenced by the technological information passed on to field level extension staff, with contradictory advice reducing effectiveness.

The remote locations where field staff work also contribute to problems in extension effectiveness due to high costs of transport to rural areas, limited geographical scale, and issues of verifying performance indicators such as number of training sessions and attendees (Aker 2010). Precise verification of indicators is necessary as the lack of reliable evidence on the impact of agricultural extension exacerbates funding problems (Aker 2010).

Besides face-to-face extension, technology transfer can be facilitated through the use of information and communication technologies (ICT). Radio programmes addressing agricultural topics are an effective way of targeting a large area, and are accessible to non-literate farmers. Mobile phones can also be used to exchange information (see Case study 2).

Case study 2: ICTs for increased access to agricultural information

ShujaazFM is one example of using ICT to generate interest and access to agricultural messages. Developed by Well Told Story, a Nairobi-based communications company, the project targets young farmers in Kenya through a free monthly comic book distributed nationally, daily FM radio and television programmes and interactive SMS. Investment in June 2010 led to circulation of the comic book growing to 600,000 copies per month with an anticipated readership of 12 million (RIU 2011). Each edition contains agricultural stories that are seasonal and relevant around the country. Examples of previous topics include vaccination of chickens, new and improved maize varieties, seed priming and conservation tillage.

Source: RIU (2011).

3.2.2 Farmer organisation and interaction

Working social networks generate collective action and it is important to develop bonding social capital among farmers with common interest, bridge social capital with markets and businesses, and link social capital with multi-level institutions (Foresight 2011). Participation in farmer groups brings advantages for group members such as developing linkages with input suppliers, improving their competitive position in the marketplace with buyers, and reducing production and marketing costs (Legg 2006). It is easier for extension workers to visit farmer groups than to visit individuals spread over a large area. Participation in local groups provides opportunities for interactive learning about new innovations and technologies (see Case study 3). Smith et al. (2001) comment that the success of such groups "has been characterised by experience, education and links gained outside of the community context ... benefiting from government, donor and NGO infrastructural investment." However, until farmers are organised into producer groups, many extension personnel will continue to work with high-resource farmers and as Farrington et al. (2002) wrote:

> Despite hopes that producers' organisations will contribute to poverty alleviation, little has been done to draw poorer farmers into cooperative arrangements from which they can benefit through greater economies of scale, bargaining power and a stronger voice.

The World Bank (2008) explains that producer organisations have expanded rapidly in developing countries, but they continue to be challenged by the set-up of value chains and global market forces. The challenge for the organisations is how to respond; for governments and donors it is how to assist without undermining the organisations' autonomy (World Bank 2008).

3.2.3 Multi-stakeholder approach

Public–private partnerships (PPP) are receiving increased attention, allowing technology transfer and advisory services to become increasingly privatised as agriculture sectors develop (Swanson et al.

2010). In central Malawi, extension staff have worked with NGOs and private companies to review paprika varieties and develop better crop advice for farmers. These PPPs allowed extensive training of smallholders in the techniques of producing high-quality paprika, and reduced risks for smallholders entering new markets (Snapp et al. 2003).

Case study 3:Farmer field schools for CA in Tanzania

The Conservation Agriculture for Sustainable Agriculture and Rural Development (CA SARD) project was implemented in northern Tanzania by the Food and Agriculture Organization of the United Nations (FAO), the German Technical Cooperation (GTZ) and the Selian Agricultural Research Institute (SARI) in 2004. The project trained extension workers in CA concepts and farmer field school methodology, and they later became farmer field school facilitators. The project trained farmers on how to apply CA technologies/practices and assisted with CA equipment: subsoilers, rippers, jab planters, direct planters and zam-wipes. The farmer field school groups also received 10 kg of seed maize, 8 kg of lablab and a 1-litre bottle of Round up (glyphosate). Each group tested several farming techniques on a shared 1-acre plot of land such as CA practices and farmers' normal practice; ploughing twice and then planting maize intercropped with pigeon, pea, beans and pumpkin. The plots were monitored by farmer field school members; farmers used their own experience and observations to make decisions on how to manage the crop. Records were kept of the type of work done, number of people per operation, time taken per operation, type of inputs, quantities/rates and cost, and farmers held a field day before harvesting to show other farmers in the community what had been achieved. Key elements that led to the success of the intervention included proper group formation leading to sustainable and stable groups, in-depth problem analysis by farmers themselves, and a participatory learning process resulting in farmer-led facilitators who were proactive in spreading CA technology to other farmers.

Source: Owenya et al. (2011).

SIMLESA is using a multi-stakeholder approach to establish innovation platforms. Innovation platforms were earlier introduced by the IFAD, DFID and other agencies. Innovation platforms bring together all value chain stakeholders at national and/or local levels to identify weaknesses or barriers in the value chain and address them to the benefit of all stakeholders. These weaknesses or barriers may relate to supplying technologies and knowledge or demanding them (see Case study 4). Innovation platforms recognise that bringing about agricultural innovation and development is a complex and multi-stakeholder activity, rather than a linear approach of research via extension to farmers.

Case study 4: Legume seed supply system in Malawi

Problems in accessing seed of legume crops at planting times have contributed to very low productivity in the grain–legume subsector. Increased productivity is possible if farmers can access sufficient quantities of seed of desirable improved varieties. The role of Research Into Use (RIU) in this initiative was to: (1) facilitate the bringing together of all stakeholders in the legumes subsector value chain to allow synergies to develop that build communication and business practices; (2) coordinate the unblocking of identified bottlenecks; and (3) empower farmer groups through training, enabling them to become effective partners of the legumes platform. Part of this training included seed production techniques for beans, soya bean and groundnut. This arrangement enhanced communication and direct interaction between researchers and farmers. Private sector companies have shown increased interest as platform issues are in line with business interests of seed multiplication. It is expected that 28 tonnes of legume seed of new released varieties will be produced benefiting around 7000 farmers by 2011.

Source: Moyo (2010).

3.3 Ecological and biophysical conditions affecting technology and knowledge scaling out

3.3.1 Agro-ecological zones

Köppen-Geiger's map of climate types for Africa (Figure 3.1)shows that out of the five main climate types, three are present in Africa: the dominant climate type by land area is arid (57.2%), next is tropical (31%) and temperate (11.8%) (Peel et al. 2007). The high diversity of agro-ecological zones across Africa requires adaptive testing and substantial modification of promising varieties, which can be a factor in limiting technology diffusion and returns to research and development (Brooks et al. 2009, Lybbet et al. 2012). Farmers are often experimental when it comes to adapting technologies to local agro-ecological conditions (Frankea et al. 2006) and the application of response farming encourages farmers to make tactical adjustments in cropping based on the amount of rainfall that is expected and the actual amount received during the year.

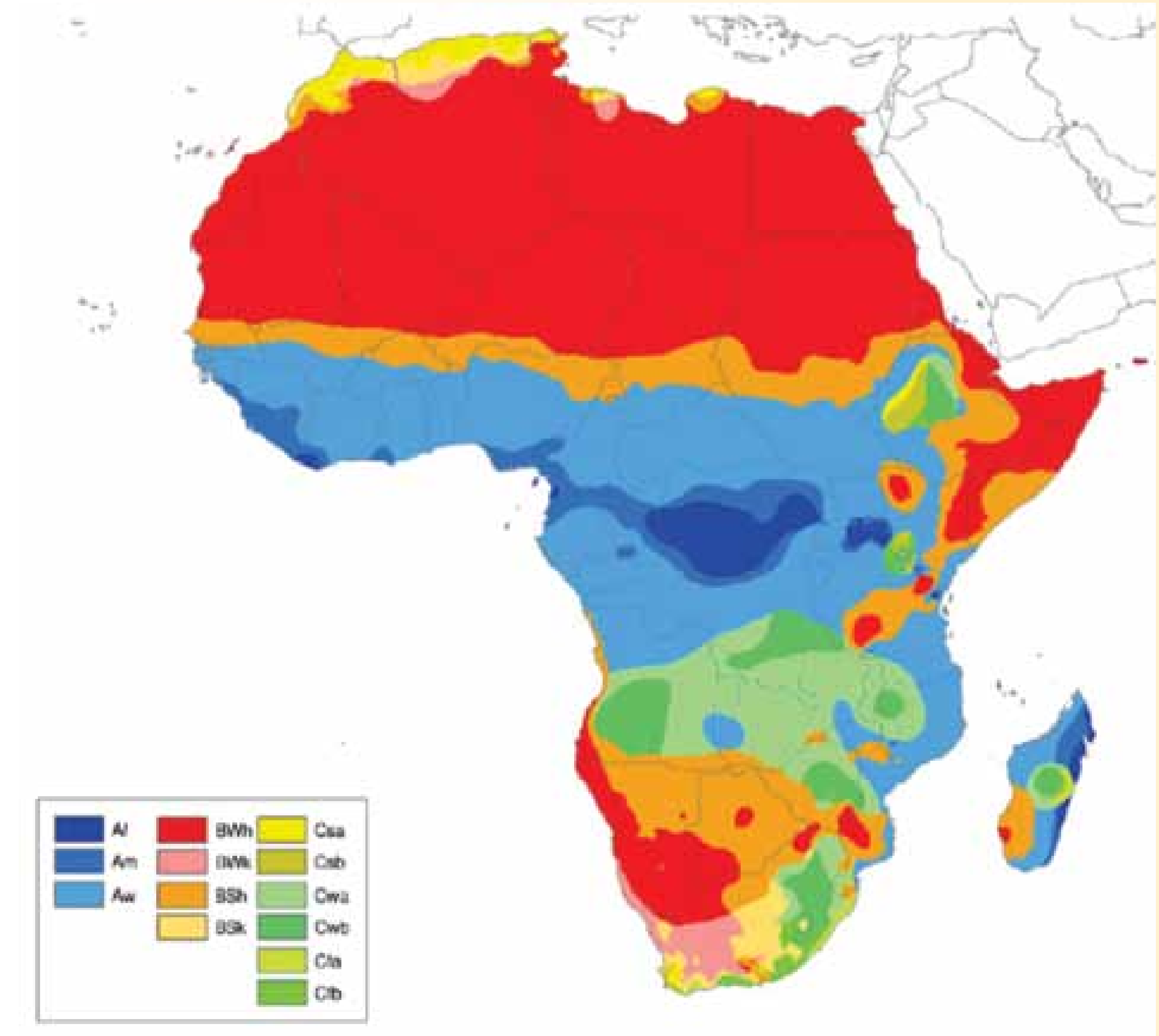
3.3.2 Land and soil degradation

Visible soil degradation and related declining yields can act as a catalyst for farmers to invest in appropriate technologies. Fowler et al. (2001) found that adoption of CA was more successful where farmers could see the effects of erosion and where they could expect a short-term economic gain. Erenstein (2003) saw increased adoption of CA in areas with poor soil fertility, a long potential growing season, low biomass weathering rates and substantial crop residue production. However, implementing technologies that fail to address problems of soil degradation can result in wasting financial and labour resources of smallholder farmers who may have invested in inputs such as fertiliser, but whose benefits are lost through continued erosion.

3.4 Social and human conditions affecting scaling out of technology and knowledge

3.4.1 Gender

Researchers, policy makers and academics often cite the importance of focusing agricultural development strategies in Africa on female smallholder farmers. However, no evidence exists that extension is specifically targeted to women, rather gender is an area that is still not addressed adequately by many external agencies and is under-represented in research and governance systems (Foresight 2011). There is a need to ensure that dissemination materials and inputs are suitable for women as well as men (Adolf et al. 2010) and that extension services place importance on using female extension workers to communicate messages to women smallholder farmers (Swanson 2008).



Code	Agro-ecological zone	Code	Agro-ecological zone
Af	Tropical rainforest	Csa	Temperate—dry/hot summer
Am	Tropical monsoon	Csb	Temperate—dry/warm summer
Aw	Tropical savannah	Cwa	Temperate—dry winter, hot summer
BWh	Arid desert, hot	Cwb	Temperate—dry winter/ Warm Summer
BWk	Arid desert, cold	Cta	Temperate—without dry season, hot summer
BSh	Arid steppe, hot	Cfb	Temperate—without dry season, warm summer
BSk	Arid steppe, cold		

Figure 3.1: Köppen-Geiger's map of climate types for Africa.

Female smallholder farmers involved in CA farmer field schools in northern Tanzania were keen to implement CA on their land once they had access to jab-planters, which enabled them to perform three tasks in one. The process of digging a hole, planting seed (perhaps applying fertiliser) and covering the hole was reduced to one activity with the aid of the jab planter. This reduced the time needed for planting, a task that is traditionally left to women, leading to increased adoption among women smallholder farmers who owned plots of land that were too small to make use of animal-drawn direct-seeders.

3.4.2 Labour

Two major factors leading to labour constraints in subsistence farming are HIV and migration. HIV and AIDS contribute to a diminished workforce through inability of sick farmers to work, and uses up time of farmers who are caring for the sick and their children. When time is a scarce resource, activities of apparent lesser importance are dropped including tasks related to soil fertility management (Misiko 2008). Low productivity and low returns of smallholder agriculture also lead to many able-bodied men leaving farms in search of more lucrative off-farm opportunities, thus contributing to labour shortages in the smallholder farming sector. New technologies therefore need to take into consideration the time constraints and labour shortages faced by many farmers. Onerous activities are unlikely to facilitate widespread adoption and any increased demands on labour should be justified through visible, beneficial and quick results.

3.5 Economic and market conditions affecting scaling out of technology and knowledge

3.5.1 Market access and development

Access to markets is essential if subsistence farmers are to be convinced to increase production to the levels required to transition to commercial farming, which can create positive change in the socio-economic conditions of smallholder farmers in sub-Saharan Africa (AATF 2010). For this change to be achieved, market infrastructure must be developed to reduce the high transport costs incurred in areas with poor quality roads (Howard et al. 2003) and increase farmers' interest in selling cash crops (Negatu et al. 1999).

Besides difficulties in physical access to markets, barriers exist in accessing finances related to the costs of entry into agricultural markets. Cadot et al. (2006) estimated the costs of entering markets for smallholder farmers in Madagascar as being 124–153% of subsistence farmers' annual production, highlighting the importance of increasing production, improving rural transport services and infrastructure, and providing credit access for smallholder farmers. Insufficient financial services for smallholder farmers are seen as a major barrier to purchasing and accessing equipment, seed, fertiliser and pesticides. Jayne et al. (2010) write:

> There appears to be a vicious cycle in which low surplus production constrains the development of markets, which in turn constrains smallholders' ability to use productive farm technologies in a sustainable manner, reinforcing semi-subsistence agriculture. Crop production expansion is difficult to sustain in the face of highly inelastic product demand, which causes precipitous price plunges when local markets are unable to absorb surplus output. Such price drops are believed to be a major cause of subsequent farm dis-adoption of improved technology.

Snapp et al. (2003) also identify price risk as a barrier to scaling out technologies. Farmers are often unable to recoup costs when they sell surplus crops immediately after harvesting when prices drop due to increased availability on the market. Farmers' perceptions are important in adoption; these perceptions are influenced by their resources and risk estimation (Negatu et al. 1999).

3.5.2 Input availability and affordability

Providing inputs when promoting new technologies can have a decisive impact on the success of scaling out. However, this comes at a high cost for the stakeholder providing the inputs and raises questions on the sustainability of the technology. The Sasakawa Global 2000 high-input maize technology project in Ethiopia provided inputs—hybrid seed and fertiliser; the farmer paid 25% of costs upfront and the remaining 75% at harvest. This scenario worked well in Ethiopia but in Mozambique where a similar project was implemented, repayment terms on credit were unclear and led to farmers defaulting (Howard et al. 2003).

3.6 Conclusion

From the review of literature, it is apparent several conditions are necessary to create an enabling environment for scaling out and for spillover. These conditions are summarised in Table 3.1; the findings are split into political, institutional, ecological, social and economic conditions, and highlights if the condition is an enabling factor or a bottleneck to widespread technology diffusion and adoption.

The factors in Table 3.1 can be applied to scaling out and spillover. However, although all of these factors are important for scaling out, only some of these influence spillover across countries. Specific conditions drawn from Table 3.1 that influence spillover are in Table 3.2.

These enabling factors and bottlenecks can be categorised into six areas:

- Investment in agriculture
- Increasing role of regional bodies and organisations
- Monitoring and evaluation of regional bodies and organisations
- Seed policies and distribution
- Private sector involvement
- Gender targeting.

3.6.1 Investment in agriculture

Increased and sustained agricultural investment from governments will help to ensure the political focus on the importance of building a productive agriculture sector in African countries. With this taking place in the context of the continent-wide CAADP framework, opportunities for exchanging experiences and lesson learning between countries are enhanced.

3.6.2 Increasing role of regional bodies and organisations

Regional agencies developing cross-national or regional approaches and policies will help to ensure regional harmonisation and improve the flow of technologies across borders. In this context ASARECA, the Southern African Development Community Food, Agriculture and Natural Resources Directorate (SADC-FANR) and the regional economic communities (RECs) such as COMESA and EAC, all have an important role as do multinational seed companies and agro-chemical providers.

3.6.3 Monitoring and evaluation of technology and knowledge transfer

Through improved monitoring of the impacts of technology and knowledge transfer approaches, the future design of strategies for out-scaling and spillover will draw on previous successes and failures. Being aware of strategies that work well in particular areas will help to target approaches in specific agro-ecological conditions or with particular groups of farmers. Monitoring and evaluation and impact assessments should therefore be built into all projects at the early stages of project formulation to ensure there is adequate baseline data for comparison. Results from impact assessments should be made available on a regional scale to facilitate planning of projects that enable spillover.

Table 3.1: Conditions that enable or act as bottlenecks to scaling out and spillover of agricultural technologies

	Enabling factors, conditions, requirements and mechanisms	Bottlenecks, barriers and unfavourable conditions
Political conditions	• Investment from governments and/or donors • Regional harmonisation of seed policies • Policies for technologies mainstreamed across government departments • Interest shown from political figures • Security of land tenure	• Reduction in donor assistance • National seed regulation and testing procedures • National phytosanitary regulations • Lack of political will • Lack of land rights • Conflict in the region
Institutional conditions	• Timeliness of information provided to farmers • Policies placing extension within the poverty reduction agenda • Improved monitoring of agricultural extension impacts • Access to information through mobile telephony and radio • Involvement in farmer groups	• Recommendations from extension agencies inconsistent with farmers' objectives • Conflicting advice given to farmers • Low motivation and accountability of extension staff • Networks not encouraged • Exclusion of the private sector
Ecological and biophysical conditions	• Adaptive testing and substantial modification of promising varieties to differing agro-ecological zones • Farmers adapting technologies themselves • Awareness of soil degradation • Adoption best in areas of high potential	• 'One-size-fits-all' or magic bullet approach to technology diffusion
Social and human conditions	• Use of female extension workers to target women farmers • Disseminating materials and inputs suitable for women • Time-saving agricultural technologies	• Women under-represented in research and governance systems • Women ignored by external agencies • HIV and AIDS affecting labour requirements • Migration depleting farm workforce
Economic and market conditions	• Improved interest from farmers in selling cash crops • Access to credit and financial services • Input provision alongside advice and technical support	• High transport costs due to poor rural roads • Price plunges when local markets are unable to absorb surplus output • Shortage or inaccessibility of seeds

Table 3.2: Conditions that enable or act as bottlenecks specifically to spillover of agricultural technologies

Main enabling factors for spillover of agricultural technologies across national borders:
• Investment from governments and/or donors
• Improved monitoring of agricultural extension impacts
• Regional harmonisation of seed policies
• Adaptive testing and substantial modification of promising varieties to differing agro-ecological zones
• Reduced donor assistance
• National seed regulation and testing procedures
• Shortage or inaccessibility of seeds
• Exclusion of the private sector
• 'One-size-fits-all' or magic bullet approach to technology diffusion
• Women under-represented in research and governance systems

3.6.4 Seed policies and distribution

Parameters concerning seed include regional harmonisation of seed policies, regulations and testing procedures; adaptive testing and substantial modification of promising varieties to differing agro-ecological zones; and improved access and availability of seeds. Governments should maintain sovereignty of their regulations and should not be collared into adapting policies under pressure from corporations with interests in seed distribution. Regional harmonisation of seed policies will increase the flow of seeds and other planting material across borders and improve availability and uptake of improved seed varieties.

3.6.5 Private sector involvement

The private sector's involvement in agricultural technology schemes has resulted in success stories, such as increasing demand for products, facilitating technology uptake, raising market awareness of smallholder farmers, and meeting the financial constraints of agricultural programmes. Private–public partnerships are an opportunity to combine expertise and knowledge from two sectors and an approach to cost-sharing. For these reasons, future designs of cross-country/regional programmes should not exclude the private sector.

The private sector is seen as an important part of the innovation platform. Research on private sector involvement in SIMLESA shows the sector has a role in providing inputs, disseminating technology and providing crop insurance. A key area for the private sector is in the production, multiplication, marketing and distribution of seed (Case study 5). Seed availability depends on numerous factors; research shows that demand and profit are important incentives for the private sector to become involved.

Case study 5: Private sector involvement in scaling out chilli production in Kenya

Mace Foods is a private limited company (Kenyan–Italian–German joint venture) that started in 2002, with its headquarters in Eldoret, Kenya. Mace Foods Europe Ltd. located in Wuppertal, Germany, handles all sales and marketing activities. Given this European Union (EU) connection, Mace Foods has rapidly increased its production, processing and export of chilli powder and other dried horticultural products to Germany, Italy, and other European countries. To expand its exports, it has steadily increased its production base. Before scaling up, Mace Foods had only two extension agents who were providing advisory services to a small group of farmers. To expand production, Mace needed an additional 1000 farmers who could produce chillies to EU standards.

The United States Agency for International Development (USAID)-funded Kenya Horticulture Development Programme (KHDP) provided a full-time extension specialist and agreed to cost-share the salaries of 20 additional agricultural technicians who, starting in 2004, were trained in the recommended production techniques. This specialist worked closely with each technician for one year and KHDP paid 50% of each technician's salary. At the end of this training phase, Mace Foods assumed the full cost of these technicians. During this one-year start-up phase, 1,000 selected farmers were organised into producer groups and trained and integrated into the Mace supplier programme. By 2008, a total of 5000 Kenyan farmers were producing chillies and other dried horticultural export products for these EU markets. KHDP also worked closely with the Kenya Seed Company to develop a sustainable source of hybrid seed for the chilli variety required by Mace Foods Europe. Kenya Seed is now the commercial supplier of this seed to Mace Foods.

Source: Swanson et al. (2010).

3.6.6 Gender targeting

Under-representation of women in research and governance systems at national and international levels can lead to the lack of focus on women-targeted extension and agricultural programmes. Policy makers are aware of the need for women-friendly agricultural technologies, but the literature shows this is far from being achieved. Through increased gender mainstreaming and female presence in national and regional organisations there will be a resulting shift in focus to provide technology and knowledge transfer approaches that appeal to and are viable for women smallholder farmers.

Part 2

Technologies, knowledge products and extension approaches

4 Findings on technologies and knowledge products

4.1 Available proven technologies

This section discusses available proven technologies and their current geographic spread across the five SIMLESA countries, and potential areas for scaling out and spillover. The section is divided into two sub-sections: 1) discussion of CA practices; and 2) discussion of maize and legume varieties. The discussion of these technologies focuses on:

- CA practices: 1) the principles of CA and the minimum packages by SIMLESA countries; 2) current practices in the various countries; 3) complementary practices to CA by country; 4) main issues in promoting CA in the various SIMLESA countries; and 5) justification for scaling out and for spillover.
- Maize and legume varieties: 1) a description of the technology or innovation; 2) the problem it aims to address or its key characteristics; 3) areas in the sub-region where the technology or innovation has been promoted; 4) similar agro-ecologies or countries where it could be applicable; and 5) justification for scaling out and spillover.

4.1.1 Conservation agriculture practices

Conservation agriculture is defined as:

> ...a resource-saving agricultural crop production practice that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. It is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to absolute minimum and the use of external inputs such as agrochemicals and nutrients of mineral or organic sources are applied at an optimal level and in a way and quantity that does not interfere with, or disturb the biological processes (Mloza-Banda 2011).

From this definition, three principles of CA emerge:

- Continuous minimum mechanical soil disturbance—seeding directly into untilled soil and keeping soil disturbance from cultural operations to the minimum possible.
- Permanent organic soil cover—maintaining year-round organic matter cover over the soil, including the use of specially introduced crops and intercrops and/or mulch provided by retained residues from the previous crop.
- Diversified crop rotations, sequences and associations adapted to local environmental conditions including appropriate nitrogen-fixing legumes and biodiversity above and in the soil to contribute nitrogen to the soil–plant system and help avoid the build-up of pest populations.

The translation of CA that has been adopted by the National Task Force on Conservation Agriculture in Malawi illustrates clearly what the practice is meant to achieve in the soil–plant system. The task force translates CA as *'ulimi wa mleranthaka'*, literally 'farming that aims at nursing or nurturing the land'. This definition clearly distinguishes CA from other resource-conserving technologies. Another local name for CA is *'ulimi wa mbwezera nthaka'*, which means 'farming that reverts soil quality'.

The distinction between CA and other soil and water conservation technologies is that CA emphasises the synergies of the various components of the system that provide conditions for minimum soil disturbance, maximum soil cover, effective weed and pest management, and crop rotation and mixes both in space and time.

All the five SIMLESA countries reported using the minimum package of CA practices—minimum soil disturbance; crop residue retention for soil cover; and crop mixes which are either in rotation or intercropped with legumes. The following discussion briefly describes each of these practices. The aim is to explain current practices in the various countries; highlight some complementary practices to the CA common package of practices; point out the main issues with respect to CA as a practice or technology; and provide the justification for their scaling out and spillover.

All five SIMLESA countries reported the common package CA as practised in their demonstration sites. However, within and across each of these countries, reports indicated that at the farm level adoption of the specific CA practices was partial based on the socio-economic situation. These findings are summarised from reported statements.

No-tillage or minimum soil disturbance

No-tillage or minimum soil disturbance involves no or limited disturbance to the soil through ploughing or making ridges before planting crops. It entails seeding directly into untilled soil, and keeping soil disturbance from cultural operations to the minimum possible. Making ridges or ploughing the soil is not only labour and energy/fuel intensive, but also leads to loosening of soil particles, rendering them more susceptible to water or wind erosion, and loss of organic matter.

The practice has been promoted in the SIMLESA countries as it is the pivotal component of CA. While these countries demonstrate the practice through the project, its promotion within each country by government and other practitioners in the sector varies. In Malawi for example, CA has become one of the key components of the agricultural strategy for the country within the framework of the agriculture sector-wide approach (ASWAp), and is widely promoted in all the agro-ecologies. In contrast, in Tanzania the practice is only gaining ground through the SIMLESA project. Additionally, some variations were also reported in the application of the practice. For example, in Kenya and Ethiopia ridge and furrow were also reported in line with minimum tillage practice but were not a common practice. Planting maize with *Desmodium* was also reported under minimum tillage in Kenya.

To conform to minimum soil disturbance, complementary practices such as hand weeding or use of herbicides[3] for weed management, direct seeding using a jab planter or a dibble stick are also adopted. However, the main problem highlighted with direct seeding is that the jab planters are not well adapted to clay soils. It is not only difficult to use jab planters to drill holes and drop the seed but they are also not properly calibrated to drop only one seed, which is the common practice introduced through the

[3] Discussed in more detail in later sections since it is a major component of the practice.

Sasakawa Global 2000 project and also widely adopted by the SIMLESA project. Jab planters clog in such soils. In similar soil types where light weeding is carried out instead of using herbicides, it has also been reported that it is quite difficult to carry out such husbandry practices. Hence, this study recommends that CA-based farm equipment be modified for wider adaptation based on soil types.

Because of its strong soil conserving aspects, major savings on labour through no-till or making of ridges and its contribution to suppressing *Striga asiatica*, the no-tillage practice significantly contributes to improving the livelihoods of the farming households. CA is a valuable practice that needs to be scaled out to all farming communities in the SIMLESA countries as well as spilled over to those that are currently not involved in the project. However, the practice requires that other soil conservation practices be adopted as necessary. For example, soil/water conservation practices such as planting vetiver grass are required on moderate to steep slopes of farm land (see Plate 4.1) to complement the practice.

Plate 4.1: Fields of groundnut and maize on sloping land under CA. The land is protected by vetiver grass planted on contours to reduce runoff through the field. These plots belong to one of the TLC host farmers in Chidzuma Section, Mvera EPA in Dowa District, Malawi.

As much as no-tillage could contribute significantly to improving the livelihoods of the farming households, there is need to assess for how long soil can remain undisturbed under no-till. It is strongly believed that after several years, a hardpan develops that must be broken, otherwise crop development could be suppressed significantly over time. During the stakeholder validation workshop, participants were divided on this issue and the debate was not conclusive, thus it necessitates more exploration.

Soil cover with crop residues

With soil cover with crop residues farmers spread the residue on to the field after harvesting crops. Hence, it is an addition to minimum disturbance of the soil. The crop residue is left on the field until the onset of the rains when planting stations are made and seeds planted. Maize stover is the most common crop residue used.[4] The practice aims to conserve moisture during the rainy season mainly to protect the crop from moisture stress during dry spells. In addition, the practice also aims to improve soil fertility through increased microbial activity resulting in decomposition of the crop residue, which adds soil nutrients, reducing demand for inorganic fertiliser. The practice also reduces fluctuations in

[4] However, common grass has also been used where maize stover has either been burnt or been used to cure tobacco nurser beds.

Plate 4.2: Mrs Christina Chalendewa, Chiwiri Section, Mitundu EPA, Lilongwe, Malawi, on one of her maize plots under no-till and soil cover with crop residues. Maize stover from the previous season can still be seen in the field.

soil temperature, for more sustainable crop development. Soil cover with crop residue also results in reduced soil erosion by holding rainwater runoff and increasing water infiltration into the soil. The overall effect is that soil moisture is retained and fertility enhanced.

This practice has been promoted in the SIMLESA countries on different scales within each country. The main challenges with the practice are: 1) competition for crop residues as livestock feed is most serious in pastoral areas such as in much of Ethiopia; maize stover is used to cure tobacco nursery beds (Malawi) and to thatch houses, and for firewood (Ethiopia and Malawi); 2) termite infestation which also damage growing crops (Mozambique and Kenya); 3) build-up of pests, e.g. crickets and maize stalk borer; and iv) planting in fields with crop residues is cumbersome and may also hinder seed germination.

In view of the potential benefits that have been reported, it is justifiable to scale out the practice within each country and to facilitate spillover to other countries.

To address some of the challenges associated with crop residue cover, the practice should be accompanied by other parallel measures where crop residues have competing uses. For example, in pastoral zones where the residues are also needed as livestock feed, pastures should be established particularly in the wet lands (*dambos*). Where maize stover is used for curing tobacco nursery beds, use of low-cost materials should be explored that would have the same impact. In areas where free-grazing of livestock is practised, change to restricted or zero-grazing practices may be necessary.

Maize–legume intercropping

Maize–legume intercropping is an example of the various practices in the third component of the CA. This component involves diversified crop rotations, sequences and associations adapted to local environmental conditions. In this practice, maize is grown in association with legumes. The practice involves planting one row of maize followed by a row of the legume mainly where pigeon pea or lablab are used as a legume. Where the common bean (*Phaseolus sp.*) is intercropped with maize, beans are planted in between or close to maize planting stations where climbing bean varieties are used. The practice aims to address declining soil fertility and the inability of most smallholder farmers to solve it through applying inorganic fertilisers due to cash constraints and limited or no access to credit to purchase these inputs.

Plate 4.3: Maize intercropped with pigeon pea, Tanzania.

Grain legumes have the ability to capture atmospheric nitrogen and fix it into the soil, hence contribute to soil fertility improvement. Most grain legumes that are used as intercrops with maize are a cheap source of protein, and contribute to household nutrition. Finally, grain legumes such as beans and pigeon pea are sold for cash and contribute to household income and poverty reduction. When the varieties and husbandry practices are chosen well, intercropping provides significantly greater total yield per unit area than growing the two crops separately.

The practice has been reported in the SIMLESA countries in varying degrees, but it is mainly used in land-constrained areas. Where land is abundant, maize–legume rotations are more appropriate. The most commonly reported legume that was intercropped with maize was pigeon pea (variety ICEAP 00040). Intercropping with Phaseolus bean was also reported in Kenya and Ethiopia. Due to high demand by the farmers, beans are also going to be incorporated in the demonstrations in Malawi during the 2012/2013 cropping season.

The practice could be scaled out to most land-constrained zones suitable for growing legumes such as pigeon pea, and maize. However, where appropriate herbicides such as Harness are not available, light weeding is done under no-tillage conditions. In Tanzania light weeding is done in plots where pigeon pea is intercropped with maize, and an appropriate herbicide is lacking. In harder soils (soils with a lot of clay) light weeding was difficult to carry out since the soils were not tilled before planting.

Maize–legume rotations

Maize–legume rotation is another practice in the third component of the CA principles together with maize–legume intercropping. In maize–legume rotation, a legume is grown in the plot where maize was grown in the previous season. In a legume–maize rotation, maize is grown in the plot where a legume was grown in the previous season. This means that maize and legumes are grown on a piece of land in succession. The practice is followed for the same reasons as under the intercropping system discussed above. However, this practice is most suitable for farmers with relatively large pieces of land.

Crop rotations like intercropping have been used in the SIMLESA countries in varying degrees over the years. The innovation is largely because the rotations are now introduced under CA and are considered as one of the practices under CA. The practice can be scaled out within these countries or spilled over to other countries without major problems. The crucial factor to consider in promoting crop rotation is the average landholdings of the farmers being targeted. The most common legumes used in rotation with maize are groundnut (regardless of the variety) and soybean. Groundnut was reported only in Malawi while soybean was reported in the rest of the SIMLESA countries.

Use of herbicides

Herbicides are used as a weed control measure to complement no-till or minimum soil disturbance. Herbicides are usually sprayed within three days after the first rains. If seed is planted immediately after the first rains, herbicides are sprayed within three days. The effect of the herbicide is to render the weed seeds dormant (estimated to be for about 90 days). Any weeds that grow in the field during the cropping season are hand weeded. The most commonly recommended herbicides reported in four of the SIMLESA countries visited are Round-up (Glyphosate) and Harness (Metalachlor or Acetalachlor). Harness is recommended over Bullet (Acetochlor) in maize fields intercropped with legumes. This is because Bullet is not selective and therefore also suppresses germination of the legume seeds where they are intercropped with maize. Harness was not reported in Tanzania; light weeding with a hoe is used in plots where maize is intercropped with legumes such as pigeon pea.

Herbicides were reported in all the four countries and are common in all the zones where CA is being promoted. In Malawi, herbicides have been widely used even by farmers who still make ridges. Ridges are used mainly to control weeds, and are not considered part of the full CA package. Herbicides can easily be scaled out or spilled over to all the zones where maize and other cereal crops are grown. However, herbicides are easily washed away by rain and therefore have a limited impact on weed control on steep slopes.

Herbicides save labour mainly in the years subsequent to its adoption. In the first year, investing in a knapsack sprayer could be a major cost for poor households. However, in subsequent years major cost savings could be made. In Tanzania, for example, 1 litre of Round-up costs about TZS 18,000 (USD 11.25) and only 2 litres are required per hectare making a total cost of TZS 36,000 (USD 22.50) per hectare. If the same piece of land were weeded using a hoe, the cost would be about TZS 60,000 (USD 37.50). The practice is also appropriate for labour-constrained households such as female-headed, elderly and frequently ill households. The benefits to the farmer strongly justify the need for herbicide use to be scaled-out within each of the SIMLESA countries and spilled over to other countries as a weed-control practice. However, there is a need to carry out an assessment of the long-term impacts of continuous use of herbicides on soil quality and the environment.

Pit planting

Pit planting involves digging pits into which seed is planted. It is adopted as a complementary practice to minimum soil disturbance. The recommended size of pits is 25 cm by 30 cm by 20 cm deep. Four maize seeds are planted in each pit by putting one seed in each corner of the pit. Currently, it is not recommended to plant in other crops such as beans or pigeon pea in the pit. This practice was only reported in Malawi. The practice has also been widely promoted in Mozambique, Zambia and Zimbabwe under the African Challenge Programme.

The practice is mainly used as a water-harvesting measure and is most appropriate for semi-arid or drier areas with low rainfall. Adopting the practice in high rainfall areas results in water logging which affects crop growth, particularly maize.

The current erratic rainfall patterns particularly affect the already drier zones in Eastern and Southern Africa. Pit planting could therefore be scaled out or spilled over to such dry zones to improve crop production even during dry spells.

In most countries, due to population pressure, fields have been cultivated for many years. Soil nutrients have been lost and productivity is low. Farmers need to apply inorganic fertilisers but they cannot afford them. This trend will continue for many years to come. CA could help improve soil fertility without using large amounts of inorganic fertiliser. The practice also conserves soil nutrients and water and gradually increases soil fertility. However, CA is not universally adaptable. Minimum soil disturbance, crop rotations or intercrops may not be applicable for all different ecological zones. Therefore CA needs to be adapted depending on the area. Some farming systems require tilling the soil, making ridges and adopting other soil conservation measures. For example, soils on steep slopes may require ridges across the slope and marker ridges planted with vetiver grass as CA cannot hold the running water.

CA is most suitable for arid and semi-arid regions. With erratic rainfall and frequent droughts due to the effects of climate change, CA could have wider application than in the traditionally dry or semi-arid zones of the sub-region. Figure 4.1 shows the geographical distribution of some CA practices.

Summary

The main problems of farming in sub-Saharan Africa are soil fertility decline and degradation and the increasingly erratic rainfall pattern. CA, coupled with crop rotation or intercropping with legumes, tackles these problems and the high cost of production through reduced input costs and labour. Trials being conducted in the five SIMLESA countries are showing promising results. Partial budgets showed that in the Awassa area (Ethiopia) the profit from intercropping maize and beans was greater than for sole crops or rotations of maize and beans or farmers own practices (Table 4.1). Similar results have been observed in the other countries. Table 4.2 provides a summary of conservation agriculture packages and practices in the SIMLESA countries.

Table 4.1: Partial budget analysis for on-farm conservation agriculture

	Treatments					Farmer's practice M + HB	
	Sole maize	HB after maize	Sole HB	M + HB			
				M	HB	M	HB
Average yield (t/ha)	6.27	5.71	1.28	5.88	0.89	4.74	0.21
Field price of grain (USD/t)	282.06	282.06	338.48	282.06	338.48	282.06	338.48
Adjusted yield (t/ha)				29,380+	5,340	23,700	1,284
Gross field benefit (USD)	1,783.7	1,610.54	7,680		433.24		1,409.38
Total cost that vary (USD)	138.11	138.11	108.24		160.94		98.28
Net benefit (USD)	509.64	1,488.45	329.32		1,817.22		1,325.2

Where M = maize variety BH-543; HB = haricot bean variety Awassa Dume.

Source: One season result for 10 m × 10 m trial at Hawassa Zuriya, Ethiopia.

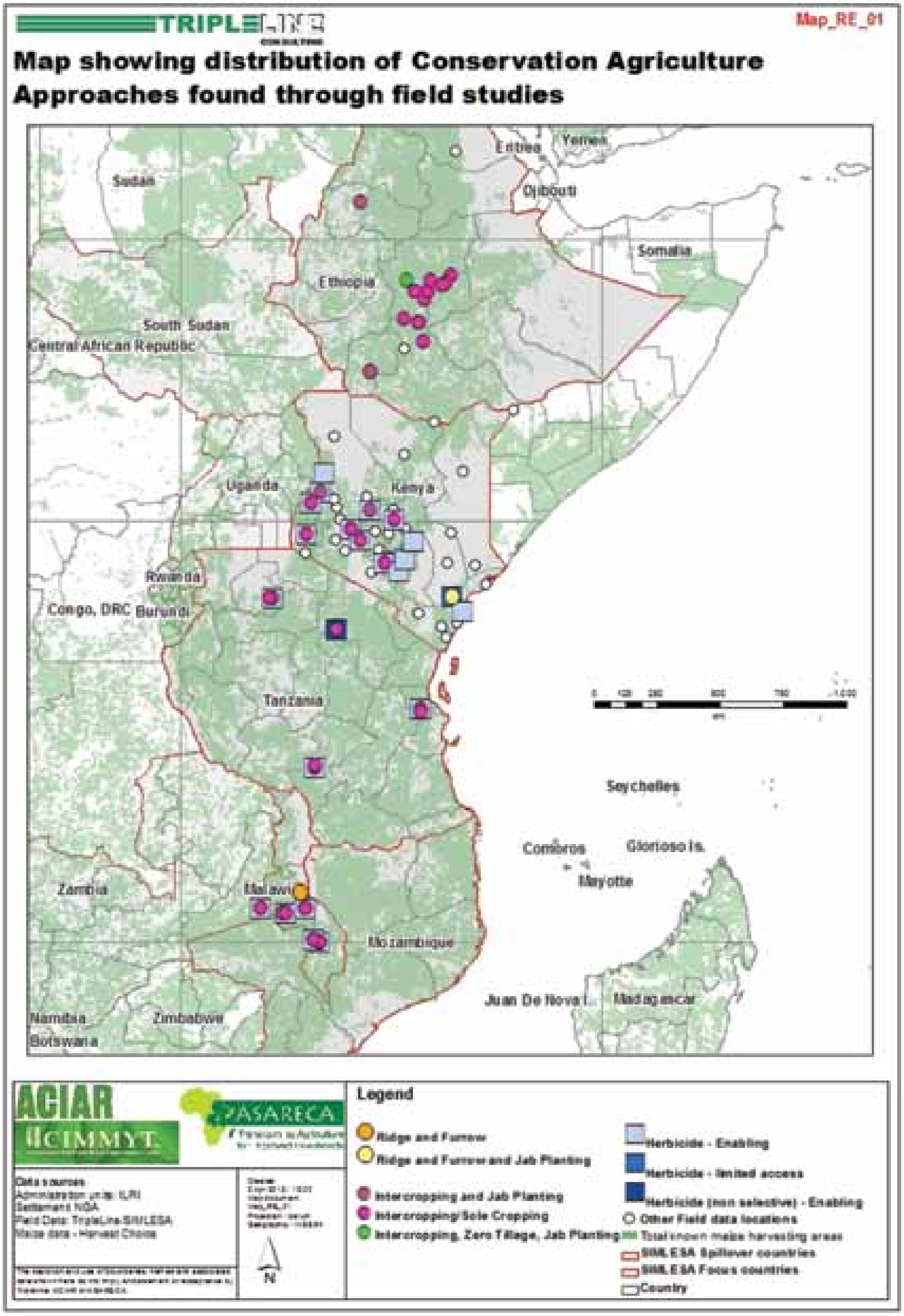


Figure 4.1: Geographical locations showing reported combinations of use of various conservation agriculture practices.

Table 4.2: Summary of conservation agriculture packages and practices in the SIMLESA countries

Country	CA package and practices	Comments and other issues	Issues with CA practices
Ethiopia	• Minimum (one pass at planting) /zero tillage • Residue cover • Rotation or intercropping **Complementary practices** • Improved varieties (adapted and compatible) • Herbicide (pre-emergence Glyphosate) + hand weeding • Recommended type and application rate of fertiliser	▪ 55 on-farm CA-based exploratory trials • Sole maize and CA • Intercropping under CA • MAB/BAM rotation CA • Farmer practice (repeated land preparation, no residue retention) ▪ 8 on-station trials • CA vs. conventional practices • Determining the right time of intercropping maize with Haricot bean	• Trade-offs between different uses of crop residue (fodder, fuel, residue cover, fencing, market) • CA implement • Weed management • Herbicide price and availability
Kenya	• Minimum soil disturbance • Residue retention (Maize/bean/pigeon pea residue) • Crop rotation/ intercropping • In aiding minimum tillage, herbicides are used • Furrow and ridges are additional practices	Eastern Kenya, with low rainfall: • Crops are maize and either common bean or pigeon pea. Spacing of beans vary with season Western Kenya, with moderate rainfall: • Crops are maize, bean and groundnut	• Lack of CA farm tools • Termites feeding on residue • Competition for residue • Build-up of pests, e.g. cricket and maize stalk-borer • Planting in residue is cumbersome, may also hinder germination
Malawi	Based on the three principles: • Soil cover • Minimum soil disturbance • Crop rotation	• Maize–legume intercropping with pigeon pea (*Mwaiwathu alimi* variety) in low altitude as well as rotation with groundnut (Chitala variety). Maize variety MH 26 • Maize–legume rotation in mid-altitude. Maize rotation with soybean (Nasoko) and MH 27	• Herbicides availability and associated costs • Livestock system of management in crop/livestock farming community • Crop rotation in limited landholding sizes • Adequate knowledge of CA principles and application • Viable policies not available to enhance adoption of (CA) soil and water conservation

Country	CA package and practices	Comments and other issues	Issues with CA practices
	Actual practices anchoring on three CA principles: 1. Residue retention • Cover crops (cowpea in low altitudes) • Crop rotation (short-term fallow—2 years with agroforestry tree species) 2. Minimum soil disturbance • Dibble stick planting • Jab planting • Integrated weed management (herbicides, hand weed, crop residue retention, intercropping) • Basin versus pit planting 3. Crop rotation and intercropping • Maize–legume (crop components, land size, farmer circumstances) • Maize–groundnut; maize–pigeon pea; maize–soybean (based on adapted legume varieties), land		
Mozambique	1. Disturb the soil as little as possible 2. Keep the soil covered as much as possible 3. Mix and rotate crops (Intercropping and rotation) Complementary practices • Jab planter • Maize varieties: Tsangano-open pollinated variety (OPV) • Ripper	**Manual labour practices:** • Maize, cowpea/bean • Maize varieties: Tsangano (an OPV) • Conventional—no residues • Basin sole maize • Jab planter sole maize • Basin cowpea/bean–maize rotation • Basin maize/cowpea/bean rotation • Basin maize/cowpea/bean intercrop **Treatments under animal traction** • Maize, cowpea/beans • Maize varieties: Tsangano (an OPV) • Conventional—No residues • Ripper sole maize • Direct seeder sole maize • Ripper cowpea–sole maize rotation • Ripper maize–cowpea/bean rotation • Ripper maize–cowpea intercrop	• Lack application of residues vs. difficulties to collect it • Direct seeders did not work well • High labour demand for residue application • Termite infestation and competition with cattle (Manica) or firewood (Angonia) • Intercropping not working well (cowpea areas)

Country	CA package and practices	Comments and other issues	Issues with CA practices
Tanzania	• No soil disturbance • Crop residue retention • Intercropping Complementary practices • Use of herbicides (Round-up) • Use of improved seed • Weed management (shallow weeding)	**Farmer practice** • What they used to do (except varieties) • Maize, pigeon pea intercropping **Conventional practice** • Maize, pigeon pea intercropping • Improved varieties are used • Use of fertiliser at recommended rates • Soil disturbance—tractor/oxen	* The CA practices apply to maize–pigeon pea intercropping • Crop residue retention in agro-pastoral farming system • CA-based planting equipment (need modification) • Weed management at early stages is difficult • Integration of CA into Ministry of Agriculture mainstream • Application of CA on sloppy areas, contour ridges should be applied

4.1.2 Varieties

SIMLESA countries have produced Proven varieties. These can be classified into two main categories: first, maize varieties categorised into hybrids and open-pollinated varieties (OPV); and second, legumes grown within the maize-based farming systems. The legume varieties mainly cover pigeon pea, Phaseolus (common) bean, groundnut, soybean and cowpea.

Proven varieties discussed in this section are those identified and promoted through the SIMLESA project. The inventory of these varieties was developed through the country visits and the stakeholder validation workshop held in Nairobi from 3 to 4 May 2012. These varieties were selected by farmers through participatory variety selection (PVS) processes from a menu of existing advanced materials being developed in the five SIMLESA countries. Most of these varieties remain pre-released as they are still going through the testing and performance assessment processes. Nevertheless, some have since been released and will be highlighted as appropriate in the discussion that follows.

The full list of the pre-released (and released) maize and legume varieties being tested in these countries are found in Tables 4.3, 4.4, 4.5, 4.6 and 4.7, and 4.8, 4.9, 4.10, 4.11 and 4.12 respectively. More details on each variety reported in these countries can be found in Volume 2.[5] Maps of the reported legume distributions are shown in Figures 7 to 11 for those where specific locations were documented, but not including general reports of usage in SIMLESA focus countries.

Two types of agro-ecologies have been selected in each country where given packages of maize and legume varieties are being tested either in rotation or intercropping systems. These are low altitude, low rainfall and high temperature and mid-to-high altitude, moderate-to-high rainfall and average to moderate temperature conditions.

To ensure clarity, the varieties for both maize and legumes have been discussed by country mainly because the list of varieties is long and most are endemic to the country where they were reported. However, where a variety appears in more than one SIMLESA country, this has been pointed out.

Maize varieties

Ethiopia: Both hybrid and open pollinated varieties (OPV) were reported in Ethiopia (Table 4.3). Hybrids comprise BH series (BH-660, BH-661, BH-543, BKH-1, BKH-1, BKH-5 and BKH-8), MH[6] (MH-130 recently released), MHQ (MHQ-138 also released and is a quality protein maize variety) and SC-403, which has also been released recently. The BH series are suited to high altitude and high rainfall agro-ecologies while the MH and SC series are adapted to low altitude and low rainfall zones.

These hybrid varieties address common problems of low yield and diseases such as leaf rust, leaf blight and grey leaf spot. However, the MH and SC series also address moisture stress (drought) and are also early maturing.

The BH varieties were developed with materials from the national research programme while MH series have incorporated traits from regionally shared materials from CIMMYT. SC 403 is a Seed Co variety that has been released in many countries where the seed company is operating. While SC 403 was released only recently in Ethiopia, in Malawi it was released more than five years ago and is about to be replaced by other newly released varieties with similar characteristics.

[5] The annex contains limited reference to Mozambique because the information contained in these matrices is largely based on field visits to the other four countries. It was difficult to obtain information on the key characteristics of the varieties being tested or chosen by farmers in Mozambique.

[6] MH stands for Melkessa Hybrid named for the Melkessa Research Station.

Table 4.3: Inventory of pre-released and proven maize varieties in Ethiopia

Maize variety	Problems addressed	Agro-ecology
Hybrids: BH-660, BH-661,BH-543, BKH-1, BKH-5, BKH-8	Major biotic and abiotic stresses: diseases (leaf rust, leaf blight, grey leaf spot; low yield)	Sub-humid, mid-altitude (BH-540 Gibe-2, Gibe-1); Some promoted for transitional mid to highland areas (e.g. BH-660, BH-661 Altitude: 1600–2200 m Rainfall: 1000–1500 mm
MH-130 (recently released) MHQ-138 (recently released) SC-403 (recently released)	Major biotic and abiotic stresses: drought/ low moisture stress; disease (leaf rust, leaf blight, grey leaf spot) low yield	Some have been promoted (e.g. Melkassa 2, Melkassa-6Q) to Central Rift Valley of Ethiopia Altitude: 1200–1700 m Rainfall: 600–800 per annum
Open pollinated varieties: Melkassa-2; Melkassa-5 Melkassa-6Q	Major biotic and abiotic stresses: drought/ low moisture stress; disease (leaf rust, leaf blight, grey leaf spot) low yield	Some have been promoted (e.g. Melkassa 2, Melkassa-6Q) to central Rift Valley of Ethiopia Altitude: 1200–1700 m Rainfall: 600–800 mm per annum
Gibe-2 Gibe-1	Major biotic and abiotic stresses: disease (leaf rust, leaf blight, grey leaf spot) low yield	Sub-humid mid-altitude (BH-540 Gibe-2, Gibe-1); some promoted for transitional mid to highland areas (e.g. BH-660, BH-661) Altitude: 1600–2200 m Rainfall: 1000–1500 mm

Although SC 403 has been widely promoted in other countries in Eastern and Southern Africa, all the other varieties reported in Ethiopia remain endemic to the country. The specification of the agro-ecological characteristics in which these varieties have been promoted assists in guiding the identification of similar zones where they can be scaled-out and spilled over.

Two types of OPVs have been reported in Ethiopia: Melkessa-2, Melkessa-5 and Melkessa-6Q, and Gibe-1 and Gibe-2. The Melkessa varieties are promoted in the central Rift Valley of Ethiopia under relatively low rainfall and low altitude while the Gibe varieties are promoted in high altitude agro-ecologies with relatively high rainfall.

The Melkessa series address moisture stress (drought) but the Gibe varieties address common diseases—leaf rust, leaf blight and grey leaf spot. The two series have been developed with materials from the national programme and CIMMYT.

Kenya: Only hybrid maize varieties have been promoted under SIMLESA in Kenya. These are KH539E, H520, KH500Q, KH533A, KH631Q KSTP94 and KH633A (see details in Table 4.4).

As already pointed out, two agro-ecologies were reported for these varieties. All varieties have been promoted in the upper midlands ranging from 1300–1500 m, with rainfall ranging between 500 and 800 mm per year, except KSTP94 that was promoted in the lower to medium midlands under a similar rainfall pattern.

Quality protein has been one of the main traits that has been incorporated in KH500Q and KH631Q varieties. Tolerance to maize streak virus (MSV), grey leaf spot (GLS) and striga are some of the major problems that some of the varieties aim at addressing.

Promotion of these varieties has remained restricted to Kenya. However, similar agro-ecologies within the region could be identified where they could be spilled over.

Malawi: Table 4.5 shows varieties that are being promoted in Malawi; they include already released hybrid varieties. MH[67] 26 is being promoted under low rainfall (500–600 mm/annum), low altitude (200–760 m) and temperatures ranging from 25–35°C. The variety aims to address low yield, drought and foliar diseases mainly maize rust and GLS. It is an early to medium maturing variety (130–140 days). The other released hybrid variety, MH27, is being promoted in med-altitude zones (760–1000 m) with temperatures ranging from 15°C to 30°C. The variety aims to address GLS and leaf blight. It is a medium maturing variety (130–145 days).

Both varieties have flint white grain. They have been developed with materials from the national research programme and CIMMYT. These varieties were incorporated into the menu of varieties under the project to ensure their entry into the seed market. It was reported that most varieties developed through national programmes are rarely found on the seed market because most seed companies want to promote their own varieties.

Both varieties have been promoted in Malawi only and have not yet spilled over to other countries. These varieties are flint, a characteristic of most local cultivars, and most farmers like them. In addition, they have good storability.

Other varieties developed through the national programme and are also included on the seed roadmap are: E7010, which is to be coded MH when released, a high-yielding, drought-tolerant and early maturing variety. It is promoted in low altitude, low rainfall agro-ecologies with high temperatures (25–35°C); MAO 7007 will also be coded MH on release, it is high yielding and drought tolerant and is being promoted in low altitude and low rainfall zones; and CZH 87 and the other 8 listed with the CZH pre-release code will be coded by the responsible seed companies. It is high yielding and drought tolerant with medium maturity (130–145 days).

All these varieties are still restricted to the districts where SIMLESA is implementing the project. These are Salima, Balaka and Ntcheu districts as low altitude areas and Kasungu, Mchinji and Lilongwe as medium altitude districts (see Table 4.5 for details on other varieties on the seed roadmap).

Mozambique: Like Ethiopia, Mozambique is promoting both open pollinated (OPV) and hybrid maize varieties (Table 4.6). Tsangano, ZM523 and ZM309, aim to address are low yield and moisture stress (drought). These varieties have already been released and are developed from CIMMYT materials. They are also widely reported in other countries in east and southern Africa where CIMMYT is operating

Variety characteristics such as poundability, grain type (flint, semi-flint or dent), grain taste (sweetness when roasted or boiled), and grain colour have not been widely reported as major factors that are considered in variety selection programmes. Out of the four countries visited, issues of gender were only reported in Ethiopia where women prefer yellow seed maize (better *injera*) while men prefer white (better income). Generally, we were told that maize variety selection research was gender neutral.

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[7] MH stands for Malawi hybrid

Table 4.4: Inventory of pre-released and proven maize varieties in Kenya

Maize variety	Problems addressed	Agro-ecology
KH539E	Low yield; disease tolerance (grey leaf spot and maize streak virus (MSV); Grain quality (dent grain, i.e. not hard. The preference is for flint (hard) grain); time taken to mature (preference is medium maturity)	Upper midland: 1300–1500 m Rainfall: 500–800 mm, well distributed Optimum temperature: 18–25°C
H520	Addresses low yield Time taken to mature (new variety is medium maturing)	Upper midland: 1300–1500 m Rainfall: 500–800 mm, well distributed Optimum temperature: 18–25°C
KH500Q	Low quality protein in conventional maize; time taken to mature (new variety is medium maturing)	Upper midland: 1300–1500 m Rainfall: 500–800 mm, well distributed Optimum temperature: 18–25°C
KH533A	Time taken to mature (preference here is early maturing)	Upper midland: 1300–1500 m Rainfall: 500–800 mm, well distributed Optimum temperature: 18–25ºC
KH631Q	Low quality protein in conventional maize; Stover to stay green	Upper midland: above 1500 m Rainfall: 500–800 mm, well distributed Optimum temperature: 18–25°C
KSTP94	Striga	Lower midlands to medium midlands: 1200–1500 m Rainfall: 500–800 mm, well distributed Optimum temp: 18–25°C
KH633A	Time taken to mature (preference mid-maturing hybrid that can be planted for two seasons in a year)	Upper Midland; 1300–1500 m asl; 500–800 mm of well distributed rainfall optimum temperature 18–25°C

Table 4.5: Inventory of pre-released and proven maize varieties in Malawi

Maize variety	Problems addressed	Agro-ecology
MH 26	Low yield; drought; foliar diseases (grey leaf spot (GLS) and leaf blights); Farmers' prefers in terms of grain colour and other attributes (preference is for White seed, flint (hard) grain, good husk cover); Time taken to mature (preference medium maturity 130–145 days)	Altitude: 200–760 m Rainfall: 500–600 mm/annum Temp: 25–35°C Soil types: alluvial soils Average pH: 6.0
MH 27	Low yield, drought, foliar diseases (GLS and leaf blights); white seed, dent grain (not hard)- preference is flint grain, poor quality of husk cover; Time taken to mature (preference medium maturity: 130–145 days)	Altitude: 760–1300 m Rainfall: 600–1000 mm/annum Temp: 15–30°C Soil types: loam Average pH: 5.7–6.0
E7010 (to be coded **MH** after release)	Low yielding, drought; time taken to mature (preference, early maturity)	Low-altitude areas: 200–760 m Rainfall: 500–600 mm/annum Temp: 25–35°C Soil types: Alluvial soils Average pH: 6.0
MAO 7007 (to be coded MH after release)	Low yielding; drought.	Mid and low altitudes

Maize variety	Problems addressed	Agro-ecology
MAO 9141 (To be coded **MH** after release)	Low yield, drought, foliar diseases (GLS and leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity: 130–145 days)	Rainfall:600–1000 mm/annum; Altitude: 760–1300 m asl; Temp: 15–30°C; Soil types: loam; Average pH: 5.7–6.0
CZH0837 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS and leaf blights); Farmers' prefers in terms of grain colour and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Rainfall: 600–1000 mm/annum; Altitude: 760–1300 m asl; Temp: 15–30°C; Soil types: loam; Average pH: 5.7–6.0
CZH0946 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS and leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference: medium maturity -130-145 days)	Rainfall: 600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30 o C; Soil types: loam; Average pH: 5.7 - 6.0
CZH 04007 (To be coded by responsible company)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Rainfall: 600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30 o C; Soil types: loam; Average pH: 5.7 - 6.0
CZH0928 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Mid altitude; Rainfall:600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30 o C; Soil types: loam; Average pH: 5.7 - 6.0
CZH0948 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Mid altitude: Rainfall: 600–1000 mm/annum; Altitude: 760–1300 m asl; Temp: 15–30 o C; Soil types: loam; Average pH: 5.7 - 6.0

Maize variety	Problems addressed	Agro-ecology
CZH0926 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Mid altitude; Rainfall:600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30 o C; Soil types: loam; Average pH: 5.7 - 6.0
CZH0837 (To be coded by responsible company after release)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Mid altitude; Rainfall: 600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30 o C; Soil types: loam; Average pH: 5.7 - 6.0
CZH0819 (to be coded by the responsible seed company)	Low yield, drought, foliar diseases (GLS & leaf blights); Farmers' prefers in terms of grain color and other attributes (preference is for White seed, flint grain, good husk cover); Time taken to mature (preference Medium maturity- 130-145 days)	Mid altitude; Rainfall: 600-1000 mm/annum; Altitude: 760-1300 m asl; Temp: 15-30°C; Soil types: loam; Average pH: 5.7 - 6.0

Tsangano (ZM 621) is adapted to mid and high altitude agro-ecologies (600–1500 m) with rainfall ranging from 600–1200 mm per year and temperatures ranging from 25–30°C. ZM523 is adapted to low altitude areas ranging from 0–600 m with rainfall of between 400 and 800 mm per year and similar temperatures as ZM621.

In addition to these varieties Dimba, an early maturing OPV and flint grain variety, is also promoted in Mozambique. It is adapted to lowlands and marginal areas with about 400–800 mm of rainfall. The variety was developed from IIAM materials.

Several hybrid varieties were also reported in Mozambique. These are: Hluvukane from IIAM materials, Olipa (IIAM), Molocue (CIMMYT CZH0511) released in 2011, SPI, is a CIMMYT CZH0524 variety to be released in 2012, and DC1, another CIMMYT CZH04008 variety also to be released in 2012.

One of the problems all the varieties aim to address is low yield. Olipa is a quality protein variety and it also addresses foliar diseases (GLS, MSV and DMR), while Molocue, SPI and DC1 address drought tolerance (see Table 4.6 for details).

Because most of these varieties are developed from CIMMYT materials, it is expected that similar varieties are also found in other countries where CIMMYT is operating but they may have been released under different names. For example, Tsangano, which is ZM621, is also found in Malawi, Zambia, Zimbabwe and other countries in the region. It can be concluded that most varieties in Mozambique have wider adaptation since they fall within regionally managed programmes where exchange of materials is enhanced through CIMMYT.

Table 4.6: Inventory of pre-released and proven maize varieties in Mozambique

Maize variety	Problems addressed	Agro-ecology
Open pollinated varieties Tsangano	Low yield and drought	Mid and high altitude: 600–1500 m Rainfall: 600–1200 mm Temp: 25–30°C
ZM523	Low yield and drought	Low to mid-altitude: 0–600 m Rainfall: 400–800 mm Temp: 25–30°C
Dimba	Late maturity, low quality of grain (not flint)	Lowland and marginal areas Rainfall: 400–800 mm Temperature: 27–35°C
Hybrid varieties Hluvukane	Low yield; low quality of grain (not flint), no tolerance to post-harvest insects	Low and mid–altitude: 400–800 mm Temperature: 27–35°C
Olipa (a QPM variety)	Low yield; Lack in quality protein (QPM) in conventional maize, lack of tolerance or resistance to foliar disease (maize streak virus (MSV), Grey leaf spot (GLS), downy mildew (DM)	All agro-ecologies Rainfall: 400–1200 mm Temperature: 25–35°C
Molocue	Low yield, and drought	Mid and high altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
SP1	Low yield, and drought	Mid and high altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
DC1	Low yield, and drought	Mid and high altitudes: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C

Tanzania: Almost all the maize varieties reported in Tanzania have been developed from the Selian Agricultural Research Institute (SARI) located in Arusha, north of Tanzania. The varieties are Selian H208, Selian H308, SAH 779, SAH 636 and SAH 638. They have been developed from regional trials (CIMMYT) and the national programme (Table 4.7).

Drought tolerance was a common problem that all the varieties aim to address. Similarly, the varieties aim to address common diseases—GLS, MSV, and Tursium blight—and low yields: their average yield on station is 6–9 t/ha.

Compared with other varieties reported in other countries for the same characteristics like drought tolerance, in Tanzania these maize varieties are being promoted in relatively higher altitudes and higher rainfall. Similarly, the temperature variation is not high among these varieties (see Table 4.7 for details).

Ideally, all maize varieties could be scaled out or spilled over to similar agro-ecologies in Eastern and Southern Africa. Drought tolerance is a common problem that most varieties that are being promoted under SIMLESA aim to address. With the growing effects of climate change, which results in erratic rainfall and frequent drought conditions, these varieties should be promoted and scaled-out beyond national boundaries. Similarly, all the varieties reported in this inventory aim to address low yields at the farmer level.

Table 4.7: Inventory of pre-released and proven maize varieties in Tanzania

Maize variety	Problems addressed	Agro-ecology
Selian H208	Diseases (lack of tolerance to blight, GLS), drought, time taken to maturity (looking for early maturity: 135 days), low yields (bred for high yield 7–8 t/ha)	Altitude: 900–1800 Rainfall: 600–1100 mm per growing season Temperature: 15–30°C
Selian H308	Diseases (lack of tolerance to blight, GLS), drought, long time to maturity (looking for early maturity: 135 days), low yield (bred for high yield: 8–9 t/ha).	Altitude: 900–1800 m, Rainfall: 600–1100 mm per growing season Temperature: 15–30°C
SAH 779	Drought (lack of tolerance), diseases (lack of resistance to MSV, GLS and Tursicum blight), long time to maturity (looking for medium maturing: 150 days), low yields (bred for high yield: 8–9 t/ha)	Altitude: 1200–1600 m Rainfall: 600–1600 mm per growing season; Temperature: 15–28°C Moisture: 600–1100 mm
SAH 636	Drought (lack of tolerance), diseases (lack of resistance to MSV, GLS and Tursicum blight), takes long to reach maturity (looking for medium: 150 days), low yields (bred for high 6–7 t/ha)	Altitude: 1200–1600 m Rainfall: 600–1600 mm per growing season; Temperature: 15–28°C Moisture: 600–1100 mm
SAH 638	Drought (not tolerant), diseases (not resistant to MSV, GLS and Tursicum blight), maturity (looking for medium 150 days), low yields (bred for high yield 7–8 t/ha)	Altitude: 1200–1600 m Rainfall: 600–1600 mm per growing season Temperature: 15–28°C Moisture: 600–1100 mm

Legume varieties

Several species of grain legumes were reported through the study. Four common characteristics of legumes that determine their incorporation in maize-based farming systems are: 1) their ability to fix atmospheric nitrogen into the soil; 2) their contribution to household nutrition as a cheap source of protein; 3) their cash income generation potential; and 4) their 'fit' in the maize farming system, either in rotation or intercropped with maize.[8] Some legume varieties are found in more than one country; the discussion that follows has been done by country.

Ethiopia: Two main types of legumes were reported in Ethiopia. The first type is beans which has many varieties (Table 4.8). The varieties reported are ECAB-0081, GLP-2, ECAB-0056, Nasir, Awash-1, Deme, Dinknash and Awash Melka. These bean varieties aim to address low yield, moisture stress and disease. They are all adapted to mid-altitude to low moisture areas. Farmers evaluated trials at each location and they selected Nasir, Dinknesh and Deme in Shala district; Awash-1, Awash Melka in Bulbula and Bofa districts. Highest grain yield has been recorded from Dinknesh, followed by Nasir and Deme. The second legume type is soybean. The main varieties are: Belessa-95, New variety-1 and New variety-2. They are being promoted to address the problem of low yield and tolerance to major diseases. They are adapted to sub-humid mid-altitude areas and in acidic soils.

[8] These systems are discussed in a later section.

Both the bean and soybean varieties can be scaled out and spilled over to similar agro-ecologies within and outside Ethiopia.

Kenya: Pigeon pea and bean were the legume types reported (Table 4.9). The pigeon pea varieties reported are: ICEAP 00040 locally released as Mbaazi 2, and ICEAP 00850. They both have similar characteristics and the problems they aim to address. ICEAP is also found in all the other countries that reported the legume. In Tanzania it is locally known as Mali. This is a hybrid variety developed and promoted through ICRISAT, hence most likely has a wider adaptation in East and Southern Africa.

Table 4.8: Inventory of pre-released and proven legume varieties in Ethiopia

Legume variety	Problems addressed	Agro-ecology
Beans ECAB-0081, GLP-2, ECAB-0056, Nasir, Awash-	Low yield; Lack of tolerance to major disease and pests Drought	Mid-altitude, low-moisture areas
Soybean Belessa-95, New variety-1, New variety-2	Low yield; Lack of tolerance to major disease and pests	Sub-humid mid-altitude areas

Several varieties of beans were reported: Kat X69, Embean 14, KK15, KK8 and KK71. The last three were developed to address root rot; X69 and Embean 14 were selected for their yield and cooking time. All varieties are adapted to high altitude areas (900–1600 m) but with relatively low rainfall (200–400 mm per year).

Malawi: Three legume types were reported in Malawi (Table 4.10). The variety for pigeon pea is Mwaiwathu alimi (our opportunity-farmers), which has the ICRISAT code of ICEAP 00557. It aims to address low yields and drought. It is a medium duration variety and is preferred by the market due to its white grain. It is adapted to medium rainfall (500–600 mm per year), grown in low altitude (200–760 m) and high temperatures (25–35°C). It is the main legume and variety used in maize–legume intercropping systems and adapted across agro-ecologies.

Groundnut—Chitala (ICGV-SM)—is the second legume type promoted in Malawi; it addresses low yield, drought, and rosette disease. It is an early maturing, medium to large seed variety. It is promoted under maize–legume rotations under similar conditions as those of the pigeon pea variety discussed above.

Another legume promoted under maize–legume rotations is soybean. The variety, Nasoko, address low yields and drought. It is medium-maturing and adapted to the mid-altitude agro-ecologies (760–1300 m) of Malawi.

Mozambique: Four types of legumes were reported in Mozambique (Table 4.11). Soybean varieties: Ocepara-4, 427/5/7, H7, and 17. Yield, earliness in maturity, tolerance of rust and virus diseases are the main problems that the varieties aim to address. While the first three are promoted in mid-altitude areas, all the varieties are adapted to mid-high altitude (600–1500 m), relatively high rainfall (600–1200 mm) and temperatures ranging between 25°C and 30°C. These varieties were developed from materials from IITA and MacKnight Foundation.

Table 4.9: Inventory of pre-released and proven legume varieties in Kenya

Legume variety	Problems addressed	Agro-ecology
Pigeon pea ICEAP 00040 (Mbaazi 2)	Low yield (new variety can yield 1.3 t/ha) compared with local varieties (500 kg/ha); Lack of tolerance of diseases	Low midlands 4 Altitude: 900–1800 m Rainfall: 400–800 mm, well distributed during growing period Temperature: 15–25°C
ICEAP 00850	Low yield (new variety can yield 1.3 t/ha) compared with local varieties (500 kg/ha); Lack of tolerance of diseases	Low midlands 4 Altitude: 900–1800 m Rainfall: 400–800 mm, well distributed during growing period Temperature: 15–25°C
Beans Kat X69	Takes long time to mature (preference Early maturing (65 days); Farmers preferences in terms of grain seed colour; Low yield (new variety can attain1.4–2.0 t/ha); No tolerance of rust and common bean mosaic virus and angular leaf spot Taking long to cook	Upper midlands 3–4 Altitude: 900–1600 m Rainfall: 200–400 mm, well distributed Optimum temperature 15–27°C
EMBEAN 14	Time taken to mature (preference maturing at 75 days); Low yield (new variety can attain 2 t/ha); Long time to cook	Upper Midlands 3–4 Altitude: 900–1600 m Rainfall: 200–400 mm, well distributed Optimum temperature: 15–27°C
KK15	Lack of tolerance to root rot	Upper Midlands 3–4 Altitude: 1500–1800 m Rainfall: 250–450 mm, well distributed
KK8	Lack of tolerance to root rot	Upper Midlands 3–4 Altitude: 1500–1800 m Rainfall: 250–450 mm, well distributed Optimum temperature: 15–27°C
KK71	Lack of tolerance to root rot	Upper midlands 3–4 Altitude: 1500–1800 m Rainfall: 250–450 mm, well distributed Optimum temperature: 15–27°C
Soybean SB19	Low yielding; low tolerance to blight	Upper Midlands 3-4. 1500–1800 m asl Rainfall: 250–450 mm; well distributed Optimum temperature: 15–27°C

Cowpea (IT16) is a determinate rust and ascochita tolerant variety. It is promoted in the north and centre of the country at altitudes of 600–1500 m, 600–1200 mm per year of rainfall and under temperatures ranging from 25°C to 30°C. The variety was released in 2011 and was developed from IITA materials.

The common bean (CAL 143) is tolerant of bacterial wilt and drought and does well even under low levels of soil fertility. Like cowpea, it is promoted in the north and centre of the country under the same conditions. It was developed from materials from the MacKnight Foundation and released in 2011.

Pigeon pea (ICEAP 00040) is a long cycle, high-yielding variety that resists pest infestation. It is promoted in the same zones as the common bean and cowpea discussed above. The variety is developed from ICRISAT materials and is also found in other countries such as Kenya, Malawi and Tanzania.

Table 4.10: Inventory of pre-released and proven legume varieties in Malawi

Legume variety	Problems addressed	Agro-ecology
Pigeon pea: *Mwaiwathu alimi* (ICEAP00557))	Low yield and drought; Time taken to mature (preference early to medium maturing); To meet market preference (for white grain)	Altitude: 200–760 m Rainfall: 500–600 mm/annum Temp: 25–35°C Soil types: Alluvial, average pH 6.0
ICEAP 0154/15	Low yields, and drought. Time taken to mature (preference early to medium maturing); To meet market preference (for white grain)	Rainfall: 500–600 mm/annum Altitude: 200–760 m asl Temp: 25–35°C Soil types: Alluvial, average pH 6.0
Groundnut: Chitala i.e. ICGV-SM 99568	Low yields; drought; Rosette disease; Time taken to mature (preference early to medium maturing); To meet market demand (for large seeded)	Altitude: 200–760 m Rainfall: 500–600 mm/annum Temp: 25–35°C Soil types: Alluvial soils, average pH 6.0
Chalimbana 2005	Low yields; drought; Rosette disease. Time taken to mature (preference early to medium maturing); To meet market demand for large seeded	Rainfall: 500–600 mm/annum; Altitude: 200–760 m asl Temp: 25–35°C Soil types: Alluvial; average pH 6.0
Kakoma	Low yields; drought; Rosette disease. Time taken to mature (preference Early to medium maturing); To meet market demand for large seeded	Rainfall: 500–600 mm/annum Altitude: 200–760 m asl Temp: 25–35°C Soil types: Alluvial, average pH 6.0
Nsinjiro	Low yields, drought, Rosette disease. Takes long to mature (preference Early to medium maturing); To meet market demand for large seeded	Rainfall: 500–600 mm/annum Altitude: 200–760 m asl Temp: 25–35°C Soil types: Alluvial, average pH 6.0
Soybean: Nasoko	Low yields and drought To meet market demand in terms of seed size and colour; Takes long to mature (preference Early to medium maturing)	Altitude: 760–1300 m Rainfall: 600–1000 mm/annum Temp: 15–30°C Soil types: loam, average pH 5.7–6.0

Tanzania: Only pigeon pea was reported in Tanzania where it is the main legume in the maize–legume intercropping system (Table 4.12). The varieties reported are: ICEAP 00554 and ICEAP 00557 adapted to low altitude zones ranging from 0–700 m with temperatures 25–30°C. These varieties were developed to address diseases, such as Fusarium wilt, moisture stress and low yields. The third variety, ICEAP 00040, is locally known as Mali, is promoted in relatively higher altitude (900–1500 m) of Mbulu and Karatu districts. These cowpea varieties are also promoted in the other countries where the crop has been reported.

As highlighted at the beginning of this section, the qualities of these legumes justify the need to scale them out more widely as a means to reverse soil fertility decline, reduce malnutrition and reduce poverty among farming households in Eastern and Southern Africa. Soybean and *Phaseolus* bean varieties promoted by SIMLESA (e.g. in Ethiopia) are also good commercial and export crops, contributing to the countries' national economies.

Limited information has been available to guide the identification of potential areas for scaling out and spillover. However, the detailed agro-ecological information that has been provided for all the crops and varieties in this report is useful in guiding the identification of such zones in the various countries.

Table 4.11: Inventory of pre-released and proven legume varieties in Mozambique

Legume variety	Problems addressed	Agro-ecology
Soybean Ocepara-4	Low yield; late maturing and pod shattering, lack of tolerance of virus	Mid–high altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
427/5/7	Low yield; late maturing and pod shattering; lack of tolerance of rust and virus	Mid–high altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
H7	Low yield; late maturing and pod shattering; no tolerance to rust and virus	Mid–high altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25-30°C
17	Low yield; takes long time to mature (preference Early maturity); and pod shattering; no tolerance of rust and virus	High altitude and most suited to Angonia site: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
Cowpea: IT16 (TL-II), IT) 18)	Indeterminate; no tolerance of rust and ascochita	North and centre, altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
Common bean: CAL 143,	Lack of tolerance of bacterium wilt; drought and to low soil fertility	North and centre, altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C
Pigeon pea: ICEAP 00040	Growing cycle (to be able to escape pest infestation); low yield	North and centre, altitude: 600–1500 m Rainfall: 600–1200 mm Temperature: 25–30°C

Table 4.12: Inventory of pre-released and proven legume varieties in Tanzania

Legume variety	Problems addressed	Agro-ecology
ICEAP 00554 and ICEAP 00557	Diseases (resistance to Fusarium wilt) Drought; Takes long time to mature (preference early maturity,	Altitude: 0–700 m Temp: 25–30°C
ICEAP 00040 (Mali)	Diseases (resistance to Fusarium wilt); Drought; Takes long time to mature (preference is early maturity: 160–180 days) Low yield (new variety can attain 3 t/ha)	Altitude 900–1500 m Temperature: 15–25°C

Summary of variety combinations

The field interviews identified use of many crop mixes in field trials, but the distribution of high varietal range cannot be mapped at regional scale. As many trials are located at the same locales, it is apparent that a wide range of crops are being piloted. However, some differences emerged in what was reported during the country visits. Beans were reported widely in Kenya and Ethiopia but the SIMLESA coordinator in Malawi confirmed they were only planned to be trialled in 2012/2013 (Figure 4.2) as were groundnuts (Figure 4.3). However, cowpea and pigeon pea have been extensively piloted in most countries (Figures 4.4 and 4.5) although more limited within each country. In Malawi, pigeon pea is limited to central region, and cowpea is restricted to the Rift Valley areas of Malawi and Ethiopia. Finally, soybean, which appears to have commercial interests, was reported only through the database as being present in limited sub-humid parts of Ethiopia (Figure 4.6). Most of the recorded locations for Kenya relate to orphan crops.

For both maize and legume varieties, limited information was obtained on gender issues. Tables 4.8, 4.9, 4.10, 4.11 and 4.12, provide the inventory of legume varieties in the five countries respectively. Volume 2 provides more detailed information on these varieties.

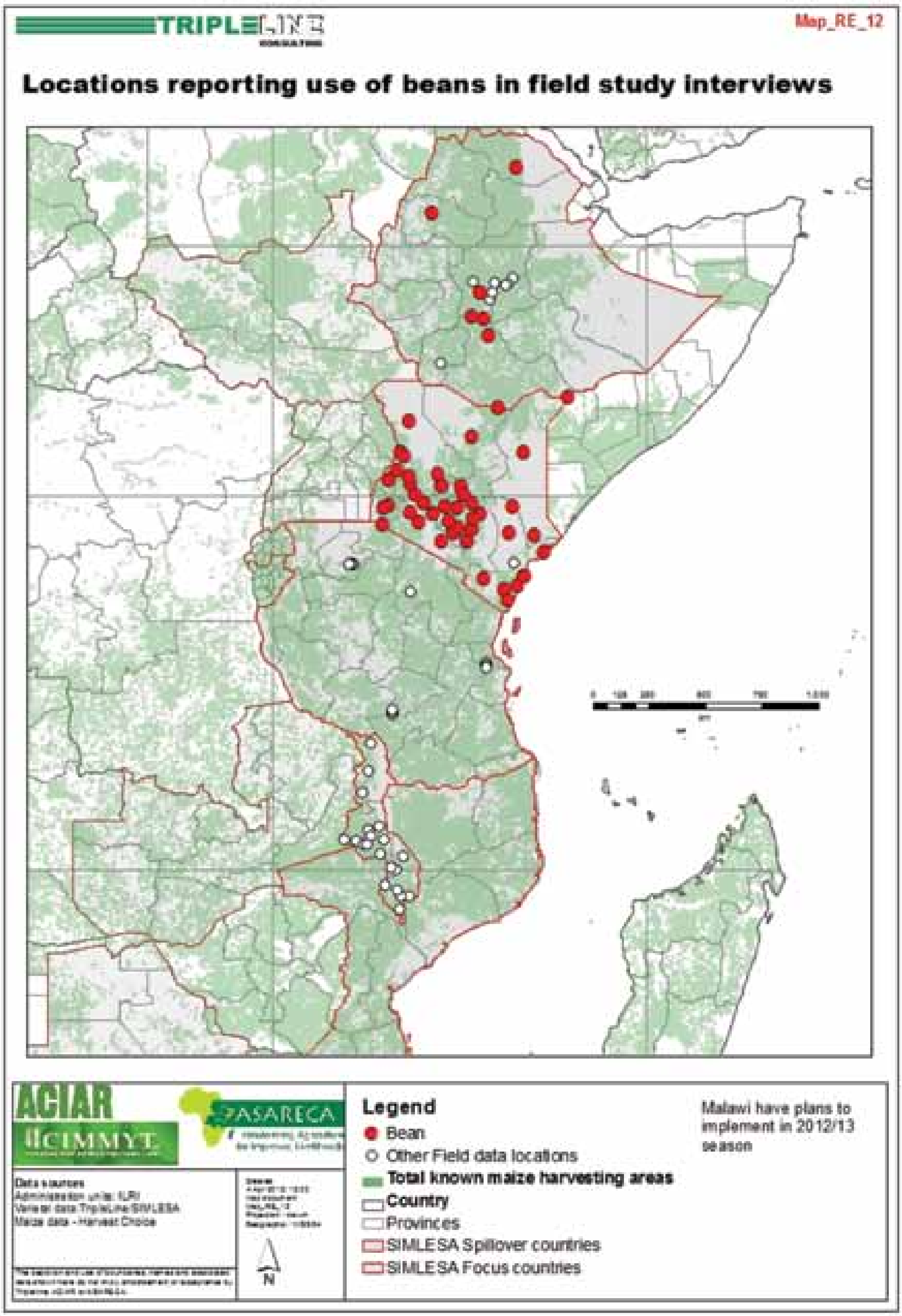


Figure 4.2: Locations reporting use of beans.

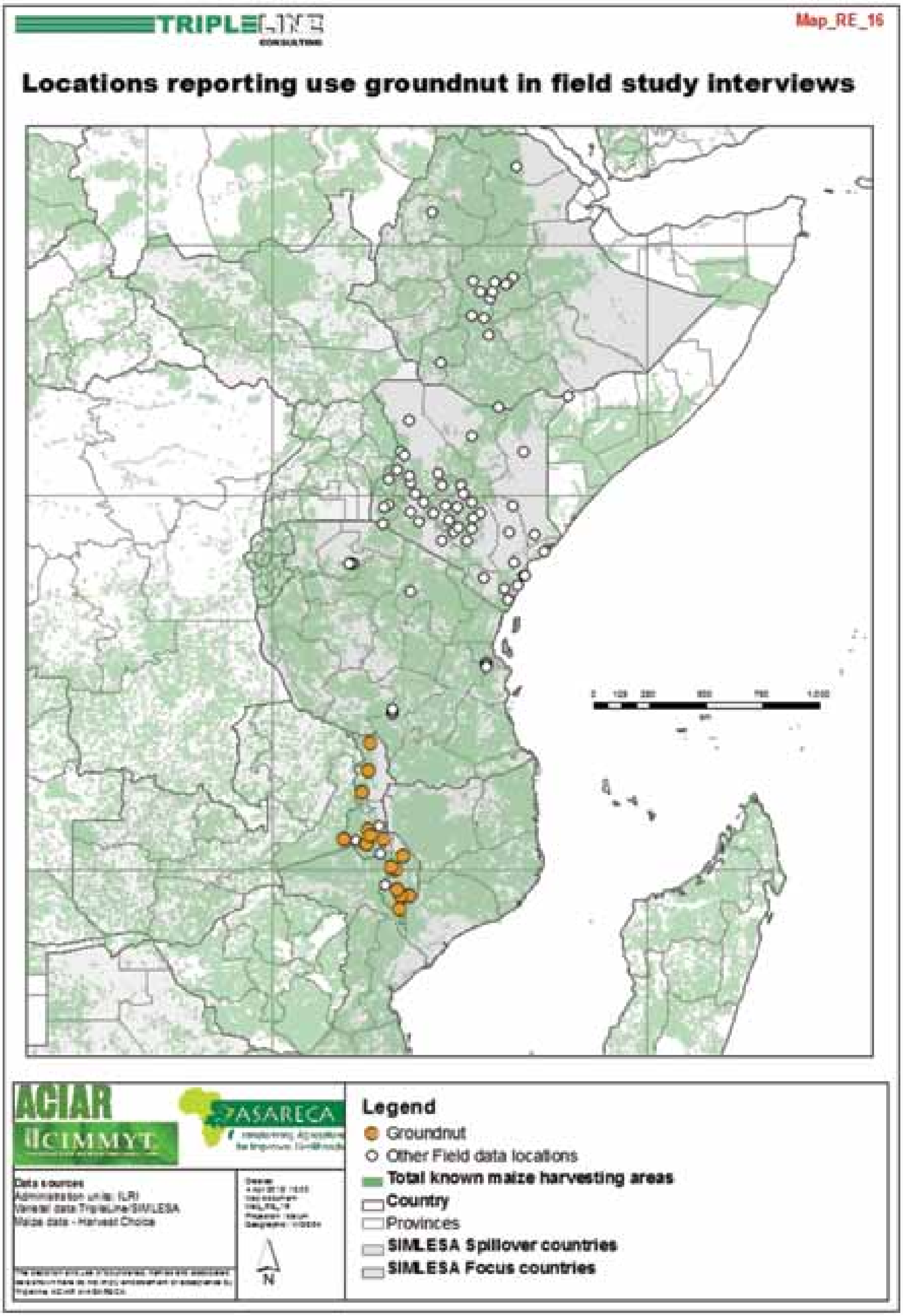


Figure 4.3: Locations reporting use of groundnut.

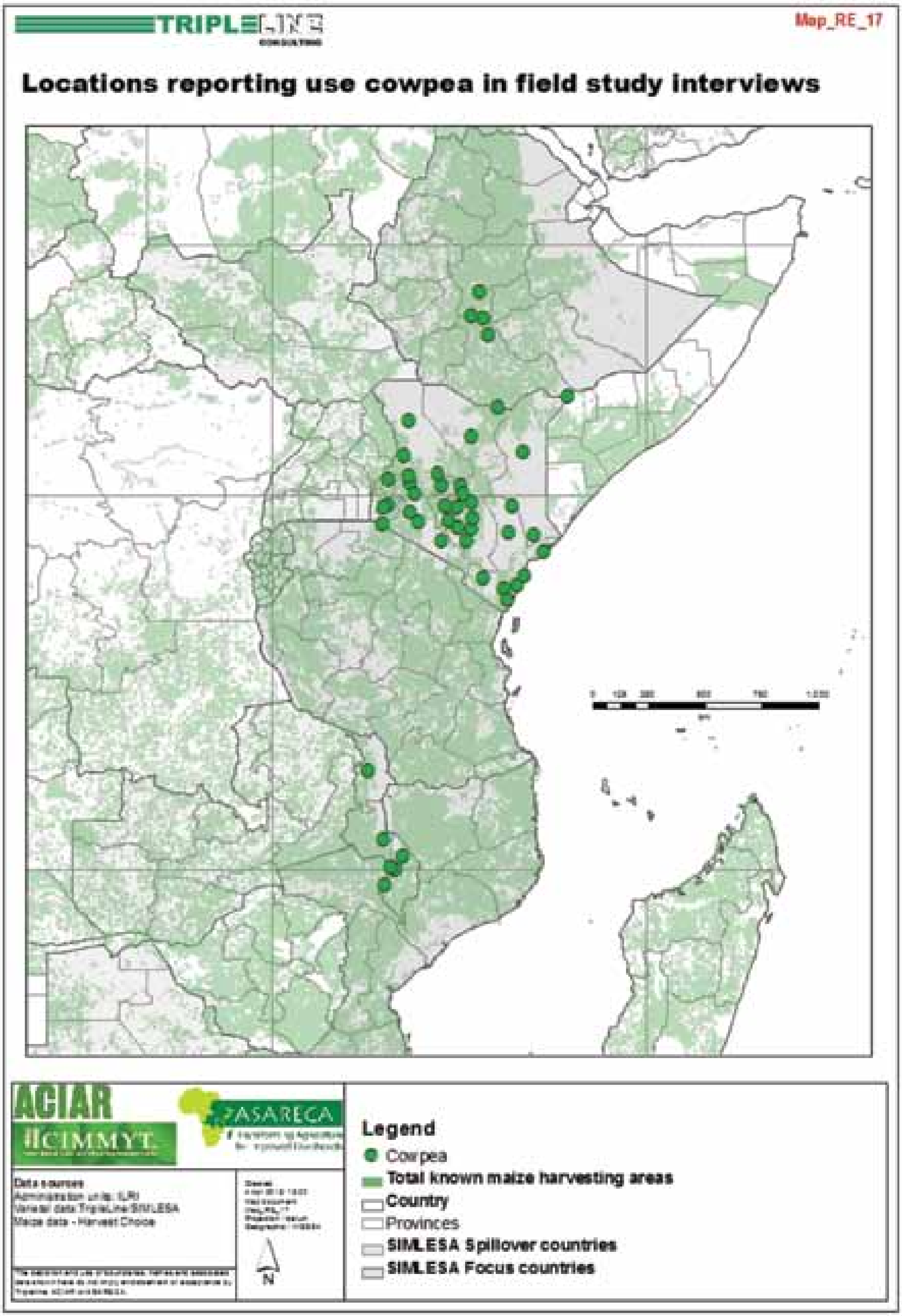


Figure 4.4: Locations reporting use of cowpea.

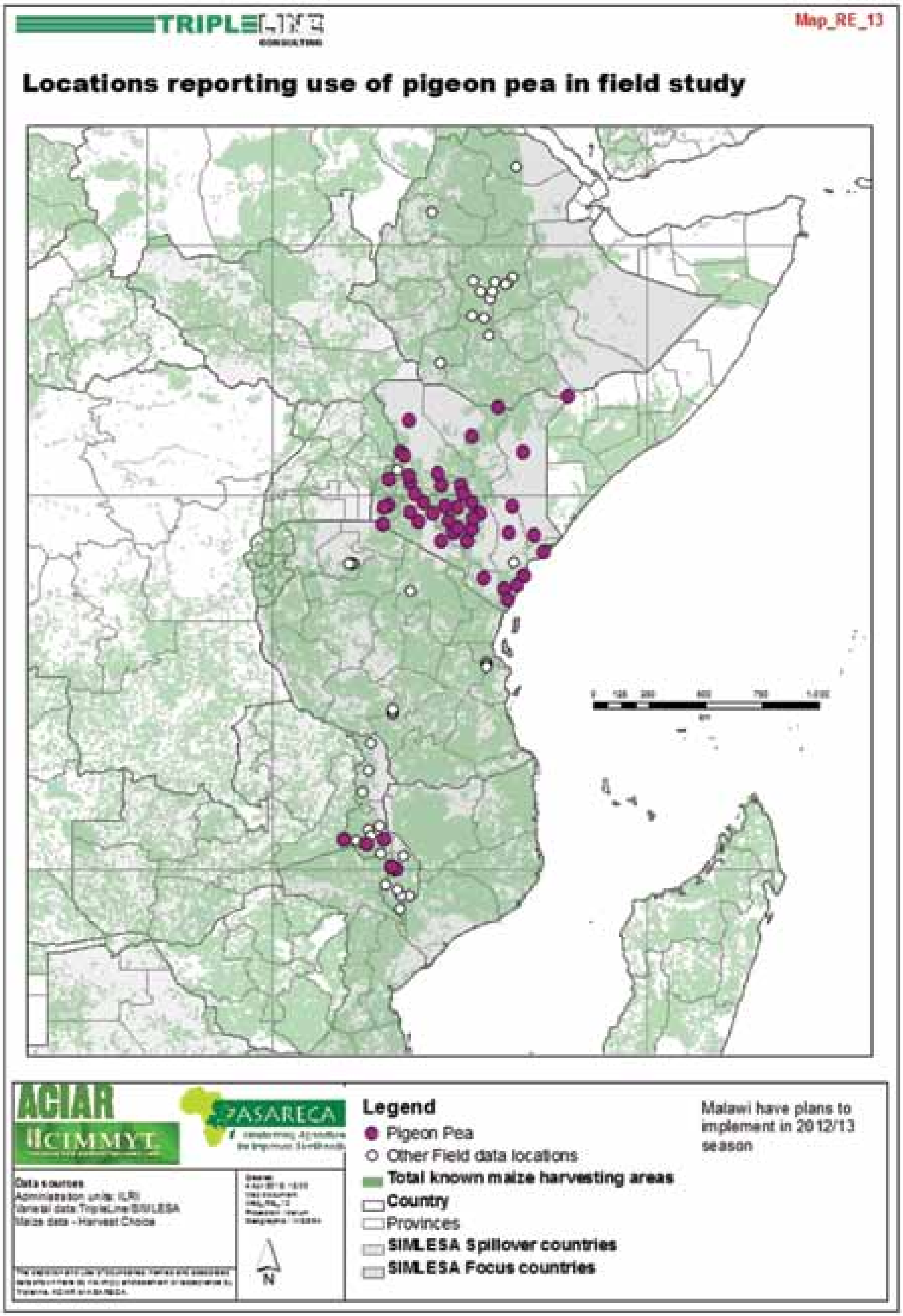


Figure 4.5: Locations reporting use of pigeon pea.

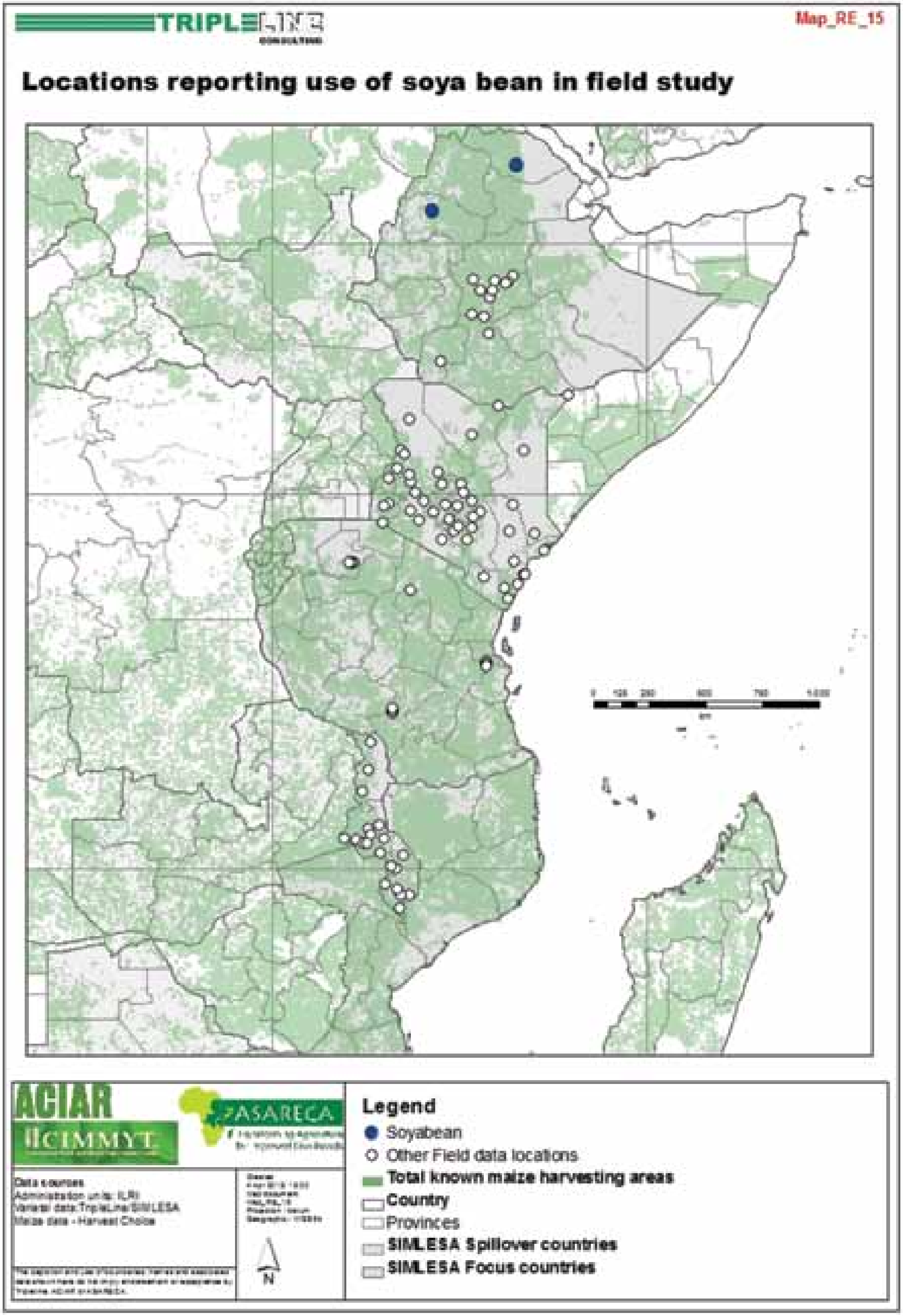


Figure 4.6: Locations reporting use of soybean.

4.2 Available extension approaches and knowledge products

This section provides findings on available extension approaches and knowledge products for the maize–legume cropping system in the ECA sub-region that can be transferred and used in other countries. Extension service providers and producers of knowledge products are summarised first. Next is a discussion of how different providers work together, e.g. through institutional linkages, collaboration and partnerships; findings concerning how SIMLESA is linking up with extension providers for effective provision of extension and knowledge products; and extension approaches being taken in the five SIMLESA countries are described—those that are prevalent across the five countries and others that are less common. Finally, the types and range of knowledge products concerning CA and maize–legume technology are described.

4.2.1 Providers of extension and knowledge products

Despite the current emphasis on pluralistic provision of extension services, findings show that governments are still the key providers of extension in all five countries. This is particularly evident in countries where the private sector is still relatively young, such as Ethiopia, and in the subsistence crop sector that is less attractive to private investment.

Most agencies (such as CIMMYT and ICRISAT) and projects (such as the regional Drought-Tolerant Maize Initiative (DTMI) and the International Food Policy Research Institute (IFPRI) Strategic Analysis and Support Knowledge System (SAKSS)) work with government extension providers at all levels across and within countries.

NGOs also provide extension services and media (such as Women in Agricultural Development and Environmental Conservation (WADEC) in Tanzania, Total Land Care in Malawi and Tanzania, and Sasakawa Global 2000 in Ethiopia. NGOs commonly either co-opt or collaborate with government extension workers, and agencies and projects often deliver extension services partly through agreements with NGOs as well as government extension agents.

The private sector markets inputs (seed, fertiliser, herbicides and pesticides) and carries out direct extension (as discussed further in Section 4.2.3) using knowledge products such as advertising and marketing materials. Through appropriate government institutions, such as the Seed Testing Unit in Malawi or the Tanzania Organisation Seed Certification Institute, the private sector is regulated to ensure that only good-quality seed is sold on the market, as a way of protecting farmers. Similar regulatory mechanisms are also in place for agro-chemicals as well as inorganic fertiliser.

As a key partner to public extension services, synergies are established through public–private partnerships (PPP) where among other activities and services, the private sector provides demonstrations of their products supervised by village extension providers. These demonstration plots also serve as stands during field days and agricultural shows where both parties explain to farmers and other visitors the technologies being demonstrated. Such practices have raised the visibility of individual private companies and the demand for their products and services from farmers.

The private sector also leverages its marketing through identifying farmer field schools supported by government/agencies. As the seed company Wakala Africa in Kenya noted: *"convincing small-scale farmers can take a lot of resources"*. To reduce costs Wakala Africa identifies when the government-affiliated farmer field schools in Embu have their field days. For example, during the maize harvest, Wakala Africa joins in the field days to target them.

The extent to which the private sector is involved in promoting maize–legume technologies and CA practices is related to the wider national policy and regulatory environment. Thus the private sector has a much greater role in Kenya than it has in Ethiopia.

Other providers of extension and knowledge products in the countries concerned are networks. The main providers are the African Conservation Tillage Network (ACT) and related national conservation agriculture task forces, crop insurance providers (such as *Kilimo Salama* in Kenya), credit providers, and farmer unions such as the National Association of Smallholder Farmers in Malawi, and associations.

Government bodies that engage to some extent in providing extension and knowledge products (in addition to the Ministry of Agriculture extension services) include public seed companies or parastatals (such as Kenya Seed Company, and in Tanzania the Agricultural Seed Agency), and scientists in national agricultural research institutes (through technology dissemination units or projects). Trade and industry ministries may become involved where agricultural products form the raw materials for industry (e.g. soybeans in Ethiopia) or where private operators would like to engage in export of agricultural products such as seed or grain (e.g. white common beans from Ethiopia). The Ministry of Trade and Commerce in Malawi issues an export certificate once government decides to allow export specific agricultural produce.

Politicians also act as special extension agents where they mainly play a lobbying or advocacy role for some proven technologies and agricultural practices. This starts when they are invited to open agricultural shows and field days to appreciate these practices and technologies. Once politicians have been convinced about a particular technology, they publicise it in their rallies and meetings, which serve as a 'convincing' voice to the listening farmers. Tanzania's public seed company, Agricultural Seed Agency, uses local political leaders or village leaders to sensitise its constituencies about seed varieties it has for sale.

Of their own initiative, politicians also may promote CA as a suitable response to climate change (Kenya) or promote uptake of hybrid maize varieties to enhance food security (Malawi). In Malawi FISP has been used to raise the uptake of improved maize and legume varieties, and has contributed to a recent improvement in maize productivity. In recent years, the FISP has also been used to promote CA. Extension workers motivate farmers to use improved maize and legume seed and inorganic fertilisers under CA practices.

In practice, many and varied kinds of horizontal and vertical institutional linkages exist among various government, private and NGO providers of extension and knowledge from national to local administrative levels. This is illustrated in relation to the SIMLESA project in Section 4.2.2.

4.2.2 Institutional linkages between SIMLESA and other stakeholders involved in maize–legume technology dissemination

Institutional linkages are essential for SIMLESA to be successful in technology dissemination in the short term, and in its sustainability in the longer term. To this end, the team carried out simple stakeholder mapping exercises with SIMLESA staff at national and field levels. In all cases key linkages were with government extension staff and seed agencies, private seed companies and; farmer associations/groups. In addition, the project had strong linkages with CIMMYT and ICRISAT.

Whilst in Malawi and Tanzania the SIMLESA project had strong linkages with the Conservation Agriculture Task Force, this was not the case in Kenya. Findings from Ethiopia indicated that linkages with other key stakeholders still require strengthening. This could be addressed by establishing innovation platforms.

SIMLESA could still make other productive linkages, for example, with DTMI, the Alliance for a Green Revolution in Africa (AGRA), the African Seed Trade Association, and ACT.

Figures 4.7 and 4.8 are examples of the many linkages that SIMLESA already has. The first example is of the institutional linkages of SIMLESA at the national level in Malawi (Figure 4.7) and the second example is of the stakeholders in the Innovation Platform in Awassa, Ethiopia (Figure 4.8).

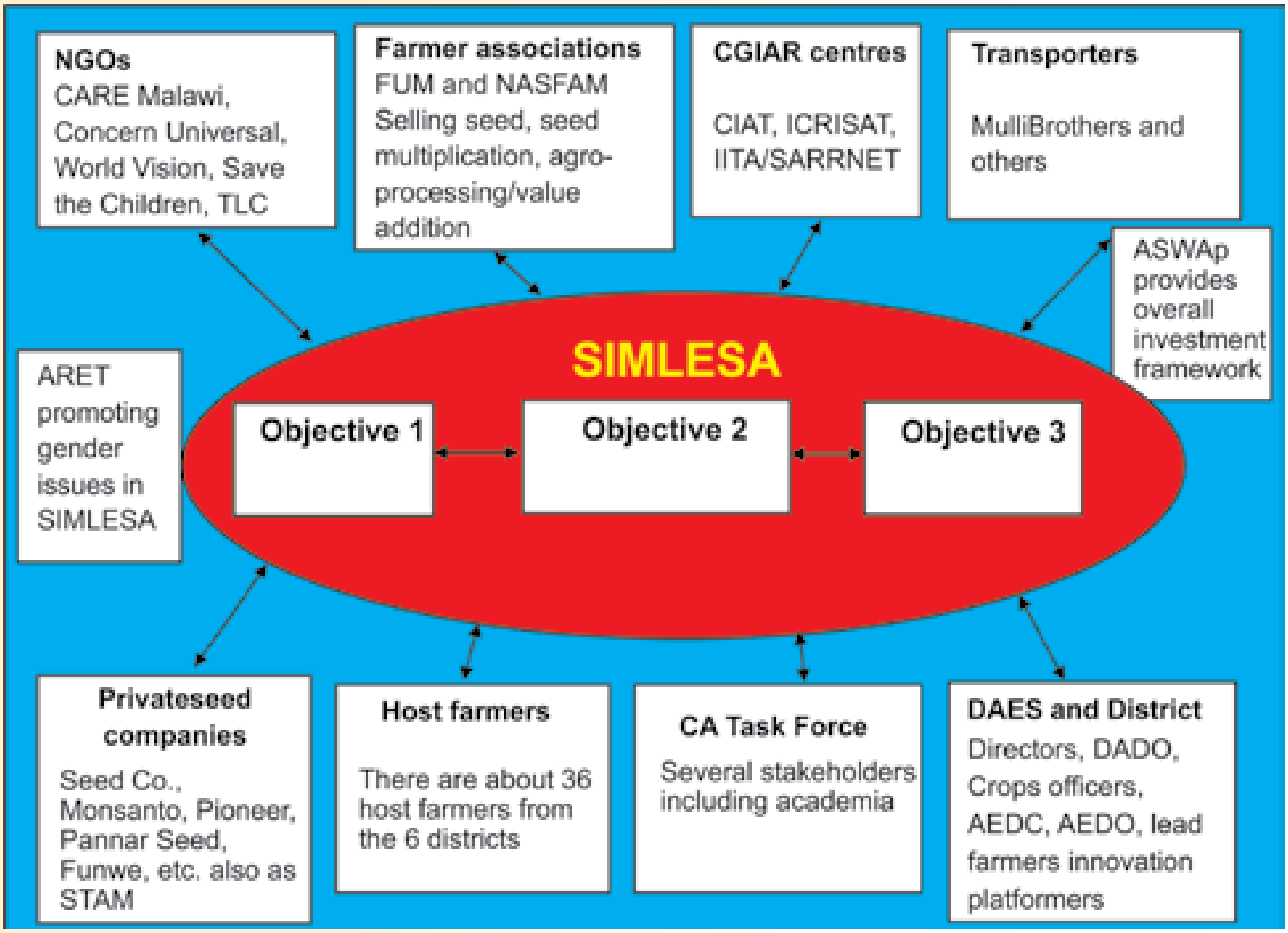


Figure 4.7: SIMLESA institutional linkages in Malawi.

4.2.3 Extension approaches

This section outlines first the extension approaches that were common and prevalent in all countries. Next is a discussion of other extension approaches that were being taken in some contexts. Many of these could also be applied in other contexts both within and beyond the five countries SIMLESA is focusing on currently.

Extension is commonly, but not always, supported by knowledge products. Some knowledge products are a form of stand-alone extension (like radio broadcasts). Knowledge products such as written, broadcast and electronic media are discussed separately in Section 4.2.4. In practice, many of the extension approaches discussed in this section incorporate the use of some knowledge products.

Several extension approaches were common to all five countries. The main one were: visits by extension officers to farmer groups and to lead/champion/progressive farmers; use of experimental trials, demonstrations and field days; agricultural shows; farmer field schools; and informal farmer-to-farmer dissemination. All these approaches are well tried and tested.

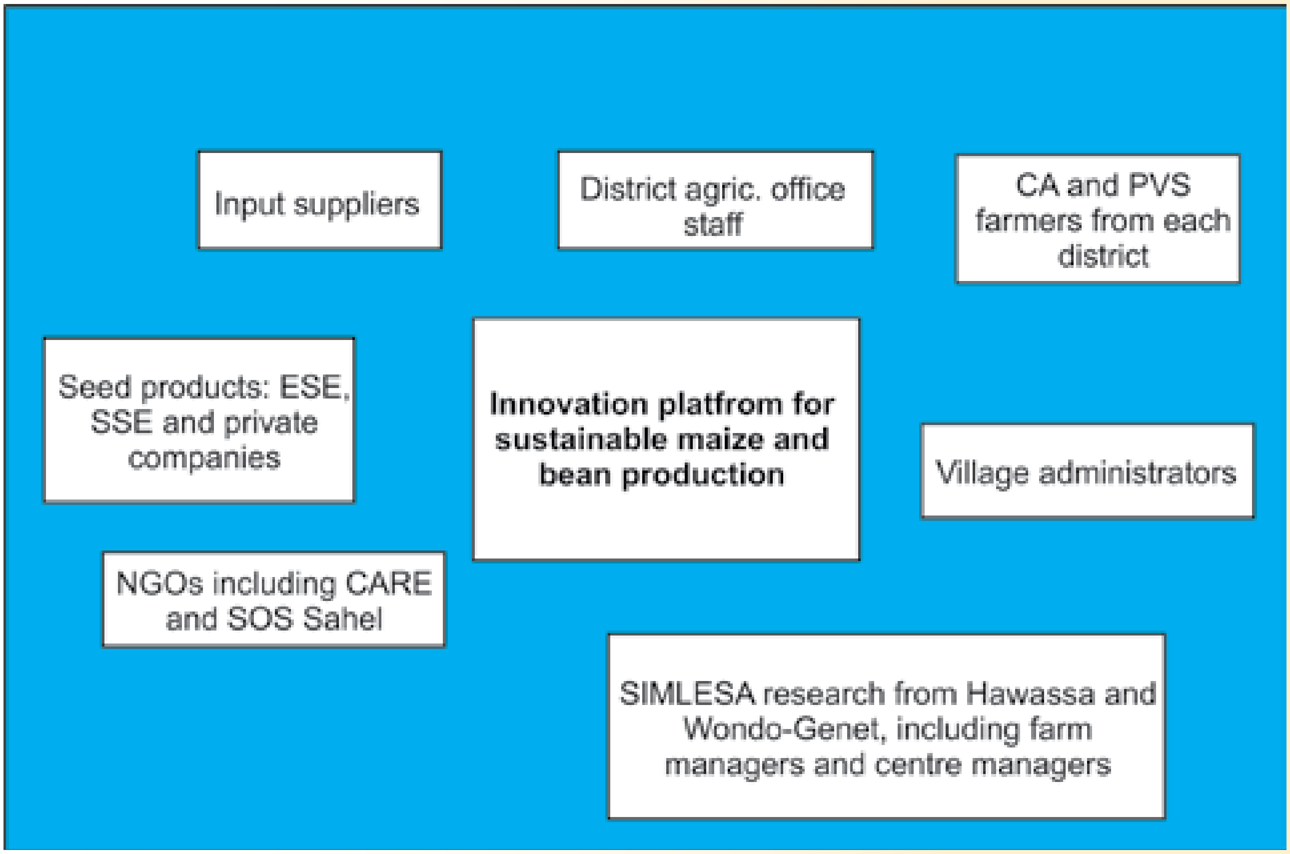


Figure 4.8: Innovation platform in Awassa, Ethiopia.

The study found that field days and demonstrations are particularly effective approaches, as long as the field days are not too formal (discussed in Section 4.3). In Ethiopia (and in the other SIMLESA countries) tillage has long been recommended practice. Findings from Ethiopia were that CA demonstrations clearly showing techniques and results help to convince farmers and others that the practice of no/minimal tillage has advantages over tillage.

Evidence of the effectiveness of field days was also gathered in the desk review as shown in the following case study.

4.2.4 Knowledge products

The study gathered evidence on available knowledge products on the maize–legume cropping system and on conservation agriculture through interviews and document collection. This section comments briefly on available communication infrastructure before providing findings on knowledge products designed for international, service provider and farmer levels. Note that materials including hard or soft copies of posters, leaflets, case studies, documentaries, etc., that were collected in the four countries visited are listed in Annex 6, Volume 2.

Aside from government extension services (supplemented by some NGO and private sector extension provision), other communication channels were mentioned. Those mentioned most were the increased ownership and use of mobile phones, and the high levels of radio ownership and audiences/listeners.

Case study 6: Field days for push–pull technology in Kenya

Field day participants included farmers practising push–pull technology (PPT), non-PPT farmers, local leaders, researchers, district and division agriculture and livestock extension workers, NGOs, community based organisations and farmer groups of diverse backgrounds. The participants were asked to compare and evaluate PPT and check plots during their participation in the event. At each field day 30–35 farmers with no previous exposure to PPT were randomly selected to take part in a research study with a final total sample of 1492 participants from 45 field days.

A total of 90% of respondents agreed that the field days assisted them to acquire knowledge and skills related to PPT components. In particular, the field days enabled them to learn about biology and damage caused by stem borers (91.6%), biology and damage caused by striga (89.6%), concept of PPT and how it works to control both stem borer and striga (92.3%) and considerations in planting cereals using PPT (89.7%).

On the overall effectiveness of field days, 97% of the respondents noted that the field days enabled farmers to learn new agricultural information, 90% indicated that farmers' expectations were achieved, 98% felt that they would attend subsequent field days, and 96% recommended field days as an appropriate method of disseminating new technologies. A total of 75% of respondents indicated they had a high level of confidence in implementing PPT, suggesting that field days were effective in demonstrating the potential of PPT and how to implement the technology on the farm (Amudavi et al. 2009).

A range of other extension approaches were found to be in use in certain contexts in the countries visited as shown in Table 4.5.

International level knowledge products

The knowledge products are in three overlapping categories. At the international level, the study found that websites, including those of the ACIAR, ACT, CIMMYT and SIMLESA, provide relevant information on CA practices and/or particular maize–legume cropping technologies.

Other knowledge products include publications in internationally reviewed journals, international workshop proceedings (such as those of the World Conference on Conservation Agriculture 2011) and newsletters (e.g. that of CIMMYT and of the Sasakawa Africa Association). In addition, ACT has produced detailed and informative case studies on CA which are available both in hard and soft copy. Through the involvement of ACIAR several radio broadcasts, television documentaries and press releases regarding the SIMLESA work have been aired in and beyond Australia.

Mid level knowledge products

A mid-level of knowledge products can also be identified. These include national and regional products designed for policy makers and maize–legume/CA service providers. Knowledge products at this level include two-page fact sheets in English produced by CIMMYT on CA; ACT case studies and guidance sheets; and articles in regional newspapers. For example, the East African (a weekly newspaper, based in Nairobi) covers six countries in East Africa and regularly carries articles related to agriculture.

Field level knowledge products

A wide range of field-level knowledge products were identified by the study team (Table 4.6).

Table 4.5: Extension approaches in use in some contexts

Approach	Notes
Innovation platforms	In use by SIMLESA but variable use beyond the project.
Discussion groups/Dialogue platforms	Discussion groups are sometimes set up at farmer field days (SIMLESA Kenya) and by private seed companies during agricultural shows (Kenya Seed Company). Not dissimilar to innovation platforms, WADEC in Tanzania set up dialogue platforms where various stakeholders come together to share their needs, challenges and priorities, which in turn inform the research agenda.
Action planning	The Ministry of Agriculture in Malawi mobilises clusters of farmers at village level for action planning based on a discussion about their problems related to agricultural enterprises.
Conservation Agriculture Task Force	SIMLESA is linking with this national task force in Kenya and Tanzania.
Exchange visits within and between countries	On a local scale supported by SIMLESA Kenya and Mozambique (visits between innovation platforms and farmer groups). Less evidence of cross-country exchange visits though referred to by WADEC, Tanzania, and DTMI.
Demonstrations arranged in strips along roads	Demonstrations are prevalent, but an approach being taken in Malawi, *mundandanda*, is a less common variant. The demonstrations are on a stretch of roadside gardens for greatest visibility and cross learning.
Farmer visits to scientists	An extension approach taken by WADEC which takes farmers to research institutions.
Trade fairs	Not as common as field days or agricultural shows. Trade fairs can be convened by public, parastatal or private seed companies. Farmers visit the location where the seeds are produced and have the opportunity to meet with the breeders and ask questions (the Agricultural Seed Agency in Tanzania for example hosts trade fairs known as Nane-Nane).
Brokerage and small packages	An innovation systems approach in which an informed agency liaises between input suppliers and village based advisers who provide advice, run demonstrations and small packages of inputs as a business (Kenya and Tanzania, Farm Input Promotion Services—FIPS).
Drama	An innovation platform in Meru, Kenya preparing a play explaining the use of CA. Similarly in Tanzania WADEC work with youth who go round the district performing dramas carrying specific messages.
Training of trainers	To ensure widespread scaling-out of technologies, training of trainers is employed by the High-Value Traditional Crops project of the Kenya Ministry of Agriculture.
Farmer training	Formal farmer training—less common now as other more participatory approaches are taken up—but still reported in some instances.

Table 4.6: Field level knowledge products with potential for wider use

Knowledge product	Notes
Posters	In English or local language, used during field days, agricultural shows and for private sector marketing in agro-dealer premises
Flyers	Very brief, often A5 size, one-sided glossy sheets advertising various varieties and technologies (mostly produced by private sector) Some 2-sided A4 ones also, for example those (in English) describing and promoting crop insurance schemes (*Kilimo Salama*, Kenya)
Brochures/Leaflets	Of various quality, length, language and for varied audiences
Information stands	Information stands for use at agricultural shows, trade fairs and field days. Usually combine use of posters, flyers, leaflets (and actual seed and input samples)
Radio broadcasts	On both national and community radio stations. Those on community radio stations often use local language. Some are interactive with phone-in and question-and-answer sessions. Widely used though in some places considered too expensive to use as a dissemination media
Video clips	Made by various SIMLESA project teams with a view to using them during field days
TV	This was referred to rarely—considered expensive and with little reach to smallholder farmers
Mobiles	So far mostly used to access market prices for maize and some legumes. Also used for other value chain activities where facilities allow, for example through the M-PESA money transfer system in Kenya
Comic strips	One example from Kenya, the Shujaaz comic produced monthly by Well Told Story. Carries agricultural messages each month, designed for youth. Wide readership in and beyond the borders of Kenya. Has accompanying radio broadcasts on over 20 community radio stations, again some of which are accessible by neighbouring countries.
Signs and symbols or totems	For trials, participatory variety selection, and demonstrations, small signs are needed to distinguish between different varieties and technological practices. Some seed companies use symbols/totems to facilitate communication with farmers for example Seed Co (Malawi) use monkey, elephant and lion totems to distinguish between different varieties: SC 403, SC 719 and SC 627 to communicate early maturing, drought tolerance, and late maturing but high-yielding maize varieties in that order.

Many of these methods are used in combination with an extension approach. For example, posters, flyers, leaflets, brochures and newsletters may all be used during field days, agricultural shows, trade fairs and even demonstrations.

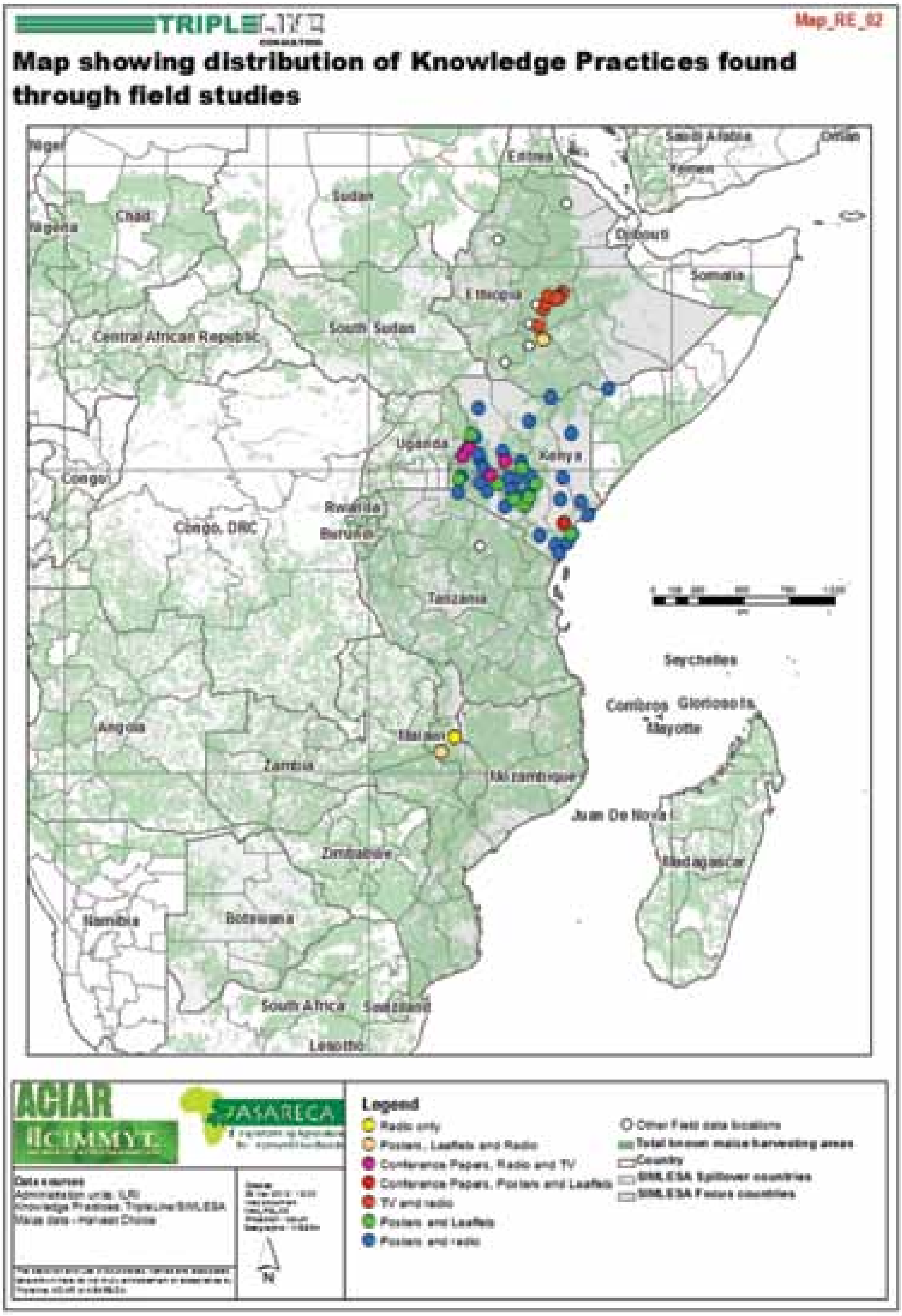
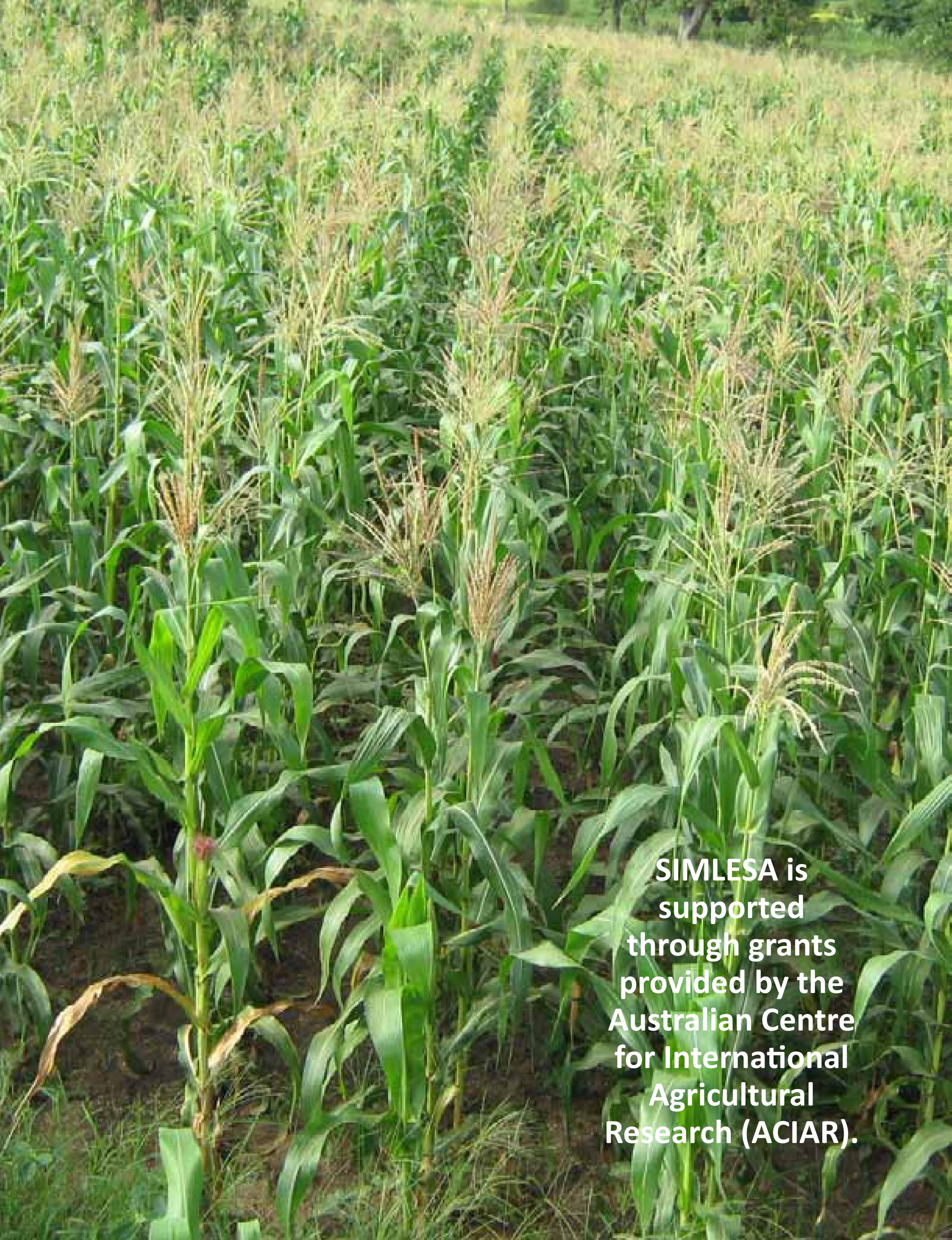


Figure 4.9: Knowledge practices reported from field interviews in all five countries.

In the reported data that were geographically located, one knowledge practice is rarely adopted and instead a series of practices have been used in combination. Posters have the widest appeal in these studies and are used in several countries (Figure 4.9) but use of leaflets is also widely reported. The use of radio is widespread in Kenya, but these locations are mostly connected with a single interview based around the arid and semi-arid districts used in the Orphan Crops project. Radio is also reported several times in Malawi. Television is less widely used (only reported in Kenya and Ethiopia).



SIMLESA is supported through grants provided by the Australian Centre for International Agricultural Research (ACIAR).

Part 3

Conditions for scaling out and spillovers

5 Findings on factors influencing scaling out and spillover

This chapter first sets the scene for the analysis on factors influencing scaling out and spillover by framing it around an innovation systems analytical framework (Section 5.1). Section 5.2 details findings regarding factors influencing scaling out of technologies and knowledge products related to maize–legume systems. Section 5.3 focuses on findings regarding factors that influence spillover of maize–legume technologies and knowledge products.

5.1 The analytical framework

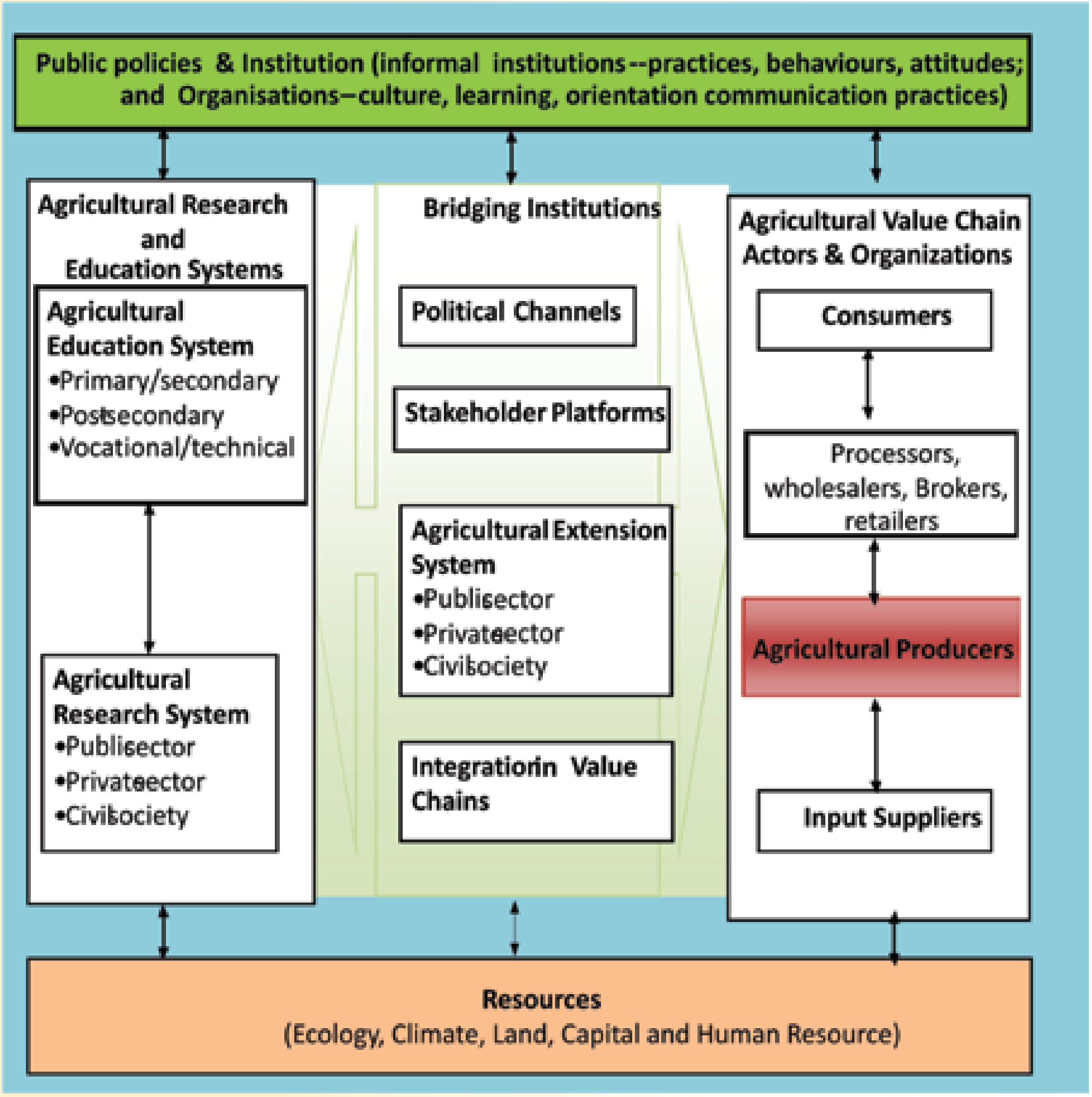
This section analyses the literature review and fieldwork findings using the analytical framework as a guide. The framework selected during the inception phase of the study is a modified national innovation systems framework taken from Spielman and Birner (2008) (Figure 5.1). Many of the constraints and enabling conditions for scaling out and spillover are depicted in the contextual boxes as they concern policy and institutional issues (top box), or agro-ecological and socio-economic resource issues (bottom box).

The SIMLESA project, with its focus on testing, scaling out and spilling over of successful varieties and conservation agriculture practices through a variety of extension approaches supported by relevant and varied knowledge products, can be seen as a bridging institution (centre of Figure 5.1. Technologies arising from public, private and civil society (on the left) are made available through scaling-out approaches, knowledge products, organisations and structures (centre) to value chain players, including farmer organisations, seed companies, processors and ultimately consumers (right hand side). This framework helps us to view the SIMLESA project objectives and activities as a system, recognising the need for, and interdependence of, each element, and to identify which elements need to change for successful scaling-out and spillover (Sections 5.2 and 5.3).

According to its project proposal, SIMLESA aims to: *enhance the process of evaluation, adaptation* ***and delivery*** *of value-adding and profitable production options to smallholders that are linked to market opportunities and provide reliable solutions to problems of food security, rural development, system sustainability and resilience* ***in the five partner countries and beyond.***

The project is therefore adding a new component to the national innovation platform by reaching out to (and learning from) other countries in the region, and also from multi-lateral and multi-country public (e.g. CGIAR) and private sector (e.g. multinational seed company) institutions.

The literature review conducted by this study responded to this by identifying and analysing past experiences, mechanisms and conditions that have enabled knowledge and technology scaling out **and** spillover within **and between** the countries of Eastern and Southern Africa and elsewhere.



Source: Spielman and Birner (2008).
Figure 5.1: Analytical framework.

The fieldwork conducted in Kenya, Ethiopia, Tanzania and Malawi (supplemented by a review of documents from Mozambique) added to the academic review through significant insights on the range of technologies selected by farmers and researchers, and their accessibility within and beyond their countries of origin. The fieldwork deliberately sought the differing perspectives of project staff, NGOs, the private sector, government officials and women and men farmers.

The five SIMLESA countries differ one from another in their history, culture, politics and development pathways, but all have major maize-based farming systems that can form the basis of sustainable, productive and profitable livelihoods for farming families if appropriate production and post-harvest technologies are developed, delivered and adopted. These form the value chains on the right side of the framework (Figure 5.1). The adoption of a value chain approach within an innovation systems framework is a reality in the region. For example, the Kenya Agricultural Research Institute (KARI) has

recently adopted the value chain approach for its entire research strategy.
Although the SIMLESA project is still feeling its way with innovation platforms, there are several examples of successful sub-Saharan African platforms to draw on (see Adekunle et al. 2012).

5.1.1 Public policies and institutions

The literature review (Chapter 3) emphasises the need for an over-arching enabling environment for agriculture, where political will and leadership is backed up by strategies, policies, regulations and resources that allow pluralistic research, extension and entrepreneurship to flourish together to the benefit of semi-subsistence and commercial farming families.

Three key aspects of this enabling environment relevant to SIMLESA are: a) land tenure arrangements that provide the security for men and women farmers to invest in the long-term health of their land; b) mainstreamed government support for conservation agriculture, and c) inter-governmental agreements leading to harmonised seed policy (see case study in Section 4.5).

The SIMLESA project is able to draw on the huge experience and expertise of organisations that serve the public good, such as the CGIAR centres. The most relevant of these to SIMLESA are CIMMYT for maize and ICRISAT for legumes, ILRI for livestock issues (e.g. maize stover quality for livestock feed, change from free grazing to restricted grazing), the World Agroforestry Centre for alternative fuel and feed sources to stover used for ground cover, and IFPRI for food security and extension issues. In addition, there are specialised regional centres and networks such as the African Conservation Tillage Network, the Africa Challenge Programme, Sasakawa Global 2000, DTMI, AGRA, the African Seed Trade Association and relevant ASARECA programmes.

5.1.2 Resources (ecology, climate, land, capital and human resources)

Maize-based farming systems span a huge range of ecologies as maize is itself a versatile crop capable of growing from warm temperate to tropical, and from semi-arid to humid conditions. The range of legumes covered in the project also reflects the ecological range from semi-arid through to sub-humid, from neutral to acid soils, from sands to clay (although CA works best on lighter soils) and from low through mid to high altitude.

In all five core countries populations are growing very fast by global standards and land is becoming a limiting factor to sustainable land-based livelihoods, requiring radical solutions. Conservation agriculture and the consequent changes farming systems bring about could be one such radical adaptation to both land scarcity and the changes that are likely due to climate change (higher temperatures and more frequent droughts and floods).

The project is mainly aimed at 'smallholder farmers', but these span a wide range from semi-subsistence farmers to fully commercial ones. Many of the technologies promoted by SIMLESA require cash (for jab planters, herbicides and seed) and an investment in the long-term health of their farms. It is unlikely that conservation agriculture will increase crop yields or soil fertility within one or two seasons. If the transition from conventional to CA is not supported financially through other measures, then only with sufficient resources will benefit, further exacerbating existing social inequalities.

Smallholder farmers are both women and men, with some households being female-headed on a temporary or permanent basis. During the fieldwork, gender was explored in relation to the appropriateness, accessibility and uptake of technologies for both women and men. When questioned, many interviewees commented that practices such as CA and varieties were 'gender neutral'. More than one researcher admitted that they were not well-versed in gender issues. Gender issues are explored in Section 5.3, and conclude that far from being gender neutral, CA and varieties have strong gender aspects. These include changing labour loads for men and women, the potential change in tasks for women and children implied in a change from free to restricted grazing, and the need to gather fuel and feed from alternative sources if maize stover is left on the field.

Preference for certain varieties and technologies can also vary between genders, with women tending to select varieties for domestic use and men for cash sale.

Interviews with *Kilimo Salama*, a crop insurance project in Kenya, indicate that around 70% of their customers are women. This implies that women are more risk averse than men.

In general, the project has not addressed gender in a comprehensive manner, but rather has assumed that gender is covered if women are involved in participatory variety selection (PVS) and invited to dissemination events. Gender training for the SIMLESA project was carried out in the early stages of the project, however, repeat training may be necessary that explains how gender can be applied to specific situation. Improved understanding of gender issues in institutions will result in increased inclusion of women in the research and development stages, therefore improving out-scaling and spillover as these new technologies will already be targeted to women farmers. Chapter 6 includes further reflections on findings concerning gender.

5.1.3 Agricultural research and education systems

The literature review indicates that farmers conduct their own research to adapt to the many different niches encountered in the five SIMLESA countries. The SIMLESA project strategy to involve women and men farmers in technology selection through PVS and participatory CA trials acknowledges the importance of their participation in selecting technologies that are relevant to, and viable in, their situations.

As reported in Section 4.2 (and tabulated in Volume 2) the SIMLESA project is testing a large number of hybrid and open pollinated maize varieties and legume species (pigeon pea, common (*Phaseolus*) bean, groundnut, soybean and cowpea) for both domestic use and income generation.

Women and men farmers are now selecting hybrids for drought-prone areas, e.g. MH130 in Ethiopia. Maize hybrids and OPVs address low yield, disease and drought constraints. Those varieties most liked by farmers are being multiplied and disseminated through public and/or private seed enterprises within individual countries. Most hybrids remain in the country of origin, although one or two (e.g. SC627) are more widespread in different countries of the region through sales by Seed Co. Similarly OPVs are mostly used in their country of origin, although ZM521 is found in Ethiopia, Malawi, Mozambique, Tanzania, Uganda, Zambia and its native Zimbabwe.

The question is why are these varieties (mostly) so confined in their spread, when there would seem to be good reasons for testing them more widely across the region?

Incorporating legumes in maize-based farming systems enhances soil fertility, household nutrition, income generation and pest management (e.g. Striga). The mix of legumes tested and promoted varies among the core SIMLESA countries. For instance, pigeon pea is only promoted in Malawi and Kenya, groundnut only in Malawi and soybean only in Ethiopia and Malawi. As with maize, the common finding is that the varieties developed in one country remain there (at least at this stage of the project when there has in some cases been only one full season of on-farm testing), despite having characteristics that could be valuable in similar conditions in other countries of the region. Some legume species such as soybean are principally for generating income. For example, in Ethiopia the private sector has invested in oil production from commercially-grown soybeans. The government is encouraging this through the development of suitable varieties for the acid soils in the sub-humid north-central and west of the country, which is otherwise under-developed). Similarly, white Phaseolus beans are being exported, while the mottled and red beans are mainly for domestic consumption and local sale.

While maize and legumes are often grown as sole crops, the SIMLESA project is also looking at intercropping as a way of maximising soil cover, maximising yield (and therefore income) per acre, enhancing soil fertility through leaf drop and rhizobial nitrogen fixation, and reducing pest and disease incidence. Results are site specific, however, positive partial budgets have been observed from intercropping maize and Phaseolus beans in Ethiopia (see Table 4.1). Results such as these could be shared at least with the other SIMLESA countries through existing channels (e.g. ACIAR, SIMLESA, ASARECA, RAILS ACTN and CIMMYT websites; conferences such as the World Conference on Conservation Agriculture [Brisbane 2011]; and newsletters) (CIMMYT and Sasakawa Global 2000).

Land degradation is highlighted in the literature review as one of the main biophysical constraints to sustainable and productive farming in sub-Saharan Africa, leading to resources such as fertiliser being wasted. The low adoption of many improved practices can be explained partly by the decline in soil productivity (fertility, structure, depth, organic matter, moisture retention) that limits the response to improved seed and fertiliser. CA is a set of principles and practices that can address this pervasive, chronic and, increasingly, acute problem. At the same time it is a mechanism for climate change mitigation as it enables crops to be grown under increasing moisture and temperature stress by aiding water infiltration and reducing soil temperatures.

No-till, together with herbicides, has been promoted in all five SIMLESA countries as it is the pivotal component of CA. However, promotion within each country is quite variable. In Malawi, for example, CA has become one of the key components of the agricultural strategy for the country within the framework of the ASWAp, and is widely promoted in all the agro-ecologies. In contrast, in Tanzania the practice is only gaining ground through the SIMLESA project.

Emphasis should be on designing technologies that are labour efficient for households affected by HIV and AIDS, migration, sickness and bereavement. Also, if farming families are to be more involved in adding value to their produce through processing and marketing, they need to free up time. The different components of CA (minimum tillage, weed control, direct planting, stover retention, intercropping) should be assessed for their labour requirement compared with conventional tillage (including the time taken to provide alternatives to the feed, fuel and construction materials normally obtained from the stover). Farmers are quick to gauge the labour requirement of any new practice in their day-to-day activities, and their assessment of the net gain or loss of time by adopting the new practice would be a valuable complement to research.

The practice of stover retention has the potential to radically change the farming systems of some locations. Maize stover is a (poor) source of livestock feed, fuel (e.g. for tobacco curing) and a construction material. Particularly for small farms, alternatives need to be found (e.g. fodder crops like elephant grass and fodder shrubs for feed and fast-growing woodlots for fuel) and free-grazing restricted within the whole community. This represents a significant intensification of farming practice across the community, and depends on good village governance and community cohesion to succeed.

5.1.4 Bridging institutions

Government extension services still predominate in the four countries visited, although NGOs (usually working alongside government) and private companies (regulated by government agencies) play a part in some parts of the country and for some crops through disseminating inputs and knowledge products in favour of their products. Joint public–private demonstrations are a good example of partnerships between the different providers. In Ethiopia where the private sector is weaker, the predominant partnership is between an NGO (Sasakawa Global 2000) and the government extension and government seed systems.

In Malawi, FISP has been used to raise the uptake of improved maize and legume varieties and has contributed to the recent improvement in maize productivity. In recent years, the FISP has also been used to promote CA (see Case study 7).

The literature review implies that the information needs of farmers and others in the value chain are not being fully met by extension services, and that their numbers, quality and reach mean that farmers, especially those in remote areas, are not receiving the support they need (even in Ethiopia where the number of development assistants has increased from 5000 to 70,000 in the past 10 years). Mechanisms being applied to overcome these limitations include formation of farmer groups of different types (e.g. farmer field schools, farmer research groups, and cooperatives), use of ICTs (FM radio, mobile phones, etc.) to reach larger numbers, and use of multi-stakeholder approaches including public–private partnerships and innovation platforms.

The main extension methods being used in the SIMLESA countries are: visits by extension officers to farmer groups or lead farmers, trials, demonstrations, field days agricultural shows, farmer-to-farmer extension and farmer field schools. Of these, demonstrations and field days were particularly effective, especially where new and sometimes counter-intuitive technologies are being demonstrated, such as no-till.

Other extension approaches being tried in some SIMLESA countries include innovation platforms, discussion groups, action planning at local level, CA task forces, exchange visits, trade fairs, small package distribution, drama, training of trainers and farmer training.

Knowledge products used alongside these extension approaches include posters, flyers, brochures/ leaflets, information stands at the agricultural shows, radio, TV, market prices through mobile telephony, comic strips and signs or totems used by companies to denote specific varieties.

More use could be made of existing SIMLESA experimental data. Good data management and sharing of outcomes of CA and PVS trials could inform lesson learning between the SIMLESA countries and also among the spillover countries.

The private sector is increasingly viewed as an important stakeholder in the innovation system with roles in input provision, technology dissemination and crop insurance (see Chapter 6). Seed companies with regional scope are particularly important for spillover. Inputs provided include seed, but the private sector needs incentives to be involved in food crop varieties (low markup) in remote areas (high overheads). Seed regulation and the costs of taking new varieties to trial can also act as barriers to private sector involvement. Even if demand is high and seeds are available, barriers continue to remain on the farmers' side, due to lack of awareness, poor access and affordability.

Financial services including credit provision and crop insurance are further sectors for private company involvement. As for seed, companies have to be assured of the commercial viability of the business; and it is usual that the poor are excluded from such services due to lack of collateral to borrow against or lack of cash to pay for insurance before harvest.

5.1.5 Agricultural value chain actors and organisations

African smallholder farms range from semi-subsistence to fully commercial units. As families transition from one to another, access roads, communications, and the availability and reliability of inputs and market information become increasingly important, as do the education levels and connectivity of the farmers themselves. All are aspects of the conditions required for scaling out technologies that require the application of new information, materials and skills and penetration into new markets. Although savings and credit cooperative societies (SACCOs) have increased in several of the SIMLESA countries, access to affordable credit for those with limited collateral is a major problem for farmers wishing to adopt technologies requiring cash for materials or equipment (e.g. jab planters, herbicides, seed, etc.).
The role of the private sector in providing inputs at the start of the value chain is covered in Section 5.1.4. Other value chain actors are involved with processing, storage, transport and marketing of crop products. To date the project has hardly considered these, as the traditional research thinking is focussed only on production. As the project involves itself more in genuine multi-stakeholder innovation platforms, it should expand the range of value-chain actors for which it provides technologies and knowledge products because the faster and smoother the flow of products along the value chain, the better this will be for the producers.

5.2 Scaling-out: Barriers and enabling factors

This section draws together all the findings from the study concerning constraining and enabling factors for scaling out. As specified in the terms of reference of this study, four types of factors are distinguished: policy and regulatory, institutional, agro-ecological, and socio-economic; each is discussed below.
During the stakeholder validation workshop in Nairobi participants discussed each barrier and enabling factor. They ranked the constraints according to what they thought were the 'killer' barriers to scaling out and spillover, and identified those enabling factors that they considered are the key drivers of change across the SIMLESA and spillover countries. Information on participant ranking of each is provided at the end of each sub-section. For the validation and ranking, exercise factors hindering and enabling both scaling out and spillover were examined together.

Table 5.2 provides a summary of the constraints and enabling factors that workshop participants classified as most significant.

At the same validation workshop, participants assessed the factors and came up with a set of overall enabling factors and key barriers (which they regarded as 'killer' constraints) to scaling out and spillover. Table 5.3 provides participants' assessment of the key overall enabling factors and killer constraints to scaling out and spillover.

5.2.1 Policy and regulatory

The key enabling and constraining policy and regulatory factors identified by the study are summarised in Table 5.4 and discussed in the following paragraphs.

Table 5.2: Summary of top constraints and enabling factors as identified by participants

Key constraining factors	Key enabling factors
Policy and regulatory	
• Low overall investment in agriculture in recent decades • Insecure land tenure	• Political will • Seed harmonisation
Institutional	
• Low government capacity • Emphasis on production rather than full value chain • Limited access to and affordability and availability of credit	• Establishment of multi-stakeholder platforms • Pluralistic and strong extension • Increased numbers of farmer organisations
Agro-ecological	
• Competing demands for crop residues (western Kenya and Ethiopia in particular) • Farmers accustomed to conventional farming practices	• CA a suitable response to land degradation • CA leads to soil fertility over time
Socio-economic	
• Poor infrastructure • Mind set regarding tillage and free grazing	• CA decreases labour requirements • Reliable markets that can drive value chains

Table 5.3: Key barriers and enabling factors for scaling out and spillover as identified by workshop participants

	Overall key barriers ('killer' constraints)
1	Low investment in agriculture over recent decades
2	Emphasis on production rather than full value chain
3	Mindset of farmers
4	Competing and conflicting demands on crop residues
5	Limited access and availability and affordability of credit
6	Limited availability of quality seeds
	Overall enabling factors
1	CA improves productivity of degraded lands
2	Labour reduction in CA practices
3	A need for effective markets to motivate CA adoption
4	Effective extension services to drive CA

Constraining policy and regulatory factors for both CA and maize–legume technologies

Historically, agriculture has not been an area prioritized for investment by government or donors. From the 1980s until the turn of the century other areas such as education, health, water and sanitation, and governance have received more attention than agriculture.

Table 5.4: Policy and regulatory factors affecting scaling out of CA practices and maize–legume technologies

Constraining policy and regulatory factors	
Common to both CA and maize–legume technologies	
• Decades of low investment in agriculture • Policy commitments that are short term	
For conservation agriculture	**For maize and legume technologies**
• Insecure land tenure	• Outdated seed laws, seed export restrictions, royalties and competition between state/parastatal and private seed companies
Enabling policy and regulatory factors	
For conservation agriculture	**For maize and legume technologies**
• Government and political backing (Ethiopia, Kenya, Malawi and Tanzania) • Change in Constitution (Kenya)	• Conducive policy environment • Increased investment in agriculture • Liberalisation of the seed market • Environment improving for private sector

Policy commitments regarding agriculture tend to be short term, changing with each change of government or even in line with donor preferences and interests. This is detrimental to CA in particular which requires long-term commitment to yield best results.

Constraining policy and regulatory factors for scaling out maize and legume technologies

The main factors constraining scaling out of maize and legume technologies all relate to seed.

The maize market in Ethiopia is inelastic as seed cannot be exported; rather the government purchases any surplus seed and keeps it in the Strategic Grain Reserve. When there is surplus maize on the market prices drop and this can reduce farmer's interest in growing maize.

The Seed Act in Malawi dates back to 1997 and requires updating to capture current issues. The revised Seed Act should incorporate regionally agreed protocols and mechanisms to reduce the sale of fake seed.

The issue of royalties was raised by interviewees of seed companies in Kenya and Malawi. The need to pay royalties constrains seed companies from drawing on government-produced foundation seed to multiply, preferring instead the free public good seed from CIMMYT. Further, because royalties are paid on the amount of seed produced records may not always be accurate, with recorded production of seed being lower than actual production.

Though in general the market is opening up for the private sector across all the countries visited, it is still restricted. There were reports from private seed companies in Malawi, Kenya and Ethiopia of being locked out of more lucrative markets by policies that favour government and parastatal seed agencies. While the well-established government/parastatal bodies tend to retain the biggest market for hybrid maize and some popular and well-known OPVs, newer private sector companies are forced to seek niche markets for other varieties that may be less profitable. This is particularly the case for legumes.
In the validation workshop participants viewed reduced investment in agriculture and insecure land tenure as the most critical constraints to scaling out.

Enabling policy and regulatory factors for scaling out of CA

The study found that CA is seen as an appropriate solution to climate change and soil degradation across the SIMLESA countries. In Malawi, CA has government and political backing. CA is a nation-wide activity under the ASWAp, with every extension planning area implementing CA. Furthermore, agricultural extension and development officers sensitise those farmers receiving farm inputs under the FISP to use the inputs under CA conditions.

National task forces for CA were mainstreamed in appropriate Government departments in most countries and seen to be active, at least in Tanzania and Malawi. There are ongoing initiatives in Malawi and Tanzania to develop policies and by-laws to manage crop residues and restrict grazing in areas under CA.

One change that was reported in Kenya is that the Constitution (2010) will for the first time allow women to own land. This in turn will provide them with the necessary collateral to access formal credit, which they may need to purchase seed, herbicides and fertiliser.

Enabling policy and regulatory factors for scaling out maize and legume technologies

Across all countries there is renewed emphasis on agriculture. Tanzania has a Kilimo Kwanza (Agriculture First) policy and is providing subsidies for inputs. Ethiopia's Agricultural Transformation Plan is investing in agricultural extension, greatly improving the ratio of extension staff to farmers. It also has a policy commitment to double maize production in the next five years and is encouraging foreign investment in legumes such as soybean and chickpea. Malawi continues to implement the nationwide FISP programme, strengthen government extension services, and in 2012 is paying special attention to legume production through a sector-wide approach and nationwide demonstrations. Case study 7 provides further information on how government commitment to agriculture and to maize and legume production can promote scaling out.

Case study 7: Farm Input Subsidy Programme for the 2011/2012 season in Malawi

In 2012, the Government of Malawi is implementing a countrywide Farm Input Subsidy Programme (FISP) for the seventh season following the successful its successful implementation in 2005/2006, 2006/2007, 2007/2008, 2008/2009, 2009/2010 and 2010/2011 that has enhanced food security in the country. For 2011/2012 FISP will concentrate on maize fertiliser, maize seed, legume seed (groundnut, pigeon pea, soybean and bean) and storage pesticides. Beneficiaries of the 2011/2012 Farm Input Subsidy Programme will be fulltime smallholder Malawian male and female farmers who are resource poor. The fertiliser package is expected to benefit in total 1.4 million farmers.

A total of 140,000 metric tonnes (t) of maize fertiliser, 70,000 t of NPK and 70,000 t of urea) will be subsidized. In addition to fertiliser, the Government will also subsidize 7,000 MT of improved maize seed, and 2,800 t of legumes (groundnut, beans, soybean and pigeon pea). Each beneficiary will be entitled to a coupon for purchasing improved maize seed, which will be packaged in 5 kg for hybrid and 7.5 kg for OPV. Coupons will also be distributed for purchasing legume seed (ground nut, soybean, bean and pigeon pea), which will be packaged in 2 kg. Farmers will be required to pay a top up of not more than Malawi kwacha 100 for maize seed while no top up will required for legume seed.

Increased investment in agricultural innovation is taking place within the context of the CAADP framework. Governments across Africa are agreeing to invest around 10% of their GDP in agriculture. Greater investment in agricultural education, research and extension, combined with enhanced policy and regulatory attention to agriculture, will allow for more rapid scaling out of successful technologies. All the SIMLESA and spillover countries have signed up to CAADP, with Malawi, Rwanda and Ethiopia making relatively high levels of commitment compared with Kenya and Tanzania.

The seed sector is gradually liberalising in all five countries and is particularly evident in Kenya and Mozambique (the latter learned from review of documents). This leads to more competition and diversity, which in turn should make better varieties of maize and legumes more accessible to small farmers and thus enhance scaling out. However, this is an ongoing process as seed quality varies.

Similarly, the scope for private sector engagement in maize and legume value chains (from input provision to processing and marketing) is gradually increasing in all the countries. As the desk review showed, greater engagement of the private sector and more opportunities for public–private partnerships provide an enabling environment for scaling out.

Overall, the policy and regulatory environment is generally supportive to scaling out CA practices and maize–legume technology. Workshop participants concluded that the key driver of change is the present political will to invest in agriculture, and for spillover it is harmonisation of seed policy.

5.2.2 Institutional

The key enabling and constraining institutional factors identified by the study and at the validation workshop are summarised in Table 5.5 and discussed in the paragraphs following.

Constraining institutional factors common to both CA and maize–legume technology scaling out

In all countries there are informal savings schemes within communities, and formal credit providers exist. However, the amounts saved within the informal schemes are low. Meanwhile, formal credit requires collateral (which female farmers, particularly wives, may not have) that often is only available at very high and variable interest rates. As they are located in district and provincial capitals, providers of formal credit are also physically less accessible to farmers.

Lack of availability and/or access to credit is a major constraint to scaling out. Smallholder farmers lacking both cash and access to credit cannot purchase expensive seed, equipment, fertiliser and herbicides.

A second major constraining factor is the low capacity of government extension systems, despite renewed investment in government extension. Extension staff are not adequately trained in CA techniques in particular, and knowledge on new maize–legume technologies that may be widespread at higher levels within a ministry of agriculture does not always reach the staff at district and lower levels. Shortage of staff also leads to poor supervision of field staff.

Extension services that lack resources cannot fund very effective extension approaches such as exchange visits, field days and demonstrations, and extension may be restricted to focusing on ‘progressive’ farmers with little onward spread.

This situation is reflected in the SIMLESA project: there are very few demonstrations of CA practices and maize–legume technologies in very few districts. Though the project seeks to expand the number of demonstrations through arrangements with NGOs, one country reported that the amount offered was not a sufficient enough incentive for the NGOs to take up the offer. Neither do local extension offices always have the resources to out-scale demonstrations to other parts of the district.

Table 5.5: Institutional factors affecting scaling out of CA practices and maize–legume technologies

For conservation agriculture	For maize and legume technologies
Constraining institutional factors	
Common to both CA and maize and legume technologies	
• Limited availability and/or accessibility of credit and lack of subsidies for farm inputs • Low capacity of government extension system • Low numbers of SIMLESA demonstrations • Focus on production rather than the value chain	
• Poor coordination • Common traditional practice of allowing animals to freely graze in fields after harvest • Limited availability and effectiveness of jab planters	• Seed availability, shortages and lack of capacity to produce foundation seed • Weak private sector
Enabling institutional factors	
Common to both CA and maize and legume technologies	
• Combination of extension providers and rise in ICTs • Use of multi-stakeholder partnerships (PPPs and innovation platforms) • Availability of crop insurance (though very limited) • Focusing on women	
• National CA task forces • Range of extension approaches • National level linkages • Good links with government, political and local leaders in field	• Increased investment in extension • Effective NGOs linking farmers to markets • Presence locally of agro-dealers • Increasing numbers and strength of farmer unions and cooperatives • Drawing up of seed road maps • Existence of trusted seed companies • Seed units in NARS • Assured markets

A final institutional constraint was the emphasis on production rather than the whole value chain. This emphasis is not confined to the SIMLESA project: it is widespread. For example, farmers in Malawi are heard to say *ulendo uwu tikayamba panjira mumatithawira,* which means, We start the journey together but you desert us along the way. Varieties and cultivation practices spread when it is clear that the uptake will be worth it to the farmer. A whole value chain approach, which innovation platforms can help facilitate, looks at barriers in the entire value chain including the strength and stability of the market. Thus soybean and chickpea production in Ethiopia are particularly interesting to farmers as there is a guaranteed market for outputs. In such a context, scaling out of varieties and farming practices is likely to be enhanced.

Institutional factors constraining the scaling out of CA practices specifically

Though national CA task forces exist and are active in Tanzania and Kenya, the study found that there has been very limited interaction between the task forces and the SIMLESA project. In Kenya, no interaction was evident. In Tanzania the CA task force in the Department of Land Resources only received an invitation to participate in SIMLESA CA activities in 2012, despite the project starting in Tanzania in 2010. Though this study is not an evaluation by any means, it is clear that where there is a CA task force in-country there is much scope for fruitful synergy.

Another area in which poor coordination constrains the scaling out of CA is where activities of different agencies are not aligned. For example, in one location in Malawi one agency is promoting CA for land management, another NGO working in the same area is advising the same farmers to store crop residues for livestock feed.

A common traditional informal practice/institution is free grazing whereby animals are allowed to freely graze on fields after crops have been harvested. This is discussed further under Section 5.3.3. (agro-ecological factors) and Section 5.3.4 (socio-economic factors) but is mentioned here as it can also be described as an institutional constraint.

A final constraint is the limited availability of jab planters. This is seen as an institutional constraint as jab planters are a key input in CA and thus SIMLESA as a project would need to address this constraint either directly or indirectly through training local artisans to make inexpensive and effective jab planters. Furthermore, the design of jab planters is not well suited to heavy and wet soils.

Institutional factors constraining scaling out of maize–legume technologies specifically
Overall, seed is in short supply in all countries visited. Maize seed multiplication must be carried out in isolation and this makes it impractical for small-scale farmers. Legume multiplication is not nearly as profitable as maize seed multiplication and thus not very attractive to most private sector seed companies. Scaling out of legume seed by private sector companies is limited to their distribution networks. For example, seed produced by Seed Tech, which has its production units in southern Malawi, is only available in the southern part of the country where the company has distribution units, even if it may also be suited to the Central Region.

A final institutional constraint to scaling out maize–legume technology is the relative weakness of the private sector in all five countries. Even in Kenya where there are many agro-dealers located in rural areas, inputs are still sometimes not available at the right time and cannot always be of reliable quality. Workshop participants considered that the top three constraints to scaling out across the SIMLESA and spillover countries were: limited capacity of government extension services, emphasis on production rather than the entire value chain, and limited access to and availability and affordability of credit.

Institutional factors that enable scaling out of both CA and maize–legume technologies

Scaling out of CA practices and maize–legume technologies can be enhanced where there is a range of extension providers. For example, in Kenya the field study learned of extension being provided by projects like SIMLESA, government extension services, NGOs and also by private sector companies. Several of the seed companies the mission met had their own marketing teams with agronomists. The companies hold demonstrations, collaborate with the government and SIMLESA in field days and shows, and produce relevant and useful knowledge products.

In Kenya the team met with staff from *Kilimo Salama*, a provider of crop insurance. *Kilimo Salama* provides a basic package of insurance for crop inputs: the amount paid back depends on the extent of drought in that growing season. Already, mostly women farmers were taking up the basic package. They take the risk of spending more on inputs for CA because of the insurance. Such crop insurance schemes are still in their infancy but are likely to become more widespread in and beyond Kenya. Crop insurance is likely to enhance scaling out: with insurance farmers can purchase expensive inputs such as planters, sprayers, herbicides and fertiliser with the knowledge that if the rains fail they will not loose everything they spent. So crop insurance reduces risk for small farmers to try new technologies.
In Mozambique concessionary companies provide inputs in-kind and also in-cash (for labour) to

farming men and women then purchase the crops from farmers after harvest and get their investment back.

Projects that recognise the role women play to produce maize and legumes are particularly relevant. Most of the *Kilimo Salama* clients are women; they are seen to be the active farmers in eastern Kenya, empowered, flexible and reliable. Meanwhile, in Tanzania Total Land Care WADEC seeks to promote women and support them specifically: *"Men are not famers in African society. They attend seminars for example when they hear there is an allowance. Youth and women are the anchor of food security in Africa. So they need to be supported"* (Total Land Care interviewee, Tanzania).

Institutional factors that enable the scaling out of CA specifically

The existence of national CA task forces is a major institutional enabling factor for scaling out CA (and spillover as discussed in Section 4.4). This is especially the case as the task forces are mainstreamed within government institutions. For example, in Malawi the task force is located in the Department of Land Resources and works with the government's FISP.

Extension approaches that enable CA scaling out have been discussed in Section 4.2. They include demonstrations (particularly those located near market places or along busy roads), field days, exchange visits, farmer-to-farmer extension, and farmer observation. Exchange visits need not be confined to farmers/farmer groups/innovation platform members visiting different districts to see CA practices. They can also involve extension staff and of researchers exchanging visits.

One female farmer in Malawi said of her CA demonstration: *"When other farmers were passing here, they used to say this is a waste of time. Why waste time spreading residues like this? This shows that you have nothing else to do with your time! And the same people stop here and ask me why I have such good maize when most fields have poor stands due to dry spells. Because of these demonstration plots, more people have taken up CA in the village during 2011–2012."*

Scaling out of CA practices can be enhanced where there are a range of extension providers. For example the field study in Kenya learned of extension being provided by projects like SIMLESA, government extension services, NGOs and also by private sector companies. Several of the seed companies the mission met had their own marketing teams with agronomists on board. The companies hold demonstrations, collaborate with the government and SIMLESA in field days and shows, and produce relevant and useful knowledge products.

Good linkages at the national level between the project and the government, financial institutions and the private sector can enhance scaling out. Discussions with SIMLESA coordinators in countries visited revealed a varying extent to which strong linkages exist (as discussed in Section 4.2.2). An example of where linkages can provide synergy is in Malawi, where farmers under FISP have been trained in how to use fertiliser more effectively, and this year will host legume demonstrations.

Evidence from all five countries shows that good communication and linkages among provincial and local commissioners, government officials, politicians and traditional leaders can enhance the scaling out of CA practices. Inviting provincial commissioners and prominent politicians to open field days and shows raises awareness of and interest in CA. Support by traditional or religious leaders locally can make a big difference. An example is from Malawi on the practice of burning crop residues for mice (a local delicacy) or collecting it for livestock feed: "The chief has sensitised all the villagers in this area. Anyone found burning crop residue is taken to the chief and is fined a goat or chickens or even taken to the police. Hence people are afraid."

Institutional factors for scaling out maize and legume technologies specifically

Though government extension services have limited capacity as discussed above, there is renewed investment in extension across all the countries. Ethiopia has committed funds to increase the number of development agents from 50,000 to 75,000 across the country in the last 10 years, making the ratio of farmers per development agents one of the best in sub-Saharan Africa. And in Malawi the government extension services are the most common source of extension information, as revealed through the baseline carried out under SIMLESA Objective 1. This disproves common thinking among donors that government extension services are ineffective.

Kenya's Traditional High-Value Crops Programme is a good example of scaling out through the Ministry of Agriculture. The programme builds the capacity of extension, and bulks and multiplies planting material including maize and several legumes and root crops. Operating across 101 districts, the programme has used a training-of-trainers approach and combined it with distribution of initial planting material in each district. The programme has distributed 207 MT of seed to over 15,000 beneficiaries. Beneficiaries pay back in kind by allowing the seed to reach more beneficiaries the following year. Case Study 8 (courtesy of Mary Karanja of the Ministry of Agriculture Traditional High-Value Crops Programme) provides an example of scaling out in green gram production.

Some NGOs are particularly effective in their innovative approaches, gendered approach, and linking farmers to markets. Local agro-dealers can enhance scaling out of maize–legume technologies, as inputs are available close to the farmer. A successful example is the not-for-profit Farm Input Promotions (FIPS) Africa Ltd described in Case study 9. (Please note FIPS is also engaged in spillover as described later in Case study 10 in Section 5.3.1.)

Increasing numbers and strength of farmer unions, cooperatives or associations can enhance scaling-out through improved access to inputs and the market and enhanced opportunities for information exchange and learning. Furthermore, existence of seed companies trusted by farmers can enhance uptake and scaling out of new technologies. Strong seed units in national agricultural research systems can enhance availability of foundation seed.

Assured markets sometimes act as an incentive for production. This is the case in Ethiopia where foreign investment in soybean and chickpea has been encouraged and farmers are assured of a market. As with the policy and regulatory factors reported in Section 5.2.1, overall institutional factors are generally enabling to scaling out both CA and maize–legume technologies. Workshop participants concluded that the most important enabling factors were, first, the establishment of multi-stakeholder platforms, second, pluralistic and strong extension and third, increased numbers and strengths of farmer organisations.

5.2.3 Agro-ecological

Table 5.6 summarises the key enabling and constraining agro-ecological factors identified by the study, and are discussed in the paragraphs following.

Constraining agro-ecological factors for scaling out CA

A major constraint, if not the main constraint, is the demand for crop residues for other uses—primarily as livestock feed, but sometimes as fuel. This point came out most strongly in the study across all countries. It is less of a constraint where farmers have enough land to provide residues for livestock as well as to use in CA. SIMLESA is trying to introduce alternative sources of fodder by liaising with The World Agroforestry Centre (ICRAF) to set up leguminous fodder nurseries.

Case study 8: Scaling-out of green gram seed and grain production

This study involved high key orphan crop (green grams N26) in Igembe South (1105 kg from 2 kg in 4 crop seasons).

1. Farmer: Mr Peter Wambua; Division: Kanuni; Location: Kiguru
2. Seed issued: 2 kg during long rains 2007—planted 0.25 acres (0.1 ha) and harvested 444 kg
3. Ministry of agriculture retrieved 4 kg for secondary beneficiary: farmer gave 40 kg of see to 20 neighbours who planted a total of 5 acres
4. Farmer replanted 8 kg (1 acre, 2008); 112 kg (1.5 acres, 2009); and 25 kg (3 acres, 2010)
5. Farmer retained as food/seed: 100 kg, 30 kg, 110 kg and 120 keg in 2007, 2008, 2009, and 2010 respectively
6. The neighbours harvested 14,560 kg (162 bags) and 10,400 kg (115 bags) during the long rains of 2008 and 2009 respectively
7. By the long rains of 2010: Farmer had 4 acres under green grams. Harvested 1515 kg (16 bags); selling price KES 6750 per bag
8. During the long rains of 2010 a total of 43 neighbours planted 54 acres under G/G N26 and harvested 24,186 kg (269 bags)
9. N26 (nick named Agriculture/Nylon) by local farmers and traders is now on sale in local markets as Kathithine, Kimongoro and Maua.
10. Farmer sold 300, 1400, 810 and 1380 kg as food/seed @ KES 90, 75, 100 and 75 per kg in 2007, 2008, 2009 and 2010 respectively
11. 51,105 kg from 2 kg seed in 4 crop seasons is a big contribution to food security

Peter Wambua, primary beneficiary

Mwinzi Kimwere, secondary beneficiary

A second constraint is that farmers are accustomed to tillage. (This constraint could also be seen as a socio-economic constraint as it relates to beliefs and human capacity.) An interviewee in Malawi pointed out that since people are comfortable with what they have been doing for many years, changing their mindsets is difficult. And an interviewee in Ethiopia pointed out that there is a psychological block to no-tillage: farmers have become used to tillage as the accepted way to farm. Furthermore, tillage is seen as the 'modern' way to farm.

Another constraint is intercropping under CA. Some species of legumes do not perform well under shade, even though they have other positive attributes.

Farmers consider that CA is harder to apply on heavy soils. The problems cited are: it is difficult for a jab planter to penetrate the soil when it is wet, as the clay can clog up the planter; and light hand weeding with a hoe, which is commonly carried out in the absence of herbicides, is harder.

Scaling out a practice relies on consistency in agro-ecology. Variation in agro-ecology can constrain scaling out of both CA and varieties. Agro-ecology can vary even within a plot of land, and certainly within districts and regions. Certain varieties or specific ways of applying CA may not be suited to neighbouring areas with different topography, soil types, altitude and rainfall. Indeed, as pointed out by ACT, CA is not suited to all farming systems, such as in pastoral areas where minimal cropping is practised and free grazing of livestock is necessary. Just as similar agro-ecologies can exist in different countries, thus enhancing the potential for spillover, so different agro-ecologies in close proximity to each other can slow down scaling out.

Table 5.6: Agro-ecological factors affecting scaling out of CA practices and maize–legume technologies

Constraining agro-ecological factors	
For conservation agriculture	**For maize and legume technologies**
• Competing demands for crop residues • Farmers accustomed to tillage/ conventional farming practices • Some legumes not shade tolerant • Agro-ecological variation, CA not suited to all farming systems, CA hard to apply on heavy soils	• Erratic/insufficient rainfall • Legume multiplication not a profitable business • Risks of contamination during maize seed multiplication by smallholders • Agro-ecological variation
Enabling agro-ecological factors	
For conservation agriculture	**For maize and legume technologies**
• Suitable response to climate change in arid and semi-arid zones • Striga infestation reduces over time • Intercropping reduces need for fertiliser over time • Intercropping maize with pigeon pea ensures more effective and longer ground cover	• Providing a package of technologies • Taking a value chain approach • Introducing drought resistant varieties • Introducing varieties that provide a combination of benefits • Common agro-ecology in surrounding area

Agro-ecological factors constraining scaling out maize–legume technology

Factors constraining scaling out of maize–legume technologies were fewer than those constraining scaling out of CA practices. They include erratic or insufficient rainfall, legume multiplication is not a profitable business, and the risk of contamination during maize multiplication by smallholders.

Workshop participants noted that competing demands for crop residues is the major constraint in western Kenya and Ethiopia, but it is a lesser constraint in other areas with lower livestock populations. They agreed that a major barrier across all the SIMLESA and spillover countries is that farmers are accustomed to conventional farming practices. To overcome this constraint, the technical capacity of extension providers and farmers in CA must be enhanced.

Enabling agro-ecological factors for scaling out CA practices

The major enabling factor is that CA is widely seen as a suitable response to climate change in arid and semi-arid zones. It gradually improves nutrient levels and moisture retention of soil; residue retention keeps soil temperatures low, enhances water penetration and reduces soil erosion. Using desmodium helps control pests and improves soil fertility, and reduces weed infestation gradually over time.

Common interview findings from all countries were that CA is also suited to areas with poor soils and striga (witchweed)-infested soil. Continued use of CA practices leads to a reduction of striga infestation over time (and where desmodium is used this is even more so).

Intercropping cereals with nitrogen-fixing legumes gradually builds up the fertility of the soil, in turn reducing the need for fertiliser in the long term. Intercropping pigeon pea with maize has the additional advantage of providing ground cover and protecting maize residues from grazing, as pigeon pea has a longer growing season than maize.

Enabling agro-ecological factors for scaling out maize–legume technology

Several respondents and organisations noted that providing a technology package, for example a combination of a variety, fertiliser application method, appropriate spacing (and where intercropping, of each variety) is more effective than providing advice on just one technology. Also noted was the importance of considering the entire value chain from the start. Moreover, keeping climate change in mind, drought-resistant varieties are particularly relevant. The value chain analysis SIMLESA is carrying out under Objective 1 this year will be most useful here.

Varieties that provide a combination of benefits are more likely to be scaled out. For example in Ethiopia, Deme bean SUG131 is not only a good variety for intercropping, but also intercropping maize with Deme bean provides good combined yields, the bean has good cooking qualities and it is quite versatile in terms of its ecological range.

Finally where the surrounding areas have the same agro-ecology as where the new technology is applied to start with, it is more likely that it will scale out to these areas.

Workshop participants considered that the key enabling agro-ecological factor for scaling out is that it is a suitable response to land degradation and soil fertility increases over time under CA.

5.2.4 Socio-economic factors

The key enabling and constraining socio-economic factors identified by the study are summarised in Table 5.7, and discussed in the following paragraphs.

Socio-economic factors that constrain scaling out of CA practices and maize–legume technologies

Poor roads (transport), storage and market infrastructure constrain the efficient operation of the value chain, and therefore affect the adoption of new technologies that might lead to surpluses that feed into those value chains.

Farmers' loyalty to tillage was discussed under agro-ecological constraints above. Decades of agricultural advisory services that have stressed the importance of tillage are not easily undone. Tillage is seen as the effective and modern way of farming, while zero tillage seems counter-intuitive. A Tanzanian farmers' viewpoint was: 'How can you produce a crop without tilling the land?' Many farmers are sceptical about CA and are waiting to see the results before they consider trying it themselves.

Another constraint is a deep-rooted suspicion of both herbicides and fertilisers. This was found among farmers across all the countries involved; they think that both damage the soil in the long term.

Another socio-economic factor that constrains scaling out of both CA and maize-legume technology is low capacity. Many farmers have low levels of education, some are non-literate, and unless taught well may find it difficult to absorb the principles behind CA, use of herbicides, or new crops like desmodium.

Lack of capacity relates to extension staff and researchers too. Discussed under institutional constraints, building capacity of extension staff, particularly those working at field level, is necessary in relation to CA practices, as extension staff, like farmers, have a mindset (and training) that tillage is the most effective and modern way to farm.

Table 5.7: Socio-economic factors affecting scaling out CA practices and maize–legume technologies

Constraining socio-economic factors	
Common to both CA and maize and legume technologies	
• Poor road, storage and market infrastructure • Rigid mindset regarding tillage and free grazing • Beliefs regarding fertiliser and herbicides • Low capacity	
For conservation agriculture	**For maize and legume technologies**
• Theft of stover • Free grazing and role of livestock	• Shortage of land • Shortage of seeds on market • Poverty leading to sale of seed • Technology not socially differentiated • Conflict of interest in innovation platforms
Enabling socio-economic factors	
Common to both CA and maize and legume technologies	
• Reliable markets that can drive value chains • Traditional/cultural practices • Farmers fairly quickly convinced by CA and some varieties	
For conservation agriculture	**For maize and legume technologies**
• Sufficient land • Decreased labour requirements • Reduced costs • Nutritional value of legumes	

Further socio-economic factors that constrain the scaling out of CA

Socio-economic factors include issues related to individual and social assets/capacities and, in particular, human capacity and social capital. One common finding across the countries was that in some (but not all) locations, theft of crop residues is a common occurrence. This relates to levels of trust within communities as well as lack of understanding as to the importance of what to some seems a strange practice.

Another factor limiting the scaling out of CA practices is the common lack of financial capital. Many farmers live in states of relative or even absolute poverty; they lack cash, and they may be indebted to local agro-dealers or even lending institutions and therefore are not in a position to draw on more credit. They are therefore unable to access jab planters, herbicides and sprayers.

Free grazing of livestock has already been referred to under institutional and agro-ecological constraints to CA. It is also a socio-economic factor as illustrated in the following quote from a farmer in Tanzania:

> The need to keep crop residue on the field among the people of this area is unacceptable because they don't want their animals to suffer. Here, people like their livestock more than their children sometimes! Among the Maasai for example, when greeting each other, they start by asking you, how are your animals before they ask about the children!! This emphasises the importance of livestock in people's livelihood systems in this area. This is because of the large number of benefits from livestock. They can sell the animals or milk for cash income or even sell manure for cash. This is a major source of school fees for their

> children. A bull in this area costs on average TZS 800,000 (about USD 520) each. With this money, one can buy three smaller animals in the neighbouring district down south, which they fatten and resell hardly eight months after and make TZS 2,400,000 (USD 1,560). What business can give you that much money in such a short period of time?!

Workshop participants categorised poor infrastructure as the top constraint to scaling out, next were mindset regarding tillage and free grazing.

Socio-economic factors that enable scaling out CA and maize–legume technology

In a few instances the study found that reliable markets have emerged that can drive the value chain. For example, soybean production in sub-humid areas of northern and western Ethiopia is flourishing because of external investment and government support.

Traditional or cultural practices can both hinder and help scaling out. Two positive examples are drawn from Ethiopia and Kenya. In the first case, in Ethiopia there is a cultural practice of providing 40 days of community labour during the off-season on natural resource conservation, which could include CA practices. In the second case, the study visit to Kenya learned that farming women and men commonly share good seed with their friends and neighbours (and this is likely to be a practice in the other countries as well).

Despite feedback that farmers are sceptical of CA, that it is counter-intuitive and they would rather wait to see the results over a number of seasons, a fairly common finding in the study was that farmers are actually convinced by the soundness and profitability of CA quite quickly. A CA host farmer in Ethiopia saw leaving stover in the field as being *"like a person wearing clothes"*, with the stover protecting the soil from the elements.

There was evidence of host farmers scaling out CA practices on the rest of their farms at their own expense, and of neighbours taking up the practice having only seen it in practice for one to two seasons.

Further socio-economic factors that enable the scaling out of CA

Where farmers have sufficient land, they are more likely to practice CA on at least part of their land, as they can take crop residues for fodder from other parts of their land. CA is especially appreciated by female-headed households and by households living with or affected by HIV and AIDS. In both contexts, labour is often in short supply and the labour-saving aspects of CA are well-suited to these households. In particular, it is women's role to weed and to carry stover from the field for animal feed: these activities are minimised under CA. Labour released through CA can be used to care for household members with HIV and AIDS, and to carry out other income-generation work elsewhere.

We provide data from a district agricultural officer in Tanzania regarding the labour-saving effect of herbicide use: 1 litre of herbicide covers 1 acre of land, the litre costs TZS 18,000–20,000 (approximately USD 12). If the land was to be tilled using a small tractor or manual labour, the cost per acre is TZS 40,000 (USD 25), then weeding costs around TZS 30,000 (USD 19) per acre.

CA allows for reduced costs in the long term due to reduced labour demands, and reduced need for fertiliser in the long term as natural fertility builds up in the soil. This makes CA an attractive practice to poor households.

The common use of legumes in CA, and in maize–legume technologies (whether intercropped or in rotation), have the additional benefit of providing nutritious food crops for the household, and crops with a market value.

Evidence from Ethiopia shows that intercropping gives consistently better yields than sole crops, and from Malawi increased yields from zero tillage with various crops.

Further, participants at a workshop to validate the findings of the study, ranked CA ability to decrease labour requirements as the top factor enabling scaling out, followed by the presence of reliable markets driving value chains. These are shown in Table 5.2.

5.3 Spillover: Barriers and enabling factors

Many of the constraints and enabling factors described in Section 5.2 concerning scaling out also apply to spillover. However, there were additional findings concerning spillover specifically. These are summarised in Table 5.8 and described in the subsequent paragraphs.

Findings regarding spillover between countries were fewer than those regarding scaling out. This was partly because scaling out is only just starting within the SIMLESA project. The study team was only able to visit Ethiopia, Kenya, Malawi and Tanzania, and therefore could not interview key informants in other countries regarding any spillover that may have taken place. However, the team did interview key informants engaged in regional networks and projects as well as CIMMYT objective leaders for the project as a whole.

5.3.1 Policy and regulatory factors influencing spillover

Enabling factors

Governments across Africa are demonstrating renewed commitment to and investment in agriculture. Common mechanisms are now in place through CAADP under the New Partnership for Africa's Development (NEPAD) of the African Union Commission. Processes for investment planning in agriculture are being streamlined across Africa and in regional economic communities (RECs), and sub-regional bodies such as ASARECA are taking on greater roles in information exchange and development of regional policies. This context is one that greatly enhances opportunity for spillover of technologies and agronomic practices.

Another general trend across Africa, which greatly enhances the policy and regulatory environment for spillover, is the gradual liberalisation of the market and increased emphasis on the role of the private sector in agricultural development. As the private sector takes on a greater role in agricultural value chain activities there is more scope for spillover of seed, agrochemicals, practices, extension approaches and knowledge products, as many private sector bodies operate regionally. Private sector engagement in extension increases the diversity of extension provision in any one country and this in turn can have a spillover effect.

An example of private sector involvement in spillover can be seen in the activities of FIPS. FIPS Africa's scaling out work has already been mentioned in Case study 9. Case study 10 focuses on FIPS Africa's actual and planned work enabling spillover.

Regional initiatives on seed harmonisation between EAC, SADC and COMESA are underway. ASARECA has an active role in promoting seed policy harmonisation in the region. The ASARECA Policy Analysis and Advocacy Program (PAAP) has registered important achievements in catalysing regional trade. Through support to research and brokering national policy changes, real impact has been made to increase domestic and cross-border trade. Between 2002 and 2008, seed imports into the region almost doubled from 9000 to about 15,000 t, and intra-ECA seed imports have more than tripled as seed exports from Kenya and Uganda have gradually increased to more than 3000 t.

Table 5.8: Factors constraining and enabling spillover of CA practices and maize–legume technologies

Enabling	Constraining
Policy and regulatory factors	
• Renewed government commitment to and investment in agriculture across Africa • Liberalisation and greater scope for private sector • Seed policy harmonisation and related germplasm exchange networks	• Seed policy harmonisation still at early stages • Limited capacity to monitor movement of germplasm between and within countries • Complicated import and export regulations
Institutional factors	
• The existence and activities of the African Conservation Tillage Network • Range of SIMLESA activities • Regional networks and bodies	• Limited linkages between SIMLESA and ACT at national (and regional) levels • Low capacity of up-coming seed companies • Low capacity to produce foundation seed • Limited shared learning between SIMLESA objectives 2 & 3 • Insufficient funding for exchange visits • Lack of suitable equipment such as jab planters
Agro-ecological factors	
• CA versatile and widely applicable • Agro-ecology in the wider region suited to spillover	
Socio-economic factors	
• The reduced labour demands in CA are an incentive to take up CA in other countries • Informal trade and sharing of seed across borders	

EAC, SADC and COMESA are looking to establish a tripartite agreement to enhance movement of seed between the three RECs. Thus seed policies, laws, regulations and procedures are being streamlined across countries on a regional basis. Seed harmonisation is a major factor enabling spillover of technologies. Though seed policy harmonisation is still underway (as discussed under policy and regulatory constraints below), agreements between EAC members are most effective to date. Tanzania for example has successfully completed all the legal changes and procedures required at a national level. One of the spillover countries, Rwanda, is now completing all the required legal changes.

One of the effects of harmonisation of policies and standards is the reduced period of testing for release of varieties developed in other countries among those countries involved in the harmonisation. Thus a variety that has been through the complete process of testing in one country and is then released may not need to pass through the entire testing process in another country. The process may be completed in 1–2 years only. Thus, it improves rates of variety release; lowers costs for seed companies in dealing with regulatory authorities; increases trade in seed of improved varieties; and, ultimately, adoption by farmers (Case study 11).

Case study 10: FIPS Africa's role in spillover of maize and legume varieties

According to its publication 'Empowering millions of smallholder farmers to put Research Into Use to improve their food security in East Africa', FIPS extended its activities from Kenya to Tanzania. With inputs by 7 seed and 2 fertiliser companies, FIPS Africa worked with local partners, including Ministry of Agriculture official, to establish 37,000 small plot demonstrations.

FIPS Africa has plans to extend networks to Uganda, Burundi, Rwanda and Malawi through which research outputs can be rapidly and cost-effectively disseminated to assist the poorest farmers attain food security, as indicated in the map.

An example of easy movement of seed under seed harmonisation is that of CG7 which is produced in Malawi. The same variety is called MGV4 in Zambia. The two are genetically the same. If Zambia does not have enough MGV4 it can import CG7 from Malawi under the SADC and COMESA seed harmonisation agreement.

Within this context there are also projects that are supporting spillover such as the Southern Africa Root and Tuber Network (SARNET), which is supporting germplasm exchange between the national agricultural research systems (NARS). Crop-specific networks like SARNET bring together national and international programmes to share materials.

Constraining factors

While seed harmonisation is indeed an enabling factor, the process itself is still underway. Some countries in the region have successfully completed all the legal requirements necessary, others are still in process and this process can be extremely protracted. Within the RECs, while the EAC member countries have reached effective agreements, reaching such agreements in COMESA and SADC is taking a little longer. For seed policy harmonisation to really work, all countries within the REC need to have established the same laws so that the flow of material among all member countries can take place on an equal and unrestricted basis.

An example where two-way spillover is still restricted is from Kenya. At present, according to the regional DTMI project, varieties still have to go through national trials before they can be released. For example, Kenya has a very stringent inspection and certification national trial system operated by the Kenya Plant Health Inspectorate Services (KEPHIS). While neighbouring countries recognise this and may allow Kenyan seed into their own countries without too much inspection, this is not the case for importing seed to Kenya. KEPHIS will insist on inspecting the seed trials in the neighbouring countries before allowing the seed into Kenya.

Export regulations can also be complicated. Malawi, for example, lacks a one-stop shop for those wanting to export seed. Three different institutions are involved before seed can be exported. First, research (Bvumbwe Research Station) conducts the phytosanitary test and provides a certificate; second, the Ministry of Trade and Industry has to provide an Export Certificate after third, the Ministry of Agriculture has given authorisation that seed can be exported.

5.3.2 Institutional factors influencing spillover

Enabling factors

Many of the stakeholders interviewed were country based, rather than regional. Their views are therefore from a country perspective. A handful of regional bodies, such as ASARECA and ACT with regional mandates, think from a regional perspective and have experience in developing regional goods.

For something happen regionally, explicit regional actions must make it happen: for example, the involvement of multiple countries in regional projects (like SIMLESA) that address problems of a regional nature, regional review and planning events, staff and farmer exchanges, joint training and regional workshops, networking, attendance of international conferences and information dissemination. It is understood that SIMLESA does all of these.

In terms of CA, the existence and activities of ACT greatly enhances the opportunities for spillover of CA practices, extension approaches and knowledge products (Case study 12). ACT, with its head office in Nairobi, also has offices in Burkina Faso, Tanzania and Zimbabwe. It also has a strong presence in Swaziland, Malawi, Zambia and Guinea.

ACT works with a wide range of stakeholders across Africa. Information is available through their website which includes policy briefs, reports and detailed case study material that could inform spillover in other countries.

At the national level many countries now have CA task forces associated with the ACT, which are mainstreamed in appropriate Government institutions and activities. In particular, the national CA task force in Malawi is closely working with the Government's Farm Input Subsidy Programme and CA practices are promoted for application with the FISP inputs.

Case study 11: Seed companies and regional harmonisation

No country is an island, and with increasing regional integration of economies around the world, it makes sense that the region should move as one in developing its maize seed sector. Regional trade blocs such as the COMESA are key to this. *"Specific actions and commitments by national governments include dedicating increased funds (at least 10% of their national budgets) for agricultural development and harmonisation of regional seed regulations,"* says Ambassador Nagla El-Hussainy, COMESA Assistant Secretary General. *"This will improve rates of variety release, lower costs in dealing with regulatory authorities, increase trade in seed of improved varieties and, ultimately, adoption by farmers."*

In East Africa, for example, the national seed policies of Kenya, Uganda and Tanzania are at various stages of development and are set to be harmonised soon. *"Effective trade and risk management strategies that buffer seed supply within countries are needed to stabilize and increase maize production in the region,"* says Marianne Bänziger, CIMMYT Global Maize Program Director. *"These will mitigate the impact of drought and national production fluctuations, which are some of the harsh realities that farmers and consumers face."*

According to Richard Amoussou, Assistant Secretary in the Ministry of Agriculture in Benin: *"The links between (community-based) seed producers and seed companies should be strengthened through contracts. This will ensure that quality seed is produced and sold to seed companies, who must finally distribute the seed to the farmers, thus improving their access." "Streamlining the seed sector will directly benefit the productivity and incomes of small-scale farmers and result in more and more affordable food for consumers—significant in the current global food crisis,"* concludes Bänziger. She says this is crucial, given the twin challenges of the global food price crisis and more frequent droughts due to climate change. (CIMMYT, Maize Without Borders).

Regional initiatives on seed harmonisation between the (EAC, SADC and COMESA are underway. ASARECA has an active role in promoting seed policy harmonisation in the region. The ASARECA Policy Analysis and Advocacy Program (PAAP) has registered important achievements in catalysing regional trade. Through support to research and brokering national policy changes, real impact has been made to increase domestic and cross-border trade. Between 2002 and 2008, seed imports into the region almost doubled from 9,000 to about 15,000 tonnes, and intra-ECA seed imports have more than tripled as seed exports from Kenya and Uganda have gradually increased to more than 3000 t (USAID 2011).

The ACT mission is: *to promote and facilitate information and knowledge exchange and partnerships to enhance support for the adaptation and adoption of conservation agriculture principles and practices in Africa. With this Mission, ACT expects to contribute to* ***enhance up scaling*** *of sustainable land and water management practices addressing both agricultural productivity and environmental/biodiversity resilience objectives. Ultimately, the results are expected to positively impact on food security and improved rural livelihood. This Mission, refined* *during 2006 from the initial mandate streamlines and focuses the core functions of ACT into* ***ca knowledge and information management (i.e. the generation, processing, storage and dissemination of lessons and knowledge on CA*** *within the broader context of sustainable land and water management). The revision has also been with a view to ensure ACT remained dynamically responsive to members and stakeholder needs and issues on conservation agriculture, specifically, and natural resource management, in general.*[9]

The ACT network is spread across Africa, and its mission includes CA knowledge and information management, making it a key organisation in enabling spillover. The ACT membership allows for a great deal of learning and experience exchange between countries, particularly through funded regional projects.

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Case study 12: African Conservation Tillage Network

The African Conservation Agriculture Tillage Network (ACT) greatly enhances the opportunities for spillover of CA practices between different member countries in Africa and even beyond Africa. The ACT mission is: "to promote and facilitate information and knowledge exchange and partnerships to enhance support for the adaptation and adoption of conservation agriculture principles and practices in Africa". With this mission, ACT contributes to enhanced spillover of sustainable land and water management practices addressing both agricultural productivity and environmental/biodiversity resilience objectives. Ultimately, the results are expected to positively impact on food security and improved rural livelihood.

ACT was initially commissioned with a geographical focus on Southern, Central and East Africa. The network has spontaneously expanded responding to active interest from rest of the continent West and North Africa. Existing synergistic collaboration and knowledge sharing across the continent has justified ACT reformation into a pan-African establishment with networking value within and among regions.

Several activities of the SIMLESA project enhance spillover. These include country exchange visits of coordinators and objective leaders; joint workshops and training, and SIMLESA project reports.

[9] http://www.act-africa.org/mission.php.

Other agencies, networks, programmes and projects that operate regionally can also facilitate spillover. These include DTMI, operating in 13 countries, the SARNET germplasm exchange project, and the activities of CGIAR bodies such as CIMMYT and ICRISAT. For example, legume varieties selected through PVS are released by ICRISAT in Malawi, Mozambique, Tanzania and Zambia. Similar agro-ecologies across these countries and the common source of parent material (ICRISAT) facilitate easy movement.

An example of a regional approach that has enhanced scaling out of CA is the FAO Emergency Unit for Southern Africa. This unit has for some years focused on a preventative approach by encouraging the uptake of CA in areas suffering from erratic and insufficient rainfall.

Private sector bodies can also greatly enhance spillover. Many seed companies trade regionally: the Kenyan companies Freschco, Western Seeds, One Acre Farm and Wakala Africa Ltd sell seed in Tanzania, Uganda, Rwanda and other countries as well as within Kenya.

One project that acts as an 'honest broker' between input suppliers and farmers is the not-for-profit, but private sector Farm Inputs Promotion Services Ltd (http://www.fipsafrica.org/). It operates in Tanzania and Kenya and has plans to extend networks into Uganda, Rwanda, Burundi and Malawi.[10]

Constraining factors

The existence of ACT has been cited above as an enabling factor for scaling out and spillover. However, in some SIMLESA countries there are no institutional linkages with ACT. This was found to be the case in Kenya despite it hosting the continental headquarters for ACT. Greater exchange of experience, learning and collaboration between ACT and national CA task forces will not only, potentially, enhance scaling out of CA, it could also enhance the effectiveness of the CA being promoted by SIMLESA and the sustainability of the SIMLESA work promoting CA.

While private sector seed companies are starting up across the SIMLESA countries, many are still small and lack capacity and experience. New seed companies need support to purchase basic seed, procure certified seed from contracted farmers, and resources for monitoring seed multiplication. AGRA is already giving such support through its PASS programme. PPPs could also be used to stimulate the private sector which once strengthened should operate independently as a full commercial business). The exchange and use of germplasm referred to above (SARNET) is constrained by insufficient capacity within some NARS to produce foundation seed.

One constraint related to the SIMLESA project specifically concerns the extent to which learning is shared. Much can be learned from the trials on various combinations of CA practices and maize–legume mixtures, as well as varieties themselves across the five SIMLESA countries. However, the project has limited mechanism in place for information and knowledge management and sharing.
SIMLESA should ensure that findings and analysis of trials from each location are shared within and between the five countries and that some comparative analysis is carried out. Such information sharing and analysis could enhance scaling out and spillover.

[10] FIPs Africa: Empowering millions of smallholder farmers to put research into use to improve their food security in East Africa.

Furthermore, it is critical that SIMLESA knowledge sharing, exchange and learning mechanisms are backed up and supported by the CIMMYT objective leaders. Where on mission, objective leaders tend to follow up on just the objective they are responsible for. If a more comprehensive approach were taken, with an Objective 2 leader also visiting PVS trials for example, and on Objective 3 leader also visiting CA demonstrations, there would be more opportunity for spillover of knowledge both between countries and objectives.

Lack of resources among agencies promoting scaling out and spillover of varieties and CA practices means that the extent to which exchange visits take place is very limited. Even within ACT the only way such visits can take place is through funded projects.

Lastly, workshop participants stressed that if countries do not have suitable equipment like jab planters then spillover is likely to be extremely limited, and suggested that entrepreneurs and manufactures in spillover countries be linked with those already producing jab planters in SIMLESA (or other) countries.

5.3.3 Agro-ecological factors

Enabling factors

An enabling agro-ecological factor for spillover is that CA is a versatile practice. Several variations are in practice already within the five existing SIMLESA countries and local adaptations of CA can easily be made.

A second major enabling agro-ecological factor for spillover is the fact that many countries in the regions share similar agro-ecologies. Germplasm exchange programmes and seed companies have already taken advantage of this by looking for markets for seeds produced in one country, in other countries in the region (Figures 5.2 to 5.6).

i) Identifying potential spillover areas from combining known extent of varieties

Only two crop combinations were possible from the Harvest Choice data, those of maize and beans (Figure 5.2) and maize and soybean (Figure 5.3), but some interesting patterns both within each map and comparing across them are discernible. Maize and beans (Figure 5.1) have huge spread across much of sub-Saharan Africa already, which shows a promising range to look at implementing new varieties and techniques. However, even within this spread, a much-heightened intensity of harvested area of the two is more prevalent in some countries (central Ethiopia, western and central Kenya, Malawi, northern Mozambique, Rwanda, northern Tanzania, and scattered around Uganda). Much of this might be due to the larger areas under cultivation in these areas anyway, but still would promote the idea that scaling up or spillover would be more advantageous than across Botswana or most of Tanzania.

Soybean has a much more limited distribution (Figure 5.3) and so its combination in areas of maize is also restricted, to north-west Ethiopia, western Kenya, western Tanzania, Uganda, and much of central Zambia. No data for Botswana, Malawi or Mozambique were present for soybean, so no interpretation can be achieved here. There are two obvious areas of more intense soybean and maize harvested areas, in central Uganda and Rwanda. Again, while conclusions must be tentative, all these areas might be promoted as areas of potential spillover of suitable varieties and techniques.

An alternative interpretation of these maps could be that there are large gaps in the current cultivation (or intensity of cultivation) of beans and soybean and if the agro-ecological factors and key inputs were available, spillover could be encouraged in these.

ii) Identifying potential spillover areas from combining general biophysical classifications

To present the maps of the three parameters used in this second modelling approach, the data were split into the different groups of soils based on general pH characteristics. Dark to light shading used for rainfall (high to medium to low) and colour used for altitude (red: high, green: medium, blue: low). The data are presented Figures 18 to 22. No interpretation has been placed on the use of a particular crop variety or combination. The maps can be used to give a general indication of where a crop might be advantageous to grow, for example, in acid, medium altitude, low rainfall regimes, or areas where less advantageous conditions prevail.

Very acid soils are present in many highland zones in Ethiopia, Kenya, NE and NW Tanzania and Rwanda (Figure 5.4). Cropping may be difficult already given the terrain but will be compounded by high acidity. There are some low-altitude locations in southern Malawi and eastern Tanzania. In most areas medium to high rainfall regimes would have to be tolerated.

Acid soils appear widespread through large parts of western Malawi, N Mozambique, Tanzania, Uganda and Zambia, more often in medium altitudes (Figure 5.5). Crops suitable for heavier rainfall regimes would be more appropriate in coastal zones of Tanzania and Mozambique, and in northern Zambia and much of Uganda. However, central Tanzania and southern Zambia would require crops tolerant to lower rainfall regimes.

Truly **neutral soils** are very rare and only referred to for Vertisols in the consulted literature. While being quite advantageous to some crops, they would be restricted to Kafue in Zambia, the western edge of Ethiopia, around Lake Victoria in Tanzania, and small pockets in other countries (Figure 5.6).

Alkali soils are also very rare in Africa and only present in a few types such as rendzina. They appear to be very restricted to dry scrubland in Botswana and a few pockets in northern Tanzania and western Kenya (Figure 5.7).

Those soils identified as having **mixed** pH (as the subtypes may vary considerably based mostly on parent material) are the most extensive (Figure 5.8). While some generalisations of the usefulness of cropping regimes might be possible based on altitude and rainfall, evaluation of local soil conditions would be essential. Lowland high-rainfall regimes predominate in Mozambique and coastal Tanzania, while more arid higher altitudes are prevalent in Botswana. Mixed soils predominate in the periphery of Tanzania at all altitudes with usually moderate to high annual rainfall, while the rainfall regime in Kenya splits between low rainfall in the east vs. higher rainfalls at higher altitudes and further west. Ethiopia can also be split into a similar highland, high rainfall/lowland, low rainfall classification.

As a consequence of similarities in agro-ecology across the region, there are a range of established and newer maize and legume varieties that could, on the basis of similar agro-ecology, spillover to other countries. Figures 5.9 and 5.10 provide two examples of such potential spillover, the first showing a bean variety that favours mid-altitude low rainfall, and the second showing a maize hybrid variety favouring mid-altitude and medium rainfall regimes.

These two maps illustrate what can be achieved using GIS. Where national GIS expertise exists and there is access to good GIS data, similar maps could be prepared for other selected maize and legume varieties. Such maps would be helpful in indicating the areas in the spillover countries that are suited for spillover of those varieties being successfully scaled out in the five SIMLESA countries.

5.3.4 Socio-economic

Enabling factors

The reduced labour demands within CA as compared to conventional tillage practice are an incentive for all households with limited labour availability within and beyond the present five countries in which SIMLESA is taking place.

A second enabling socio-economic factor for spillover is that of informal sharing and trade of seeds (particularly legume seeds) across borders. This is enhanced by inter-marriage, which is quite common on country borders. Aside from sharing sees, agronomic practices such as CA can be observed across borders and in this way spillover can take place.

Informal sharing of knowledge and technologies across borders and the (generally informal) trade along borders, is difficult to monitor, thus it is difficult to build up an evidence base regarding this practice and future potential.

While this chapter has described the findings regarding barriers to and enabling factors for scaling out and spillover, the last chapter starts with reflections on findings regarding gender and the private sector, and moves on to outline conclusions and recommendations.

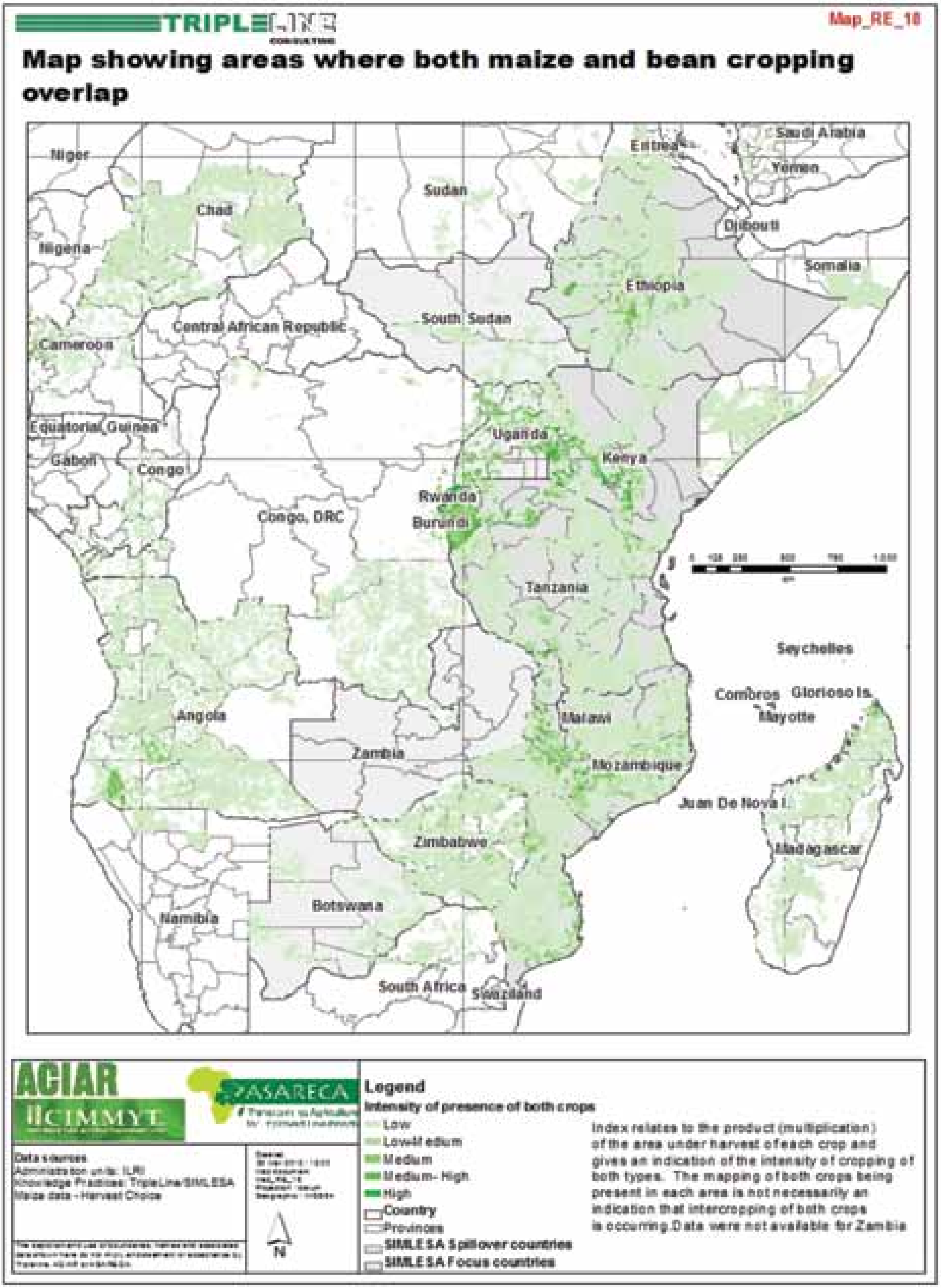

Figure 5.2: Areas where both maize and bean cropping already occur.

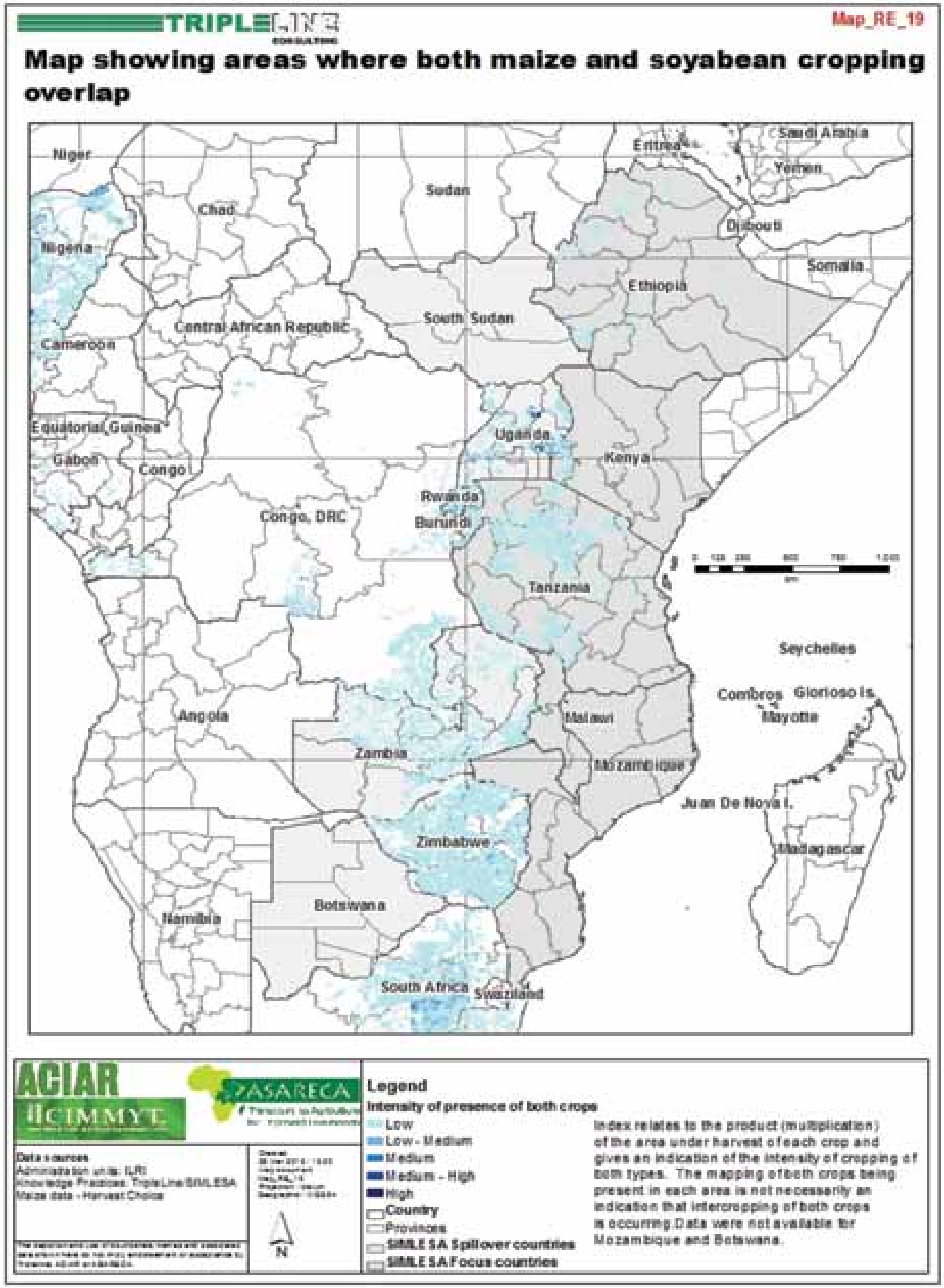

Figure 5.3: Areas showing overlap where soybean and maize cropping already occurs.

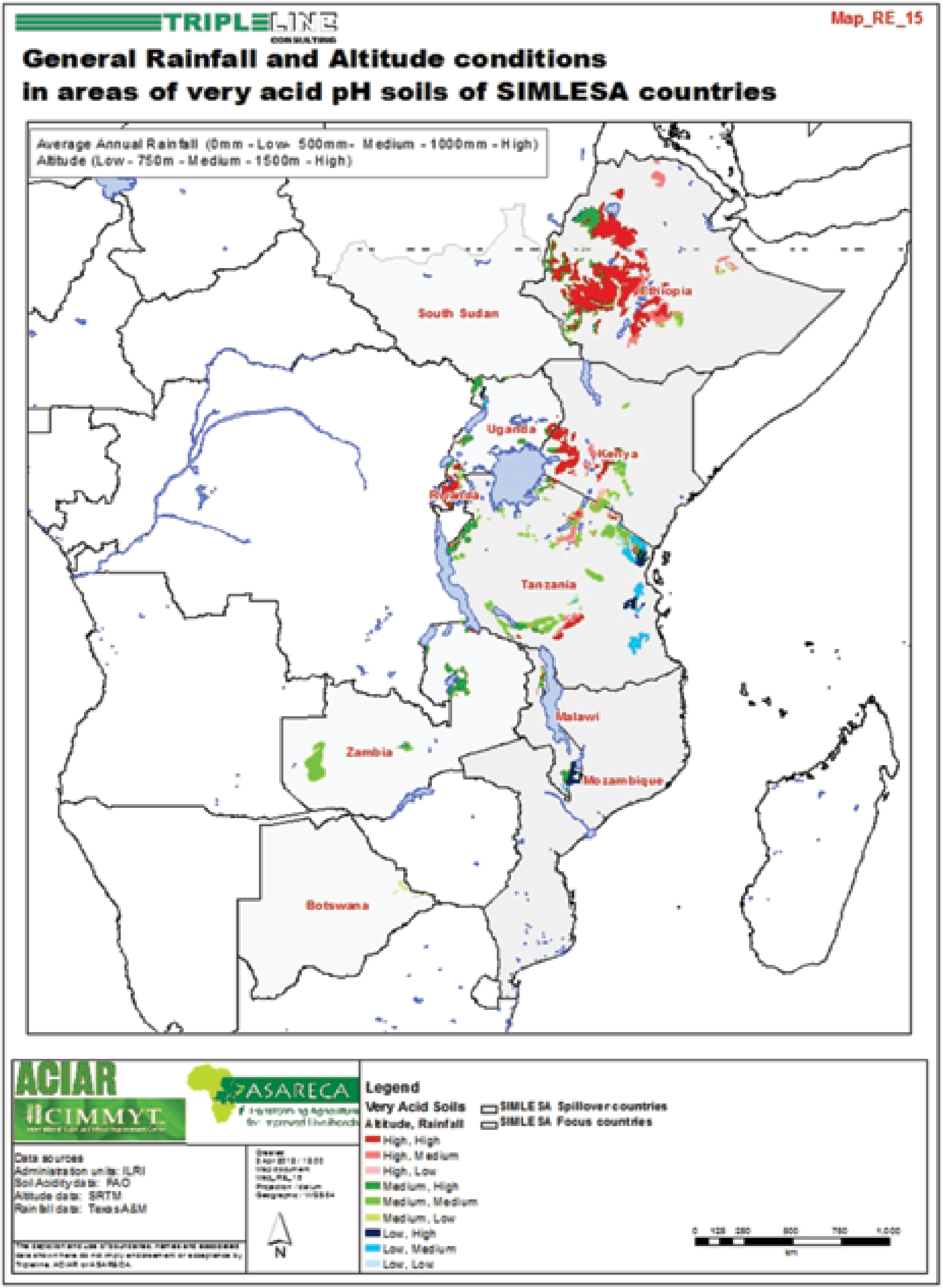

Figure 5.4: General rainfall and altitude conditions in areas with very acid soils in SIMLESA countries.

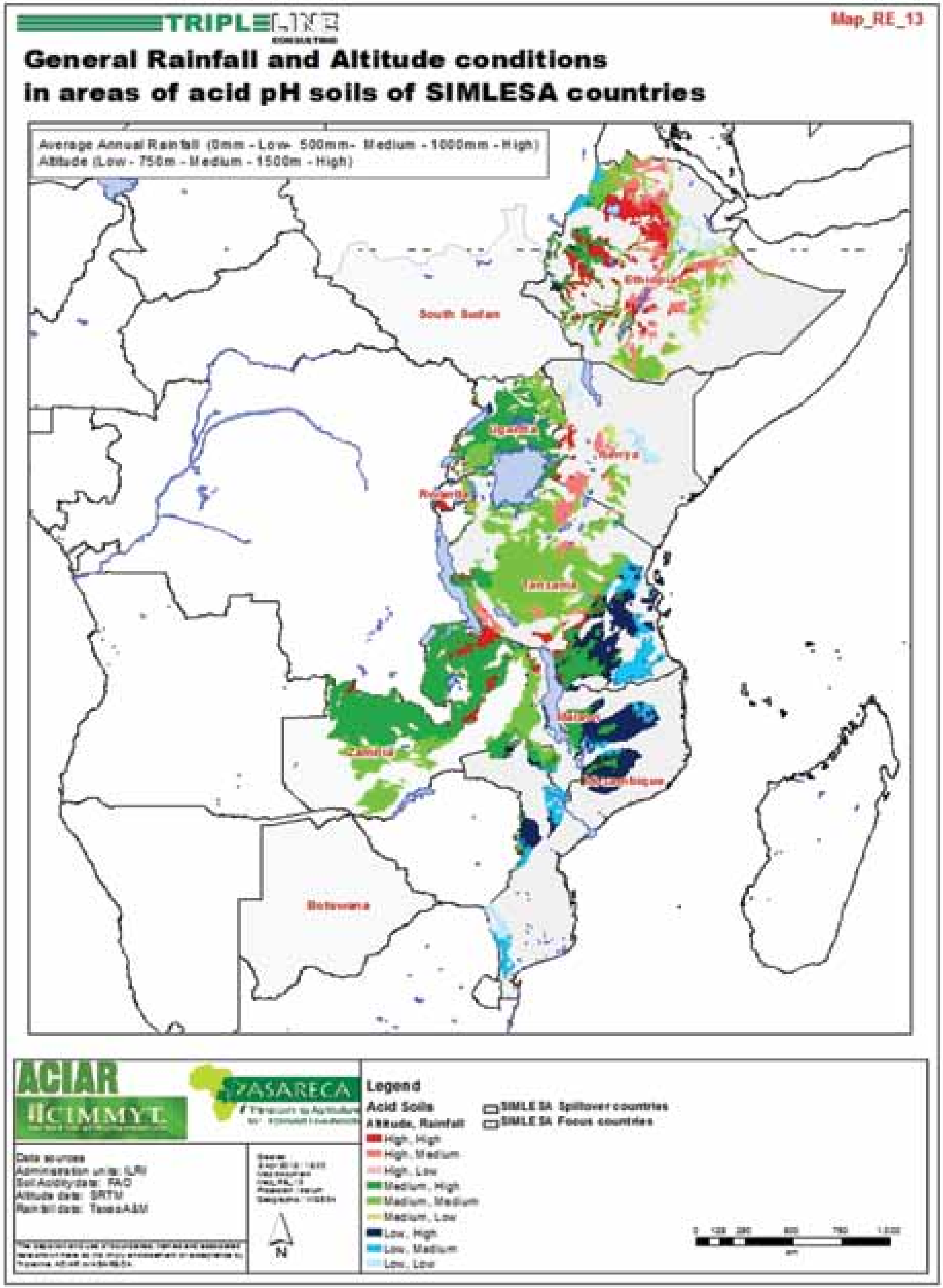

Figure 5.5: General rainfall and altitude conditions in areas with acid soils in SIMLESA countries.

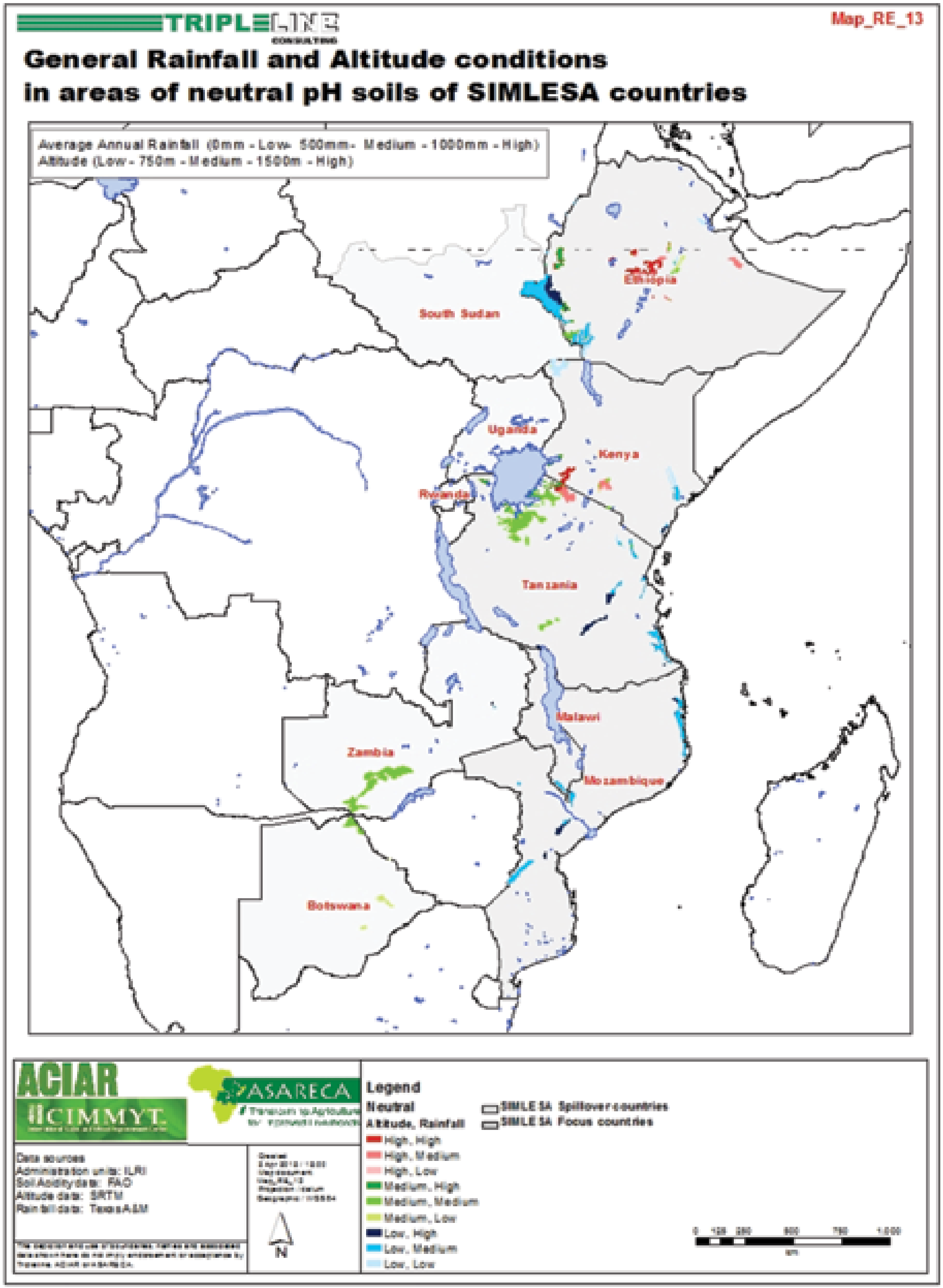

Figure 5.6: General rainfall and altitude conditions in areas with neutral soils in SIMLESA countries.

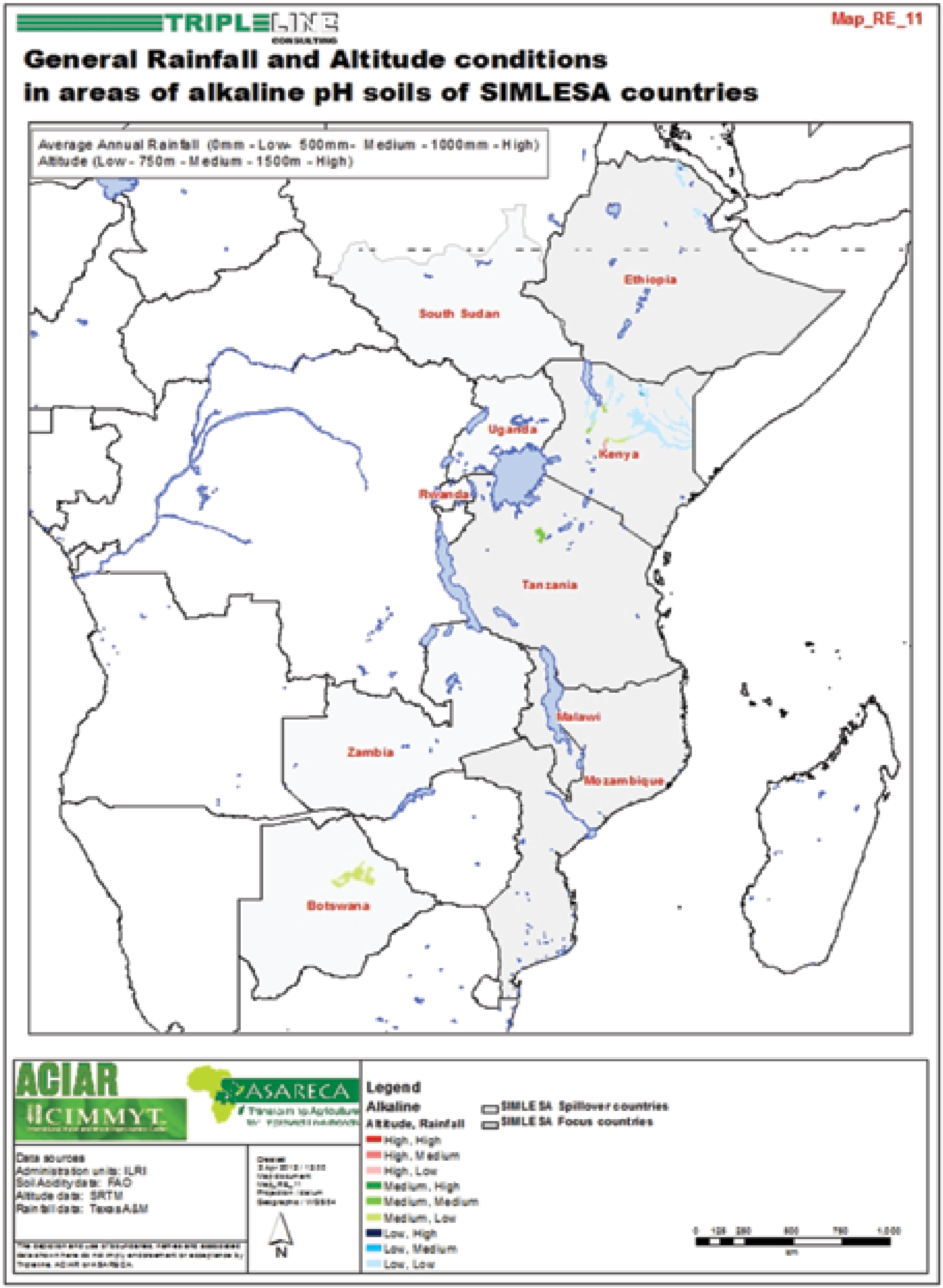

Figure 5.7: General rainfall and altitude conditions in areas with alkaline soils in SIMLESA countries.

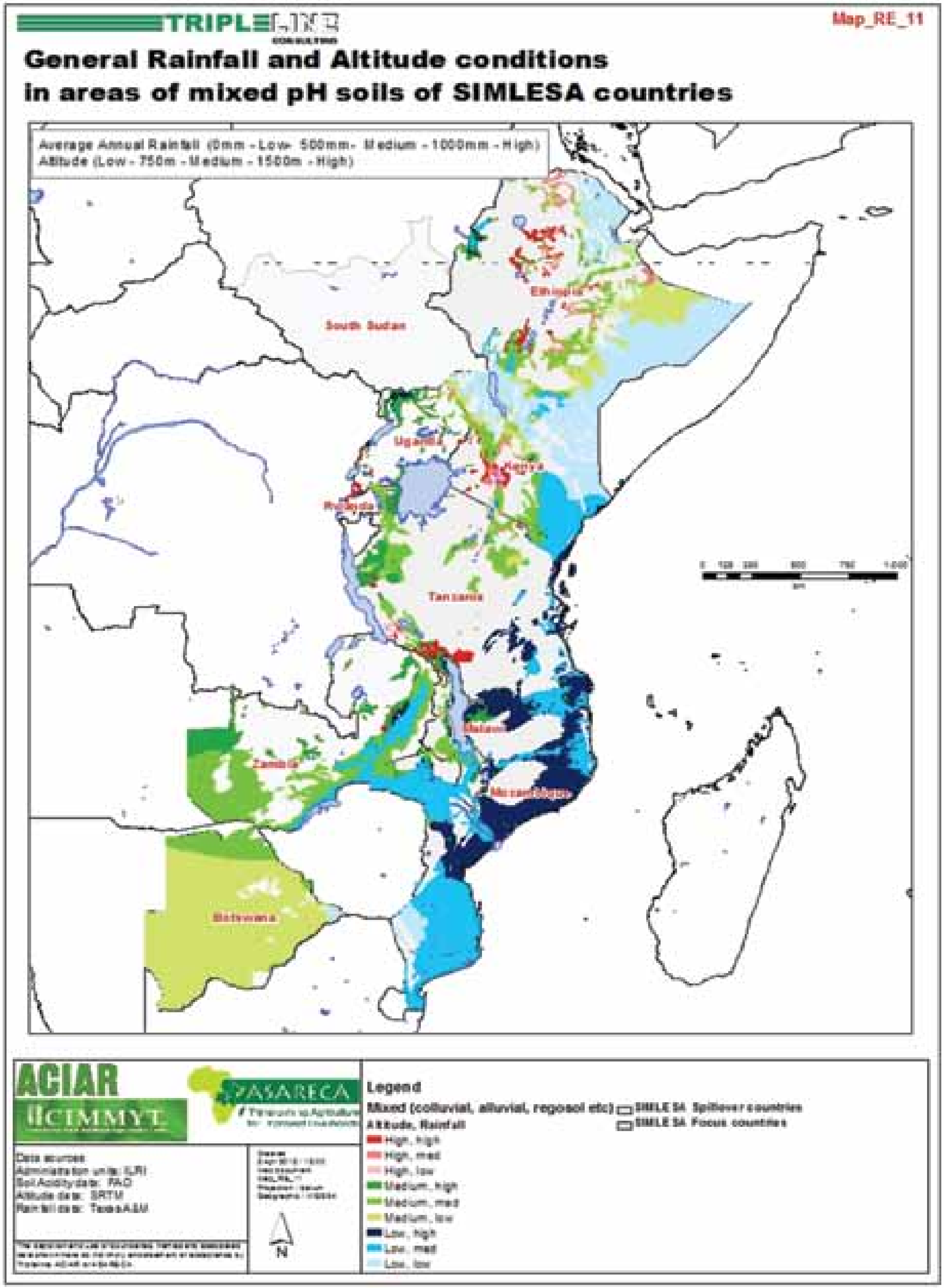

Figure 5.8: General rainfall and altitude conditions in mixed soils of SIMLESA countries.

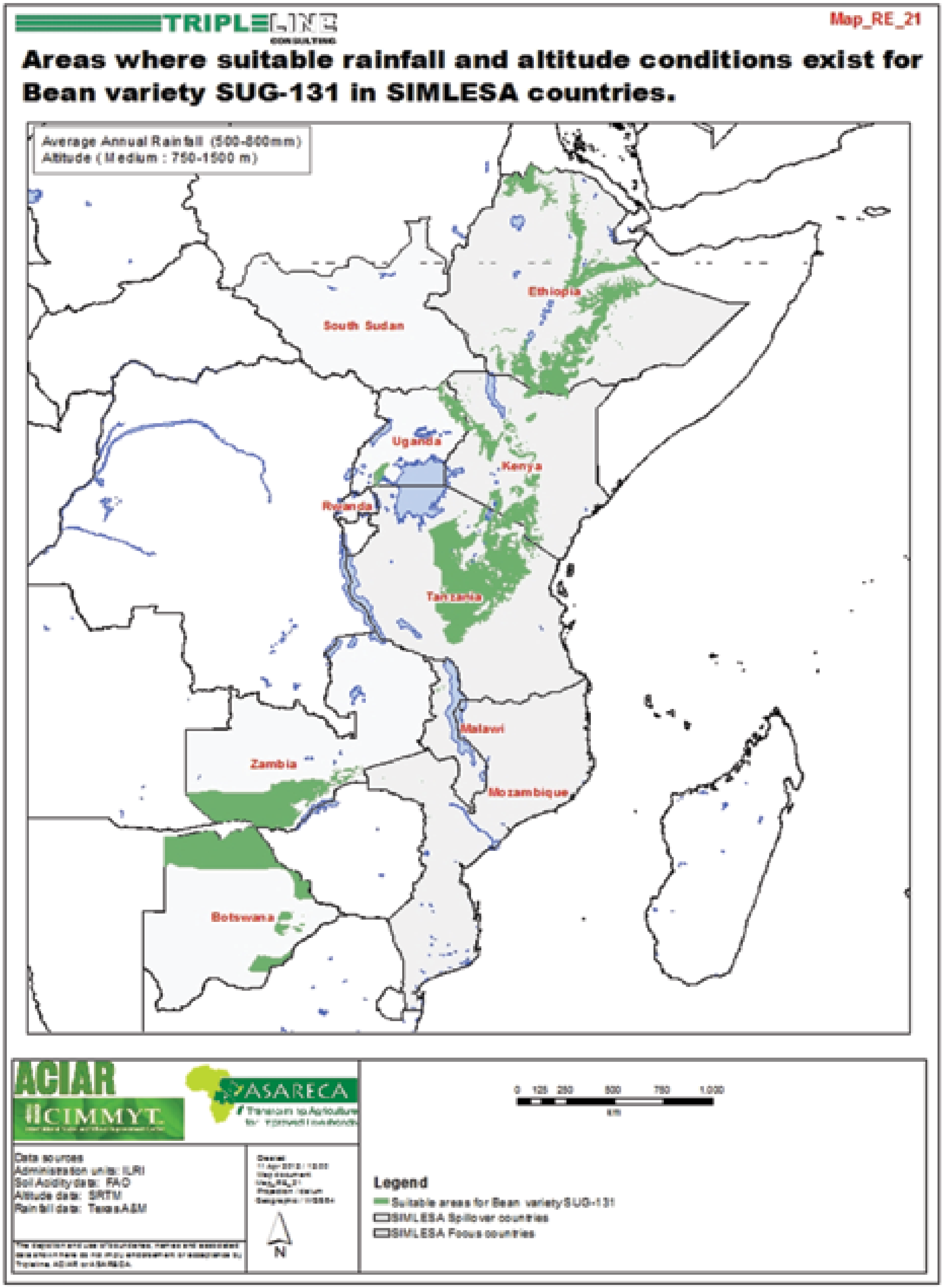

Figure 5.9: Potentially suitable areas for bean variety SUG-31 given rainfall and altitude constraints.

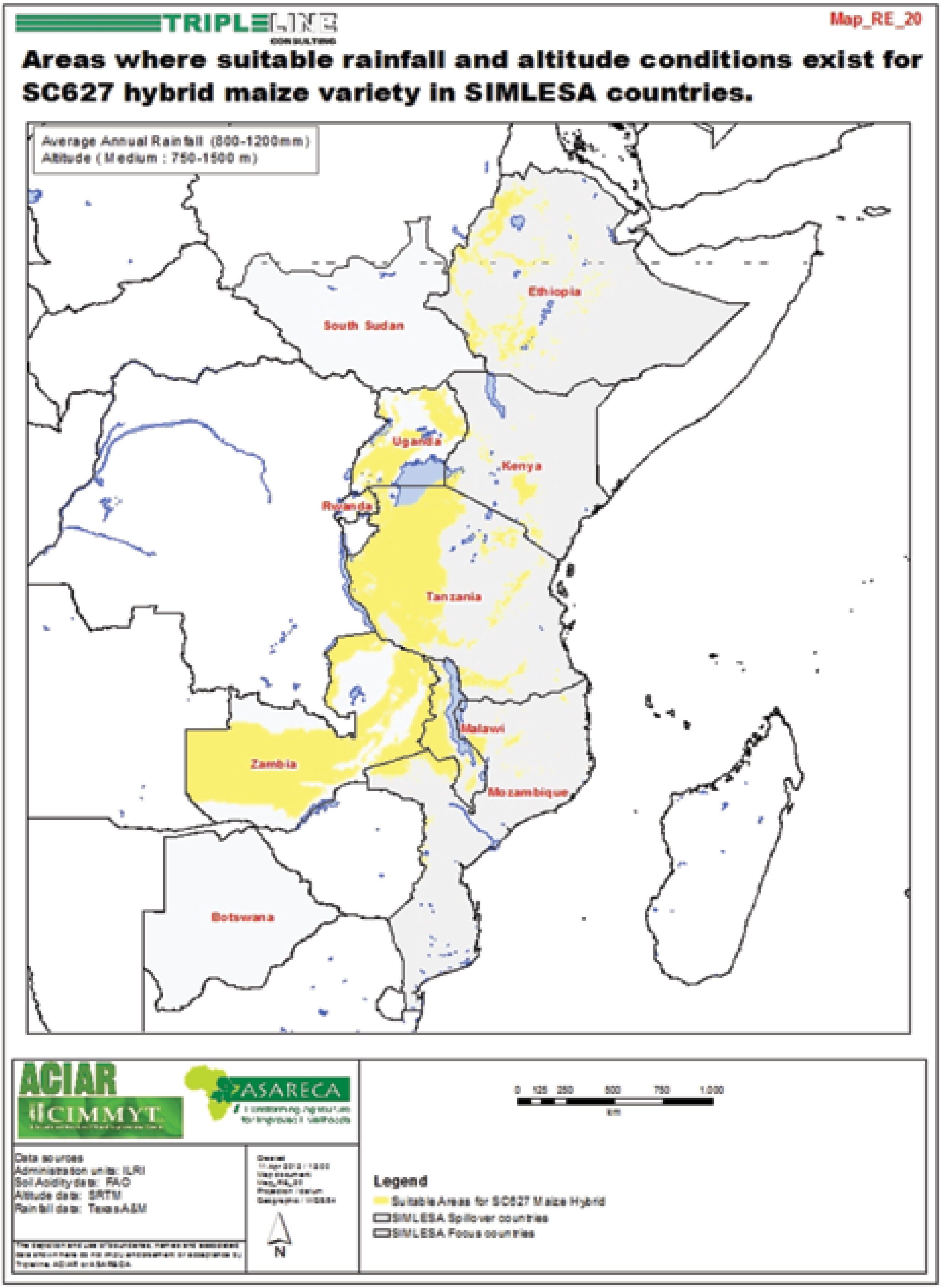

Figure 5.10: Potentially suitable areas for SC627 Maize hybrid given rainfall and altitude constraints.

6 Reflections, conclusions and recommendations

This final chapter brings together findings, starting with gender (Section 6.1) and the private sector (Section 6.2). Section 6.3 provides thought on the GIS process and potential use in future for informing spillover strategies. Section 6.4 provides general conclusions and Section 6.5 provides recommendations for SIMLESA regarding how it can enhance spillover in the time remaining before the project ends. Finally, Section 6.6 provides more general recommendations at national policy and institutional levels regarding spillover. The recommendations combine those from the study team and from the validation workshop.

6.1 Analysis of findings concerning gender

During fieldwork, gender was explored in relation to appropriateness, accessibility and uptake of technologies for both women and men. Many interviewees commented that practices such as CA and in particular maize/legume varieties were gender neutral. This section examines in detail comments from respondents on aspects of gender. The section also explains how decisions to adopt practices such as eliminating tillage, using herbicides, using crop residues for soil cover, and deciding what seed to buy, can vary significantly between gender categories. One participant commented that: "whatever men could do, women were also able to do, so all the technologies are gender neutral." While it is true that women are able to practise such technologies, uptake, scaling out and spillover of technologies will be much more successful if attention is paid not to what women farmers can do, but to what women farmers choose to do. Three areas—labour, preference and risk—were identified to explain why these technologies and practices cannot be gender neutral.

6.1.1 Labour

Men and women have different tasks in the cropping cycle and these tasks are altered with adoption of CA. CA is considered labour saving because it eliminates tillage, makes use of time-saving equipment such as jab planters, and reduces weeding. However, the new distribution of on-farm responsibilities needs to be further evaluated to see the balance of benefits and disadvantages in terms of labour demand. The time saved by eliminating tillage is time saved for men, as ploughing fields is traditionally a male task. ACT states that practising CA saves time for women by reducing the weeding requirements. However, weeding is only reduced in circumstances where farmers are applying herbicides to control weeds or once adequate crop cover to suppress weed growth has been achieved, which usually takes two to three years. If herbicide is not applied then weeding time can potentially increase in the first few years of CA practice. If herbicide is applied to control weeds, water is needed to dilute the herbicide, therefore creating labour for women who collect water. Spraying herbicides is normally a male task.

With the need to protect crop residues for soil cover, animals are unable to graze freely which may result in increasing the labour engaged in finding and transferring fodder to tethered animals. This eliminates the need for livestock to be accompanied while grazing, a task often done by children. However, it may mean that women are expected to go further afield to find fodder for their livestock, potentially adding to their workload. This problem can be overcome by training farmers in growing fodder shrubs and limiting livestock numbers.

6.1.2 Preference

Preference for certain varieties and technologies can also vary between genders. Men are often enticed by cash crops and market prices whereas women farmers are more likely to use a variety that benefits household use. Examples of this include consideration of the poundability of maize grain, a particular concern of female farmers as it is their task to pound the grain into flour. In Ethiopia women farmers prefer yellow seeded maize as it makes better injera, whereas men prefer the white seeded maize as it provides a better income. Furthermore, women often prefer red bean varieties for their home consumption properties of cooking time and taste, while men prefer the white bean varieties, as they command a better market price. Women therefore appear to be more concerned with meeting household food security needs through subsistence farming rather than generating income through commercial farming.

6.1.3 Risk

Interviews with Kilimo Salama indicate that around 70% of their customers are women. By investing in crop insurance, women are able to protect their households from the effects of crop failure. This is a major incentive for women, as crop failure affects women and children in several ways: men often migrate in search of casual labour leaving the women to take care of all household and farming duties; food supplies dwindle; and children may drop out of school. A secure household therefore tries to limit risk, and by investing in crop insurance vulnerability is reduced therefore encouraging women farmers to expand use of a new technology on their land. The notion of risk reduction can be applied on a wider scale for technology and knowledge transfer. For example, using demonstration plots where farmers can witness and practise new technologies gives them the necessary experience and skills before implementing a new practice on their own land.

Labour, preference and risk are factors that influence a farmer's decision to implement a new technology. These decisions can differ between men and women, rendering the term gender neutral obsolete. With this is mind, it is possible to highlight areas in which strategies have already been implemented to specifically encourage women farmers, and areas in which more work can be done. Much targeting of female farmers occurs at the technology dissemination stage, but gender inclusion and mainstreaming require more than this.

6.1.4 Training and dissemination

Dissemination of technologies has focussed on women and men and numerous cases have been documented where women have been more involved in field activities, demonstrations and field days because of deliberate efforts to include female-headed households. Evidence shows, however, that gender has not been considered when trying to promote specific maize or bean seeds. Since women purchase these seeds their preferences for varieties with benefits for household consumption must be noted. While women may have been successfully included in group formation and demonstrations, this is only one aspect of gender inclusion as inclusion should continue during the research and development stage.

6.1.5 Research and development

Interviews highlighted that SIMLESA workers have been trained in gender mainstreaming. However, some staff are unaware of gender issues or have admitted to not fully understanding gender issues and how they should be applied. Gender training for the SIMLESA project was carried out in the early stages of the project cycle to incorporate such considerations right from the onset. Repeat training may be necessary that explains how gender can be applied to specific roles of SIMLESA workers. The term gender neutral should be avoided, as it is more than likely used in situations where gender has not been properly considered. Both men and women may be able to perform the same tasks, but this does not make a technology neutral as this pays no attention to the different preferences of women and men. Improved understanding of gender issues within institutions will come with increased inclusion of women in the research and development stages. In the process out scaling and spillover will be improved, as these new technologies will already be targeted to women farmers.

6.1.6 Monitoring of uptake

Research on technology uptake shows little evidence of gender-disaggregated data for uptake. Improved monitoring of uptake and the difference in trends between men and women will help to inform researchers, scientists and extension agents of what technologies are being adopted by women, helping to feed in to future strategies for out scaling and spillover. Where figures are available, they are often given as the number of women and men who have adopted a certain technology or variety; in many cases women have recorded higher uptake. However, these figures fail to consider the proportion of female and male farmers in the area. A more indicative figure could be given by recording the percentage of women who have adopted a technology out of the total number of women farmers in a particular area. This should be compared to the same percentage of adopting male farmers, therefore giving a clearer indication of the success of a technology between men and women.

6.2 Analysis of findings concerning the private sector specifically

The private sector is an important part of the innovation platform. Research on private sector involvement in SIMLESA identified roles in input provision, technology dissemination and crop insurance.

A key area of involvement for the private sector is in the production, multiplication, marketing and distribution of seeds. Availability of seed depends on numerous factors with research showing that demand and profit are important incentives for private sector to become involved. In Kenya the Drought Tolerant Maize Initiative notes that big seed companies tend not to trade in low-potential areas. Even when demand may be high, there may not be any incentive for private companies to involve themselves due to lack of profitability, such as the case highlighted by FIPS Africa in Kenya, where bean multiplication is at a rate of around 25 to 1, considerably lower than that of maize at 10,000 to 1.

Seed companies are mainly involved in maize seed production and much less in legume seed and OPV maize varieties. Legumes, as self-pollinated crops, can be recycled without a major loss in yield. Similarly, most OPVs can be recycled for two to three seasons without a significant loss in yield. Hence, these do not constitute a steady, predictable demand and profitable products for most private seed companies. As a result, seed production for legumes and OPVs is largely done by emerging seed companies (Malawi), and farmer associations through contracting out farmer groups. However, exceptions exist as with soybean in Ethiopia where the private sector is strongly involved in seed production. Similarly, in Malawi, Demeter Seed Company has emerged to be a successful and fast-growing legume seed company in the country.

Competition is another factor that may limit out scaling: a new maize variety may not be released unless it has a 10% advantage over the current best variety. Seed regulations and costs of taking new varieties to trial can also act as barriers to private sector involvement, as demonstrated in Case study 13.

Case study 13: Encouraging adoption of Africa's orphan crops (Kenya)

After three years of toil, Janey Leakey can finally take a breather. Leakey, a founding director of Leldet Seed Company in Kenya, is now assured that improved varieties of underutilized seeds (pigeon pea, sorghum, soybean, chickpea and groundnut) will finally be approved for production by the Kenya Plant Health Inspection Services (KEPHIS). It has taken her three years to get to this point and she could not hide her excitement during her presentation at the PASS grantee meeting in Bamako. *"It has taken so much heartache to get here, this is a big achievement and I am so excited about it,"* Leakey told the over 300 participants.

Leakey said the shortage of improved varieties of orphan/underutilized crops in Kenya is caused by two factors facing most breeders in universities and research institutions: cash constraints; and avoiding the highly bureaucratic process of certifying crops. *"You have a quagmire of all this germplasm which sits in universities and research organisations and needs to be taken through the process of commercialisation,"* she said.

Leakey was motivated to start a seed producing company three years ago when she could not find improved seed varieties to plant on her farm. The orphan varieties readily available in Kenya were produced as far back as 1984 at the Kenya Agricultural Research Institute. Through her grant from AGRA, Leakey has been able to go through the long process of paying a fee of up to USD 2000 to take an improved crop variety to the national trials.

As she anticipates official approval by KEPHIS to allow commercial release of the varieties, she is also seeking new ways of disseminating the underutilized crops. Leldet has conducted 600 demonstrations across Kenya, showcasing at least five varieties planted per site. An estimated 21,000 farmers have visited these demonstrations. Once demonstrations are established, Leldet sells small seed packs to farmers through farmer field days and agricultural shows. The small packs are sold in 80 g for USD 0.15 (KES 10), or 400 g at USD 0.7 (KES 50). On average, 150 farmers are reached in a single field day. The low cost of the small packs limit farmers' risk, and encourage them to try something new.

Source: http://www.agra-alliance.org/content/story/detail/1040.

Even if demand is high and seeds are available, barriers continue to remain on the farmers' side due to access and affordability. Seeds may not be available locally because agro-dealer networks are poor, and even if seed is available farmers may struggle to spare the financial capital necessary to invest in improved varieties, choosing instead to use recycled seed.

Most seed companies have established retail seed distribution networks. In some cases, the fast development of such input distribution networks is facilitated through government programmes such as the FISP in Malawi or through special projects such as RUMARK (in Malawi and Tanzania). Most such input distribution outlets are found along good road networks or in urban areas or small townships, leaving remote areas unserved. Nevertheless, in countries where a relatively large number of seed companies exists competition is stiff. The companies advertise aggressively through roadside demonstrations in addition to expanding their retail networks either through their own outlets or by supporting expansion of agrodealer retail networks in the rural areas.

In CA, the private sector has a key role in designing and manufacturing equipment such as animal-drawn direct planters, rippers and hand jab planters. Although success stories have been recorded of manufacturing firms developing CA implements, lack of equipment is still widespread. This acts as a barrier to out scaling CA.

Another barrier to adoption of new varieties and practices is lack of awareness. The private sector has a role in disseminating technologies; this has been widely practised in SIMLESA countries through participation in demonstration and field days for varieties, CA practices and herbicide application. These demonstrations often tie in with selling or providing input packages to farmers who attend. These demonstrations linked with packages not only give farmers an opportunity to visualise and test the new technology, but also give the attending companies a chance to promote their brand and develop customer loyalty.

Financial services including credit provision and crop insurance are further areas for private sector involvement. *Kilimo Salama* is a private sector insurance provider for farmers, whose agents are grassroots farmers, who are able to provide clear advice and training. To apply for insurance, farmers need to have a minimum of quarter of an acre of land and a mobile phone through which payments can be made. A total of 70% of *Kilimo Salama* customers are women farmers.

Therefore private sector involvement can be determined when combined factors of demand, competition and profit provide enough incentive to invest. From the point of view of farmers, the combined factors of access, affordability and awareness are needed if they are going to invest their limited financial capital in new technologies and practices.

6.3 Thoughts on the GIS process

The use of GIS to identify current technologies and varieties and to model potential areas for spillover shows promise. In identifying existing areas, the spread of different techniques gives indication of where some practices and crops are more prevalent or concentrated, and where gaps could highlight possible areas in each country where scaling up could occur.

For modelling potential spillover using biophysical parameters, there is correlation between agro-ecological zonation maps available for some SIMLESA countries. However, a uniform agro-ecological map of all countries was not available for this study. Using separate biophysical parameters has value over agro-ecological zones: one can target where certain crop variety combinations and CA practices could be optimised within certain biophysical constraints and fine-tune the quantitative thresholds based on scientific results, rather than rely on broad categories of agro-ecological zonation. While not giving exact locations and parameters for success, it could assist strategic planning of where campaigns for practices or varieties could be more locally targeted to produce higher success rates.

Such broad-brush use of GIS data has limitations. While GIS results in powerful graphical products that can easily be digested and interpreted, its use to identify potential spillover areas at the regional scale of the SIMLESA countries requires careful identification of appropriate parameters, sourcing of accurate and relevant data, and careful interpretation.

For current technologies and variety use, the mapping would benefit from a much more detailed set of data points and exact locations than was possible in such a review. Only a small number of interviews could be tied to specific locations. While there was a propensity of results from Kenya and to a lesser extent, Ethiopia, data from the other two field countries were extremely patchy, which limits the utility of this sort of analysis. Also due to other factors, the interview may not have covered the parameter to be mapped. Follow-up data for Malawi were sought after the field visit for some key parameters and included in the database, which did reduce these biases. Despite this, a few interviews (for example the orphan crops project in Kenya) had significantly more geographical reference than most interviews, which could be seen to skew the results on the map in favour of those techniques and practices considered with that activity.

A more extensive geographically referenced survey of technologies both from within and outside SIMLESA activities would be helpful to give not only a more realistic spatial pattern of trials, varieties and spillover approaches, but also allow better interpretation of where gaps in knowledge between countries could be addressed. Despite this, the patterns derived in the maps submitted provide an interesting platform for debate and raise more questions for future study.

When combining two cropping areas, the simple product of the two crop harvest areas is no indication of the intensity of the individual crops: one would have to return to the original datasets to determine this. Second, the interpretation is no indicator of whether these two crops are intercropped at present or indeed grown by the same farmers.

When modelling biophysical parameters to suggest potential spillover, better defined parameters could be obtained by improving quality of input data in the following areas:

- The **spatial and temporal accuracy** of the data. Many of these biophysical data sets rely on highly variable factors both spatially and (for example with rainfall) temporally. The modelling here has used many assumptions to simplify the processing across the whole SIMLESA region.
- The **resolution** of the data used. The data used here has a guiding resolution of 10 km for each piece of information. This means that only gross generalisations of parameters are possible given the scale of the study. Therefore, if a parameter such as soil pH is used in any analysis, this is only a generalisation of conditions on the ground, and micro-topography, microclimate and human interaction to improve soil will all vary considerably within the 10 km.
- The **appropriateness** of the parameter. For example, in this simple analysis work over the regional scale, one study's interpretation of annual average rainfall has been used as a parameter. A more appropriate measure might be the use of rainy season rainfall totals (i.e. prime growing season rains).
- The **range** of parameters used. A very limited set of biophysical parameters universally important to crops has been used here; other parameters might have been more appropriate such as degree days, growing seasons, rainy season rainfall totals. Some of these parameters are difficult to consistently measure or model over a spatial surface.

As well as improving input data quality, the use of modelling parameters can also be improved. The arbitrary thresholds used for rainfall and altitude are to show the general principle; in practice, different varieties have been shown to have different ranges of both optimum altitude and rainfall. All too often in this study, only qualitative information was provided on the usefulness of a variety, sometimes only mentioning 'good yields', without saying the parameters responsible for the good yields. Where sufficient detail on two biophysical parameters was obtained, Figures 5.8 and 5.9 show the potential for use in determining possible geographical uptake. If a systematic classification of all varieties were obtained showing all major biophysical parameters (not just the ones listed used in this modelling, but others such as degree days, slope and aspect), more subtle modelling could produce more accurate potential suitable spillover and scaling up results for both individual varieties and combinations. However, this is a study that would take considerably longer to perform than within the current project and would also depend upon the availability of more complete and appropriate biophysical GIS data across the region.

The potential for mapping suitable locations where CA practices would be appropriate given biophysical parameters is more difficult to realise. Firstly, CA can improve the existing natural environment, so using mapped data of 'natural conditions' is not necessarily appropriate. Second, soil texture is an important parameter (sandy soils have been shown to adopt well to the practices highlighted in this study) but given the micro variation in soil profiles it might be misleading to interpret these from the FAO global soil GIS data set used here.

Only biophysical parameters were used in this model. Other data which were considered included access to market data and excluding suitable land in reserved areas such as national parks, but pan-African data sets of such parameters at suitable resolution were not forthcoming. In particular, regional datasets based on studies of access to markets and inputs for the mix of maize/legume varieties identified in the study are not sufficient, taking into account both local and more commercial marketing of these products. We recommend more geographical studies in this area.

Given these constraints, there are benefits from this approach and SIMLESA might consider a full-scale study on them. It would involve identifying carefully all biophysical parameters for the crops, establishing thresholds or at least suitability rankings for different varieties and combinations, sourcing best resolution data for the area needed, and then applying a refined version of the model used here.

6.4 Conclusions

The SIMLESA project has made a good start in all five countries and across all objectives. The five core SIMLESA countries have different histories, cultures and political systems, and are at different levels with regard to their private sectors; the priority given to agriculture in national spending; the plurality of their extension services; and other key country-specific factors.

The PVS and participatory CA trial methodologies, supported by on-station trials, are identifying technologies and practices that are relevant to farmers' ecological and socio-economic circumstances. A range of maize (hybrid and OPV) and legume (pigeon pea, Phaseolus bean, soybean, groundnut and cowpea) varieties have been selected and are being multiplied and disseminated in-country for a mix of domestic and commercial use.

On-station and on-farm CA trials are in the process of identifying CA practices that are viable and effective under a range of climatic, edaphic, social and economic conditions. The full adoption of CA into mixed-farming situations where free grazing is common and stover is used for various purposes will require radical changes in farming systems and community organisation.

The most critical problems of farming in sub-Saharan Africa are soil fertility decline and degradation, and the increasingly erratic rainfall pattern. Conservation agriculture coupled with crop rotation or intercropping with legumes tackles these problems as well as the high cost of production through reduced input costs and labour. Emerging results from most of the trials being conducted in the SIMLESA countries are showing promising results. Partial budgets showed that in the Awassa area (Ethiopia), the profit from intercropping maize and beans was greater than for sole crop or rotations of maize and beans or farmers' own practices.

A range of (mostly conventional) extension approaches and knowledge products is being used (trials, visits, demonstrations, field days, farmer–farmer, farmer field schools, discussion groups, action planning, task forces, trade fairs, small package programmes, credit and subsidies, training of trainers, farmer training, agricultural shows, radio, TV, video, mobile phones, posters, flyers, leaflets, drama, comic strip, signs and totems) by the project and its partners to promote the technologies.

A tentative start has been made to establish innovation platforms linking public, NGO, private and farmer actors for the development, dissemination ad use of technologies. The main emphasis of each country team is on scaling out technologies **within** country (and especially within the test locations); less explicit emphasis or activities has so far been devoted to spillover **between** countries.

Most maize hybrids remain in the country of origin, although one or two (e.g. SC627) are more widespread through sales of Seed Co in different countries of the region. Similarly maize OPVs are mostly used only in their country of origin, although ZM521 is found in Ethiopia, Malawi, Mozambique, Tanzania, Uganda, Zambia and its native Zimbabwe.

The main factor constraining spillover of varieties between countries is the lack of harmonisation of seed laws and regulations. The project has some design and implementation components that enable some between-country spillover, e.g. five countries are involved across Eastern and Southern Africa; joint review and planning events, workshops and training courses; joint attendance of international conferences; a newsletter and a website. However, further activities are necessary to explicitly promote and locate findings and technologies that can be spread successfully between countries.

The study has identified the enabling factors and constraints to both scaling-up and spillover in four categories: policy and regulatory; institutional; agro-ecological and socio-economic. A set of recommendations follow, which suggest how the constraining factors can be overcome and how to build on the enabling factors.

While the field visits had limitations of time to gather detailed data, the study has shown that the use of GIS in both the identification of current technologies and varieties, and in the modelling of potential areas for spillover shows some promise. In the identification of existing areas, the spread of different techniques gives indications where some practices and crops are more prevalent or concentrated, and where gaps could highlight possible areas in each country where scaling-up could occur.

Objective 1 baseline and socio-economic surveys have been carried out. However, the social and economic aspects of technology design and dissemination have received less emphasis (gender analysis was weak and there was little social differentiation of farmers by resources and assets).

The importance of the private sector in providing affordable and dependable inputs and services (including financial and insurance services) is clear, but there is tension between government parastatals and the full liberalisation of the market place for these services.

The success of the project in promoting selected technologies within country is partly dependent on conditions beyond its control. This includes the encouragement given to the private sector, and also improvements to basic infrastructure and facilities (roads, storage and market facilities, mobile phone coverage, financial institutions etc), and the extent to which CAADP commitments to raising agricultural spend to 10% of national GDP are met.

6.5 Recommendations

These recommendations draw on both the preliminary recommendations put forward by the study team, and those agreed upon during group work in the validation workshop. Recommendations for SIMLESA are given first followed by those for country governments. In each section recommendations made by workshop participants and the study team are listed before other recommendations put forward by the study team are listed.

Outputs from two sets of group work are drawn upon—group work related to extension approaches and knowledge products, and group work on strategy options. During the former one group looked at how SIMLESA can improve its role as a bridging institution and the second at best practice for establishing effective innovation platforms.

6.5.1 Recommendations for SIMLESA

A key recommendation made both in the workshop and by the team concerned **institutional linkages and coordination.** The SIMLESA project needs to increase the interactions and synergies it has with other national regional and international bodies concerned with CA and maize–legume scaling out and spillover. This is important to ensure sustainability keeping in mind that SIMLESA is a relatively short term project. Such linkages are necessary at all levels including those with provincial and local commissioners, government officials, politicians and traditional leaders. Regional and international networks or organisations (public and private) providing opportunities for the spillover of technologies (including ASARECA, CGIAR centres, ACTN, FAO, DTMI, SARNET, FIPS, multi-national seed companies etc.) should be used by SIMLESA wherever possible.

Workshop participants acknowledged that the coordination needed to establish and maintain linkages at all levels is hard work and not the sort of work scientists would normally prioritise. During the group work participating countries ranked their strengths in coordination and results ranged from just 2, to 5 out of 10. However, participants acknowledged that the project must secure strong national and regional commitment to scaling out and spillover of maize–legume technologies and CA practices. To achieve this good coordination and networking are vital.

Some linkages exist informally, i.e. through personal connections, but establishing and strengthening official linkages (e.g. between SIMLESA and ACT, AGRA and other relevant national and regional organisations) would be more effective and sustainable. One suggestion made was that SIMLESA annual meetings at country level could be used to enhance the SIMLESA role as a bridging institution by inviting representatives of national farmer organisations, traders associations, politicians, universities and other organisations to relevant sessions of the annual meetings. Furthermore, the project could link with country or local level working groups (e.g. maize working groups), where these exist, especially as such working groups often include major stakeholders such as the private sector, researchers and farmer organisations.

The project should ensure cooperatives and farmer unions are included in training of trainers and knowledge product distribution. Workshop participants suggested that the project link up with strong farmers unions in each country.

Workshop participants noted that despite the need for strong linkages there are insufficient resources to make all these linkages. However, effective use of resources could be made by liaising with the other organisations and having joint meetings and demonstrations, and by seeking complementarity and avoiding duplications. The group recommended that combining resources is the best way to scale out, with relevant projects, agencies and organisations working on common interest areas.

While coordination, networking and strengthened institutional linkages was seen as a key priority, there was also much discussion concerning innovation platforms). Workshop participants noted that the SIMLESA innovation platforms are key bridging institutions and their role could be further enhanced. The SIMLESA project should adopt a more explicit innovation platform approach, involving a wider set of actors and reducing its focus on production. Recent analysis of innovation platforms in sub-Saharan Africa (Adekunle et al. 2012) can inform the establishment of country and local project platforms. Similarly, ongoing work supporting farmer innovation by PROLINNOVA can inform the already good participatory work by the project.

Innovation platforms set up by IFAD, DFID and other projects and NGOs exist in many countries. Where SIMLESA has not already done so, it could link up with these existing platforms, some of which indeed focus on maize and legumes, learning from them and collaborating with them. Furthermore, some of these platforms and their organisers received extensive training in how to establish and facilitate an innovation platform. The SIMLESA project could identify those key resource people and learn from them. Workshop participants suggested preparing a quick inventory of all existing innovation platforms in each SIMLESA and spillover country, particularly those that concern maize or legumes. Innovation platforms could be made more effective in the following ways:

- Bring in all relevant stakeholders including all value chain players
- Set clear objectives
- Set roles and responsibilities
- Establish guidelines and an operational framework for setting up and running innovation platforms
- Identify and manage stakeholder interests
- Monitor effectiveness and impact
- Build capacity
- Establish effective communication mechanisms
- Establish effective experience sharing mechanisms within and between countries

To sustain innovation platforms, participants stressed the importance of building trust and transparency among the different stakeholder groups involved in the platform (researchers, extension agents, farmers, input providers, processors, traders, etc.). They also discussed whether and how innovation platforms could be institutionalised for long-term sustainability. This may not always be needed, as often an innovation platform seeks to address weaknesses in the value chain. Once these are addressed it may no longer be needed WHAT?, or it may gradually evolve into a limited company, cooperative or other type of organisation.

Factors necessary to institutionalise and sustain innovation platforms include: an experienced organiser/leader/promoter; basic finance/seed money; and sustainable and effective technology generation and provision. Mainstreaming the innovation platforms in existing government initiatives including in the extension system and any system of farmer organisation and commodity chains would help.

A third recommendation was the need for **greater emphasis on monitoring, documenting and lesson learning** regarding the uptake and adaptation of SIMLESA technologies, and the effectiveness of knowledge products. This would provide feedback that would in turn improve dissemination processes and products.

The workshop recommended that SIMLESA should revisit its monitoring and lesson learning processes, to ensure that processes being followed for example in setting up innovation platforms, are recorded and shared. Participants acknowledged that the project could do better with documenting lessons. Many of the outputs from CA and PVS trials and demonstrations could inform other countries including the spillover countries. Similarly reports on exchange visits, field visits and processes such as lesson learning on the establishment and running of innovation platforms could all greatly enhance shared learning between SIMLESA and spillover countries. Currently, although the project organises farmer visits to different countries, such visits are rarely documented.

Lessons from trials, extension approaches and knowledge products, innovation platforms, scaling out and spillover should be shared through making greater use of the SIMLESA website. Lessons can also be learned and applied by examining successful examples of political intervention in the scaling-out process.

Several suggestions were made specifically for and by **spillover countries**. First, participants suggested that the spillover countries could inform ASARECA of the key organisations in the agricultural innovation systems in their countries, including the research, extension, and other value chain actors and organisations that would be key partners for spillover activities.

Second, spillover countries were advised to get the support of national bodies before they embark on any project related to maize–legume and CA scaling out. This applies within the SIMLESA countries also. Scaling out within the SIMLESA project will be enhanced by aligning the SIMLESA country programmes with government policies and strategies if this is not already the case.

The study team made additional recommendations.

The project lacks dissemination specialists to analyse the client base or develop different knowledge products. If resources allow, or could be leveraged, permanent or consultant staff should be recruited to increase dissemination activities and enhance project impact. Use of ICTs to maximum advantage should be encouraged, as there is increasing ownership of radios and mobile phones in rural communities.

Perhaps through Objective 1 study, the project should further understand the radical farming systems changes implied by the uptake of CA in mixed farming situations, and the secondary work necessary on restricted grazing, providing alternative feed and fuel sources.

CA requires that farmers change their mindsets away from deep-rooted beliefs that tillage is necessary for good crops. That will take time, and it will be difficult to convince people unless they see the results for themselves. Therefore the current emphasis on farmer trials, demonstrations and field days should be maintained. The use of video—narrated by farmers—is the nearest proxy to seeing the plots face-to-face and, wherever possible, within and cross-country exchange visits for both farmers and service providers should be funded.

Objective 1 studies could be carried out on affordable finance options for smallholder farmers to enable them to purchase equipment, seed and herbicide required for adoption of project technologies, taking into account examples such as Sasakawa Global 2000 in Ethiopia, concessionary companies in Mozambique and the FISP programme in Malawi.

The comparative labour inputs for CA vs. conventional tillage should be further investigated, and technologies minimising demand for labour selected. It may be useful if the project provided a standardised package, or basket of options, of CA practices.

Further funding for exchange visits (researchers, extension agents and farmers) should be leveraged by SIMLESA. This would be used for this very effective dissemination mechanism.

Tanzania, Malawi, Ethiopia and Mozambique could learn from the crop insurance scheme available to smallholders in Kenya (Kilimo Salama).

6.5.2 Recommendations for country governments

The most commonly mentioned factor constraining spillover is the **lack of harmonised seed policies and regulations,** meaning that the transfer of genetic material between countries is difficult. While seed harmonisation is in progress, there is some way to go, and efforts (by ASARECA and others) need to be maintained so that there is free exchange of seed within the COMESA bloc.

How to enhance seed harmonisation was the key point covered in group work regarding recommendations for country governments. Rules for moving parental material vary from country to country. For example, Kenya and Ethiopia have stringent rules while those in Malawi and Mozambique are less stringent. There are also variations in the extent to which seed harmonisation has been realised within each of the regional economic communities.

Consequently, workshop participants recommended that SIMLESA could lobby the chief executive officers of NARS and the SIMLESA project steering committee (which is made up of senior NARS personnel) to influence the relevant national legislative bodies responsible for enacting the new laws to enable seed harmonisation across each REC.

Workshop participants also noted that there are other ways to speed up spillover. For example, regional seed companies can relatively easily trade certified seeds across borders. And SIMLESA staff had managed to secure inoculants for trials on aflatoxin biocontrol relatively speedily by going through the African Agriculture Technology Foundation. Similarly better linkages with ACT may help the project and spillover countries access CA equipment and cover crop seeds.

With regard to the private sector, an analysis of the negative impact of seed royalty payments on the multiplication and dissemination of new varieties could lead to refinements in the availability of foundation seed to seed companies. Generally, encouraging private sector involvement in providing seed will allow for wider and faster scaling-out.

Scaling out could be enhanced if farmers trusted that the seed they were purchasing is of consistently good quality. More work should be done to enhance the quality of goods and services (e.g. seed quality) provided by different providers, particularly those from the private sector, to facilitate scaling out (e.g. reduce complaints that cooperatives do not provide good-quality seed to their members).

Workshop participants felt it was important to lobby those governments that as yet do not promote CA as a mainstream activity, to consider doing so. Long-term government commitment to CA across ministries and programmes will lead to more uptake of this practice.

Parallel to scaling out CA in the five SIMLESA countries and to efforts being made for spillover of the various practices to non-SIMLESA countries, farm implements such as jab planters that are adapted for CA conditions should be developed and widely distributed in the farming communities.

On **innovation platforms**, participants noted that while those at the grassroots can help in scaling out, national level innovation platforms are less effective in promoting spillover. There should be more of the existing national maize and legumes innovation platforms and how they could enhance spillover. The study team made several additional recommendations:

1. Scaling out will be enhanced by the continued drive by national governments towards meeting CAADP targets on agriculture.

2. Policies that can lead to improved security of land tenure for smallholder farmers will enhance scaling out (of CA in particular).
3. Train extension staff and build capacity of training institutions in CA and the latest technologies.
4. Community resource centres stocked with information materials that farmers can access in the rural area can enhance farmers' access to knowledge about CA and new varieties.
5. Include CA in the school curriculum and put demonstrations in schools to help spread technologies quickly.
6. GIS is a powerful tool that SIMLESA should use to identify similar areas in different countries so that technologies can be correctly targeted. SIMLESA should make contact with Harvest Choice where very useful expertise and data sets reside.

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