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SUSTAINABLE INTENSIFICATION OF MAIZE-LEGUME SYSTEMS FOR FOOD SECURITY IN EASTERN AND SOUTHERN AFRICA (SIMLESA)

LESSONS AND WAY FORWARD





SUSTAINABLE INTENSIFICATION

OF MAIZE-LEGUME SYSTEMS FOR FOOD SECURITY
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LESSONS AND WAY FORWARD

EDITORS

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ACIAR

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The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. ACIAR operates as part of Australia's international development assistance program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. It commissions collaborative research between Australian and international researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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Cover: Maria Gorete (far right), farmer and SIMLESA project participant, plants maize with her daughters in Angonia, Mozambique. At the end of 2017, more than 230,000 farmers had adopted sustainable intensification technologies.
Photo: © CIMMYT. Photo by Peter Lowe.

Foreword

More than 1.3 billion people live in Africa, a number expected to almost double to 2.5 billion by 2050. Food insecurity and resource degradation in a changing climate are pressing concerns with geopolitical significance. For decades, agricultural researchers have been alarmed by the wide gap between the yields that are technically possible on African research stations, and those that are typically achieved in African farmers' fields. Leading researchers from Africa and internationally (including Australia) have long understood that it is insufficient to just focus on single interventions in one part of the system (e.g. better seed varieties, or improving fertiliser application). Durable, meaningful improvements can only be effected by understanding the whole farming system, including the policy and market contexts within which farmers operate.

For almost a decade, the Australian Centre for International Agricultural Research (ACIAR) brokered and invested in an ambitious, multidisciplinary applied research program in eastern and southern Africa to identify the pathways to sustainable intensification of diverse maize–legume farming systems.

The program, called the *Sustainable intensification of maize–legume cropping systems for food security in eastern and southern Africa*, and known as SIMLESA, typifies the work of ACIAR. ACIAR is mandated by the *Australian Centre for International Agricultural Research Act 1982* to work with partners across the Indo-Pacific region to generate knowledge and technologies to underpin improvements in agricultural productivity, sustainability and food system resilience. We do this by funding, brokering and managing research partnerships for the benefit of partner countries and Australia.

SIMLESA is one of the largest research partnerships ever funded by ACIAR. From 2010 to 2019, the program harnessed the energy and talent of researchers from eight countries in eastern and southern Africa, Australian Universities notably the University of Queensland in Australia and three international research centres belonging to the CGIAR system, all led by the International Maize and Wheat Improvement Center (CIMMYT).

SIMLESA is a flagship program that demonstrated to stakeholders at all levels, from farmers to business people, policymakers and ministers, the promise and opportunity of conservation agriculture-based sustainable intensification (CASI). It showed that holistic farming systems intensification; integrated combinations of reduced tillage, modern maize and legume varieties; retention of crop residue for preserving soil cover; and moderate doses of organic and inorganic fertiliser can deliver benefits to farmers and their environment. SIMLESA conducted a nuanced, rich and contextualised analysis of the benefits and trade-offs of the proposed innovations, which, overall, lifted production, reduced costs and helped farmers to better manage risk.

Constraints and obstacles to adoption of the innovations by farmers were studied and collective mechanisms to overcome these were tested. SIMLESA fostered many innovation platforms—multi-stakeholder, grassroots institutions that allow farmers, their suppliers and their customers to interact and collectively improve farming and food systems. Agriculture ministers from the eight partner countries strongly endorsed the CASI pathway in Uganda in May 2019. This reflects a key policy achievement of SIMLESA, paving the way to country-led expansion of SIMLESA practices and innovations in eastern Africa.

This majestic monograph, *SIMLESA: Lessons and way forward*, is a comprehensive, authoritative synthesis of selected results and lessons from this 10-year partnership, reflecting the hard work and hard-won lessons learned by more than 60 African and 15 international and Australian scientists.

Thank you and congratulations to the editors and authors of the 26 chapters of this book and the many more scientific articles that have been produced to document the SIMLESA project. This timely book should be useful to practitioners of CASI in eastern and southern Africa (and well beyond) for many years to come.

A handwritten signature in black ink, appearing to read 'A. Campbell', with a stylized, cursive script.

Andrew Campbell
Chief Executive Officer, ACIAR

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Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
ACMAD	African Centre of Meteorological Application for Development
ADOPT	Adoption and Diffusion Outcome Prediction Tool
AEZ	agroecological zones
AGREN	Agricultural Research and Extension Network
AIP	agricultural innovation platforms
AIS	agricultural innovation systems
AMESD	African Monitoring of the Environment for Sustainable Development
APSIM	Agricultural Production Systems sIMulator
ARC	Agricultural Research Council
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASCII	American Standard Code for Information Interchange
BARC	Bako Agricultural Research Center
C	carbon
CA	conservation agriculture
CAADP	Comprehensive Africa Agriculture Development Program
CASI	conservation agriculture-based sustainable intensification
CCAFS	Climate Change, Agriculture and Food Security
CEC	cation exchange capacity
CGIAR	formerly the Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CMIP	coupled model intercomparison project
cm	centimetre
cmol	centimole
CV	coefficient of variation
CORDEX	Coordinated Regional Downscaling Experiment
CSA	climate-smart agriculture
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EIAR	Ethiopian Institute of Agricultural Research
ELD	Economics of Land Degradation
ENACTS	Enhancing National Climate Services
ESA	eastern and southern Africa
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agricultural Organization
FISP	Farm Input Subsidy Programme
FURP	Fertilizer Use Recommendation Program
g	gram
GCM	general circulation models
GMES	Global Monitoring for Environment and Security

GPCC	Global Precipitation Climatology Centre
ha	hectare
hPa	hectopascal
HPW	haulm plus pod wall
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IIAM	Instituto de Investigação Agrária de Moçambique (Mozambique)
IIED	International Institute for Environment and Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society at Columbia University
ISPC	Independent Science and Partnership Council
ISPM	Instituto Superior Politécnico de Manica
K	potassium
KALRO	Kenya Agricultural and Livestock Research Organization
KARI	Kenya Agricultural Research Institute
kcal	kilocalorie
kg	kilogram
km	kilometre
l	litre
m	metre
mg	milligram
mm	millimetre
MG	megagram
Mha	million hectare
MSG	Meteosat Second Generation
Mt	million tonne
N	nitrogen
NARES	National Agricultural Research and Extension System
NARL	National Agricultural Research Laboratories
NARO	National Agricultural Research Organization
NARS	National Agricultural Research System
OA	Oxfam America
OC	organic carbon
PUMA	Preparation for the Use of MSG in Africa
QAAFI	Queensland Alliance for Agriculture and Food Innovation
RANET	Radio and Internet for the Communication of Hydro-Meteorological and Climate Related Information
RETIM	Reseau de Transmission d'Information Météorologique
RFE	African Rainfall Estimation Algorithm
SC	soil carbon
SI	sustainable intensification

SIMLESA	Sustainable Intensification of Maize–Legume Systems for Food Security in Eastern and Southern Africa
SLM	sustainable land management
SNNP	Southern Nations and Nationalities and People
SoRPARI	Somali Region Pastoral and Agro-pastoral Research Institute
SPSS	Statistical Package for Social Scientists
SSA	Sub-Saharan Africa
SST	sea surface temperature
t	tonne
WMO	World Meteorological Organization
yr	year
ZimCLIFS	Zimbabwe Crop Livestock Integration for Food Security
µg	microgram



Introduction

Agricultural intensification is essential to boost household food security and incomes for African smallholder families, to feed growing African cities and to contribute to the expanding global demand for food in the coming decades.

The maize mixed farming system, which extends from Ethiopia in the north to Mozambique in the south, already underpins food supply in eastern and southern Africa. However, effective intensification is threatened by widespread degradation of land and water resources from Capetown to Cairo. Scientists and policymakers also recognise that the pathways for intensification must be sustainable for decades to come, hence the concept of sustainable intensification and its association with conservation agriculture (as conservation agriculture-based sustainable intensification (CASI)). CASI has been embraced by many governments in the region—most notably in high-level events in 2015 and 2019 convened by the Association for Strengthening Agricultural Research in Eastern and Central Africa.

This publication is a valuable compendium of research-for-development achievements from the *Sustainable intensification of maize-legume cropping systems for food security in eastern and southern Africa* (SIMLESA) program. It covers many aspects of CASI, including climate variability, soil erosion, market access, crop and livestock productivity, and policy.

Overall, a large number of smallholder families adopted and benefited from SIMLESA research results before the program closed. In the words of Josefa Leonel Correia Sacko, Commissioner, Rural Economy and Agriculture of the African Union, ‘looking at #SIMLESA’s evidence, we can say that #conservation agriculture works for our farmers’.

Both sustainable intensification and CASI are associated with sustainable agriculture and land restoration, embracing environmental, economic and social aspects of sustainability and underpinning increased food production, diversification and food and nutritional security. Food security has been a concern of many societies since the dawn of settled agriculture about 10 thousand years ago, when fertile land resources were abundant and the global population might have been less than the current population of Malawi (19.1 million). Now there is widespread degradation of African land resources upon which the population of 1.3 billion primarily depends for food. The population of Africa is projected to nearly double to almost 2.5 billion by 2050.

Strategies to address agricultural intensification and food security challenges have evolved over the centuries. Beyond the simple Malthusian population and food production concept, some milestones in the evolving debate include the Club of Rome analysis in the 1960s, the Food Summit in the 1970s, the Bruntland environment and sustainable development report in the 1980s, the Rio Earth Summit in the 1990s, the United Nations Millennium Development Goals in 2000 and the Sustainable Development Goals in 2015.

Framed by the Millennium Development Goals in 2009, the SIMLESA program was formulated for the eastern and southern African region by African research leaders, international researchers from the International Maize and Wheat Improvement Center, Australian scientists and the Australian Centre for International Agricultural Research. At the time, the region suffered from rampant rural poverty and hunger, widespread soil erosion, extreme seasonal variation in food crop yields and striking gaps between farmers’ actual and potential food crop yields. These conditions were prevalent across the maize mixed farming system in at least eight countries in the region, from Ethiopia to Mozambique.

To add to the challenge, national agricultural research institutes were under-budgeted in many countries and the once-strong multidisciplinary and participatory skills of farming system research teams had been eroded in favour of disciplinary research. Of great concern, there had been little improvement in food security, agriculture or resource management over the preceding decade.

Because of the prevalence of similar food production and security constraints across the maize mixed farming systems, SIMLESA was designed as a regional program. Rather than reinforcing the prevailing disciplinary research, for example strengthening varieties and fertiliser management research, the SIMLESA program sought different and new research approaches and themes to impact on the prevailing yield gaps, production risks, resource degradation and food insecurity in the region. The complexities of this multifaceted challenge called for context-specific participatory, integrated and systems research-for-development that would generate scalable, sustainable intensification technologies and knowledge.

Conservation agriculture was a promising approach, building on earlier experimentation in the region to improve soil moisture (green water) management and soil health, and reduce maize and legume yield gaps and seasonal variability. Natural complements to the conservation agriculture theme were drought-tolerant maize and legume varieties. Preliminary analysis identified other complementary research themes, namely farming systems modelling, multistakeholder innovation platforms and appropriate-scale mechanisation. In order to assure widespread impact, complementary research-in-development on scaling models appeared potentially valuable, including socioeconomic constraints to adoption, commercial seed multiplication and distribution, and managed spillovers of research results between countries. During the formulation process, research on appropriate-scale mechanisation and socioeconomic constraints to adoption of CASI were spun off into complementary regional research projects.

The development of the research design in exceptionally close consultation with eight countries of the region and Australia underpinned two other distinguishing features of SIMLESA: strong national ownership of, and substantial national co-investments in, the program. During two phases over nine years, the program research generated technologies that significantly increased productivity, resilience and household food security. These were scaled to nearly half a million farm households and spilled over to neighbouring countries. The program results established the confidence of agricultural leaders in sustainable intensification as a pathway to food security and economic development.

The research results are documented in 40–50 scientific articles and summarised in administrative reports such as the final program report, and the research data are publicly available through international databases. However, as a complement to the scientific papers and administrative reports, this book contains a unique set of analyses of SIMLESA activities written by the actual researchers, comprising more than 60 African national scientists and 15 international and Australian researchers. In many respects, this book could be compared to the historical accounts of other major international research and development programs in Caqueza Valley (Columbia), Puebla Program (Mexico), the Green Revolution in India, Pakistan and Bangladesh or the rebuilding of Cambodian agricultural research early this century. It is yet another example of a successful large-scale international agricultural research partnership, which is the core approach of ACIAR, and of the immense value that arises from collaboration between Africa and Australia.

The 26 chapters of this book are grouped into five sections. Following the scene-setting opening chapters (Section I), the regional section (Section II) outlines key cross-cutting research as the context for Section III, in which the national multidisciplinary research teams—the voices of Africa—analyse national experiences. The fourth section discusses the potential for institutional reform and scaling of the research results in the region. The final section identifies possible ways forward, building on the SIMLESA results.

This book outlines many key lessons concerning CASI that can underpin improved productivity, soil health, resilience and food security, and ultimately contribute to the achievement of the United Nations Sustainable Development Goals. These are relevant, with adaptation, to all African regions, and it is hoped that African researchers, policymakers, research leaders and development agencies will find the volume of great value. More generally, this book will serve as a reference for those studying African agricultural science and food security. It will also be of interest to Australian and international scientists who wish to support the development of African farming and food systems.

A handwritten signature in black ink, reading "John Dixon". The signature is written in a cursive style with a large, sweeping initial "J".

John Dixon
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