ASARECA
Transforming Agriculture
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Why the low adoption of agricultural technologies in Eastern and Central Africa?

Why the low adoption of agricultural technologies in Eastern and Central Africa?

Prepared by
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Abbreviations and acronyms

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AIS	Agricultural innovation systems
CABE	Centre for African Bio-Entrepreneurship
CFU	Conservation Farmers Union, Zambia
CLUSA	Cooperative League of USA
CMD	Cassava mosaic disease
DRC	Democratic Republic of Congo
EIAR	Ethiopian Institute of Agricultural Research
ECA	Eastern and Central Africa
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus group discussion
IITA	International Institute for Tropical Agriculture
IRRI	International Rice Research Institute
KMUS	Knowledge Management and Upscaling Programme, ASARECA
LM&CF	Land Management and Conservation Farming
MACO	Ministry of Agriculture and Cooperatives, Zambia
MDG	Millennium Development Goal
M&E	Monitoring and evaluation
NARO	National Agricultural Research Organization, Uganda
NARS	National agricultural research systems
NGO	Non-governmental organisation
NRM	Natural resource management
SAARI	Serere Agricultural and Animal Research Institute
SECID	South-East Consortium for International Development
TIMPs	Technologies, innovations and management practices
USAID	United States Agency for International Development
ZNFU	Zambian National Farmers Union

Foreword

Agriculture is arguably the most important vehicle for realising economic development, creating employment and reducing poverty in Africa. In the Eastern and Central Africa (ECA) sub-region, agriculture accounts for about 43% of the gross domestic product (GDP) and over 60% of exports. About 70% of the population and nearly 90% of the poor work in agriculture where they depend on increased agricultural productivity to lift them out of poverty.

Agricultural productivity and growth in ECA is therefore critical for economic growth and livelihoods. However, unlike other regions of the world, ECA and Africa have continued to experience low agricultural productivity and have lagged behind in total and per capita food production. For example, in the last decade Africa's share of world food production was a meagre 3.9% while Asia, North America and Europe had 47.7%, 14.8% and 12.2% respectively. Coupled with the high population growth, the low productivity has contributed to the increase in food insecurity and food imports in the sub-region where, for example, between 1980 and 2007 Africa's total net food imports in real terms grew at 3.4% per year.

Improved agricultural technologies are widely recognised as the key means of addressing most of the causes of low productivity such as pests and diseases, soil infertility and low yielding crop varieties and livestock. Over the past decade, research institutions in ECA have generated numerous technologies, innovations and management practices (TIMPs) that are effective in addressing most of these factors. However, many of these TIMPs have not been widely adopted by the intended users, especially smallholder farmers. To help resolve this challenge, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) commissioned a study to determine the factors responsible for the low adoption, which culminated in this report. The report identifies key factors of low adoption and provides strategies to address them. ASARECA envisages that stakeholders within the region will find the report useful and make concerted efforts to address the identified factors and challenges that contribute to low adoption of improved TIMPs in ECA to provide the growth impetus the sector requires.

About ASARECA

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is a not-for-profit sub-regional organisation comprising 11 countries: Burundi, the Democratic Republic of Congo, 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 ECA.*

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

Agricultural technology adoption in sub-Saharan Africa has been widely studied. However, most of the studies have focused on micro factors related to farm resource and farmer characteristics, farm systems, market-related factors, and variables related to access to services. Similarly, farmer preferences as factors that significantly influence the decision to adopt have been considered in some studies.

Although these micro-level adoption studies have identified important factors, their application at macro-level has had limited effects in terms of spurring technology adoption. This is because by themselves, the micro-level factors cannot address key political economy issues. Moreover, from the perspective of agricultural innovation systems (AIS), such adoption studies have focused on the technology (product) per se, with limited consideration of processes, marketing systems and institutions.

This study sought to establish why most of the available proven technologies have very low or no adoption and impact by looking at technology adoption from a systems perspective. This meant applying AIS along with the value chains framework to bring together the micro-level adoption factors and the key macro adoption issues. In other words, the study sought to establish the macro foundation of the micro factors of low technology adoption.

The study covered 5 (Democratic Republic of Congo (DRC), Ethiopia, Kenya, Sudan and Uganda) of the 11 member countries of ASARECA. Since 1997 ASARECA has supported the development and dissemination of agricultural technology by its member national agricultural research systems (NARS). Scientists in NARS, in partnership with other stakeholders such as the international agricultural research centres operating in the region, developed proven technologies and made them available for adoption. The study that led to this publication focused on factors that contribute to the low adoption of technologies for staples, high value crops, livestock and natural resource management (NRM).

The output of the study reported in this publication provides ASARECA and its stakeholders with a better understanding of why the technologies and innovations are not widely adopted by intended users. It also provides recommendations for improving adoption, some illustrative case studies, best practices and promising approaches and methods for scaling-up adoption of technologies and innovations in the ECA sub-region.

I thank the team of consultants working under the auspices of the Nairobi-based Centre for African Bio-Entrepreneurship (CABE) and many others who directly and indirectly contributed to the study that led to this publication.

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

Executive summary

For several years the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has supported research for technology development implemented by national agricultural research systems (NARS) within the Eastern and Central Africa (ECA) sub-region. These projects have generated and promoted demand-driven, proven technologies and innovations for uptake by end users. However most of these technologies have had very little or no adoption and impact. The purpose of this study was to identify, analyse, establish and, where possible, engender the underlying causes for the poor adoption, provide examples of successful and best practices on dissemination and out-scaling approaches from adoption case studies, and recommend strategic interventions that may address the causes identified for the poor adoption.

The ASARECA member countries covered were Ethiopia and Sudan (representing northern Africa), Kenya and Uganda (representing East Africa), and Democratic Republic of Congo (DRC; representing Francophone and Central Africa). The study team engaged NARS in the selected countries to prioritise technologies using four commodity/enterprise clusters: natural resource management (NRM; chemical fertiliser, organic farming and minimum tillage); staples (cereal—maize, sorghum and millet; and tubers—cassava, potato and sweet potato, and cooking bananas); high value crops (fruits, vegetables, beans and peas); and livestock (dairy, beef and poultry).

The following selection in each country was based on the importance of the enterprises to the national economy and available proven technologies along a given enterprise value chain:

- DRC: Organic farming (NRM), cassava (staple root crop), beans (high value crops) and beef (livestock).
- Ethiopia: Lime and chemical fertilisers (NRM); hybrid maize (staple cereals), pulses—haricot beans and chick pea (high value crops); and dairy (livestock).

- Kenya: Chemical fertilisers (NRM); hybrid maize (staple), vegetables and tomatoes (high value crops); and dairy (livestock).
- Sudan: Chemical fertilisers (NRM); hybrid maize (cereal for livestock feed); vegetables—okra and onions (high value crops); and dairy (livestock).
- Uganda: Conservation agriculture—minimum tillage (NRM); maize—Longe series; cooking bananas (staple); dessert bananas (high value crops); and Serere Agricultural and Animal Research Institute (SAARI) chicken (livestock).

The analytical framework used three approaches: 1) adoption models with a cognitive (or sense-making) lens as the basis of this study; 2) a value chain analysis, to identify the position of technology in the enterprise chain, the actors involved and their roles and linkages in technology delivery; and 3) an agricultural innovation system as the organising approach. This ensured that the micro-level adoption factors for selected technologies were put in context and linked with the main macro adoption issues, especially the political economy of: commodities, market and service delivery infrastructure, gender-based constraints, policy and institutional environment. These approaches helped elicit, categorise and prioritise the main root causes of low adoption of the selected technologies from which strategic recommendations were derived.

Important insights into the root causes of low adoption and limited out-scaling of technologies/innovations came from primary data collected from key informants. The informants were policy experts, technical personnel in the ministries of agriculture and livestock; focus group discussions (involving farmers, traders and researchers), and review of secondary literature. The analysis leads to the conclusion that apart from the micro-level factors of adoption (related to farm systems, farmer characteristics and preferences), which have been studied and addressed over time, there are major macro-level factors responsible for low adoption. These factors are related to the performance of the technologies, their delivery and management mechanisms, access to extension and other support services, commercialisation of extent of commodities, effectiveness of marketing systems, gender-based constraints and the overall policy and institutional processes responsible for creating an enabling environment for adoption.

The following key messages were enriched by comments and contributions from researchers, technical personnel from ministries, farmer representatives and private extension organisations, and by participants at a validation workshop. Further, international lessons were drawn from successful technology adoption stories of upland rice varieties in China, and zero tillage practice in Zambia.

Key messages

1. **Improve technology performance by appropriately aligning technology attributes with end-user preferences that take into account socio-economic and agro-ecological conditions.** This requires well-crafted, enterprise-specific policies that are synchronised with micro and macro factors, especially the politics that influence how resources are allocated regionally to promote technology adoption. This is backed by capacity building of local actors in adapting technology to agro-ecological zones, and using media/information and communication technologies (ICT) to reach and facilitate participation of different social groups. The successful promotion of upland rice in Yunnan Province of China demonstrates the importance of agro-ecological targeting of technology, and macroeconomic policy support.
2. **Adopting comprehensive gender-mainstreaming strategies is a prerequisite for effectively addressing gender-based constraints which undermine adoption and productivity of agricultural technologies.** NARS in ECA are at different stages of mainstreaming gender. For example, DRC and Sudan have no mechanisms to mainstream gender in research. However, some effort exists in extension, albeit not very strong. Efforts to mainstream gender in the other three countries are inadequate. These efforts focus largely on gender capacity building, but with limited attention to other key gender-mainstreaming pillars such as overall support and commitment by leadership, accountability necessary to hold all actors responsible for gender mainstreaming, and a gender-responsive organisational culture. To overcome this situation, organisations must develop and adopt comprehensive gender-mainstreaming strategies that incorporate the four pillars—commitment, capacity, accountability and a facilitating culture. Some technologies such as minimum tillage reduce the

drudgery in farming. If the environment is conducive, minimum tillage will be well received in other countries in Africa just as it has been in Zambia.

3. **Commercialisation of enterprises through vertical integration that promotes interaction for knowledge sharing can create the impetus needed for technology adoption.** In ECA, the value chain framework is only partially developed, except in the dairy sector in Kenya where notable success has been achieved. Coordinating all public and private actors in the chain is the major weakness. Commercialisation of available technologies requires incentives for increased production, good marketing infrastructure for aggregation, and linkage to financial services. Market structures, ICT platforms and Internet access need to be developed to create room for price incentives to attract new technology adopters. Increased vertical integration and franchising product marketing supported by credit from financial institutions can spur adoption. However, countries in ECA must negotiate finance arrangements that will ensure that women farmers, who have traditionally been left out, are able to access credit.

4. **Institutional reforms are necessary to promote the efficiency and effectiveness of technology generation and delivery systems.** Countries in ECA are too politicised, tribal and divided to foster healthy competition in technology generation, promotion and adoption. Yet technology development and adoption thrive better in an environment where the work ethic is strong and less adversarial, and opportunities exist for innovation. The solution lies partly in using a wide range of actors and approaches to provide extension and advisory services (EAS). Furthermore, success in technology adoption is more likely for commodities with assured market. This is demonstrated by the dairy sector in Kenya and the successful promotion of zero tillage in Zambia. All players in EAS need to learn soft skills that motivate competitiveness such as working habits, practices, trust, empathy, dedication and sacrifice. Process audit systems that can help develop metrics to measure service efficacy and results are needed.

5. **Governments in ECA need to strengthen the enabling policy environment.** The influence of political power in enterprise policy design should not be overlooked since smallholders are fragmented and lack lobbying power to influence enterprise-specific policy and to promote technology linked

to marketing systems. Thus, there ought to be deliberate policies that coordinate activities of farmers and promote their collective action such as those cited in the success of upland rice in Yunnan Province. Political space is necessary to lobby for technology support and marketing infrastructure, insurance, extension, use of ICT in technology promotion and adoption, as reflected in the zero tillage farming in Zambia. In ECA, for example, the capacity for seed distribution, especially for staples and livestock pasture, is inadequate mainly because the distributors (agro-dealers) are concentrated in urban centres. In addition, supportive infrastructure such as roads and properly equipped storage facilities is poor. Some countries have strong seed regulatory systems while others have limited regulatory frameworks, leading to poor-quality seed. In this respect, harmonising and rationalising seed policies championed by ASARECA, which have had positive consequences in some countries, should be fast-tracked in all countries.

1

Introduction

The role of agricultural technology in growth and poverty reduction has been broadly discussed, in particular for low income African countries (Diao and Nin-Pratt 2007). Sub-Saharan Africa is the only region in the world where poverty is still strongly a rural phenomenon, where undernourishment has been increasing over the past 20 years and where those living on less than $1 a day have become poorer (World Bank 2005c). This weak economic performance is closely linked to low technology adoption which slows productivity growth in the agriculture sector (Wolgin 2001, Mwambu et al. 2004, Byerlee et al. 2005, Diao et al. 2006, Christiansen and Demery 2007). The recent crisis in world food prices further highlights the urgent need to significantly improve the agricultural performance of African countries. Food insecurity is a major problem in sub-Saharan Africa despite concerted efforts by donors and scientists to promote technology adoption. The prevalence of food energy deficiency among the populations of some of the study countries ranges from 37% in Uganda to 76% in Ethiopia (Smith et al. 2006). Problems of diet quality associated with the region's high rates of micronutrient deficiencies are widespread.

Much emphasis is placed on technology as a prime mover of agricultural productivity that improves food security and human welfare. Yet, according to Hall et al. (2008), evidence suggests that agricultural research has largely failed to make its promised contribution to social and economic development. Furthermore, research-led technology transfer has been ineffective in bringing about innovation. Scientists have generated a plethora of technologies, which, unfortunately, continue to gather dust on the shelves of national agricultural research organisations. Hence, improvements in human welfare in sub-Saharan Africa remain elusive. Part of the solution lies in paying greater attention to political economy perspectives, including gender-based constraints. Empirical evidence from Burkina Faso, Kenya, Tanzania and Zambia shows that allocating land, labour, capital and inputs (fertiliser) equitably could increase production by between 10% and 20% (Blackden and Bhanu 1998). The Asian and Latin American approaches to technology delivery and adoption are reported to have strong enabling policy by governments, high investment in research and infrastructure, and public and private collaboration. The success of zero tillage in Zambia and upland rice in Yunnan Province of China (see Chapter 5) demonstrates this commitment.

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) identifies two powerful instruments for the sub-region's agricultural systems that can contribute to improved food security and growth in agricultural production. These are improved delivery, uptake and adoption of scientific knowledge, technologies and innovations and providing policy options. This is in line with the objectives of the Comprehensive Africa Agriculture Development Programme (CAADP), which targets a 6% annual rate of growth in agricultural productivity by 2015, and is also in line with the Millennium Development Goals (MDGs) of halving the number of hungry people by 2015. The most current FAO State of Food and Agriculture Report (FAO 2011) emphasises that gender inequality is one of the reasons agriculture in developing countries is under-performing, and recognises its reinforcing nature of MDG 1 (Poverty and food security) and MDG 3 (Gender equality).

Agricultural technology adoption in sub-Saharan Africa has been widely studied. However, most of the studies have focused on micro factors related to farm resource and farmer characteristics, farm

Reasons why farmers do not adopt improved technologies:

1

They are either unaware of the technologies or of the benefits of using them.

2

The technologies are not available or are unavailable when needed.

3

The technologies are unprofitable.

systems, market-related factors, and variables related to access to services (Kaliba et al. 1998, Tesfaye et al. 2001, Abay and Assefa 2004, Tura et al. 2010). Similarly, farmer preferences as factors that significantly influence the decision to adopt have been considered in some studies (Adesina et al. 1997, Sally et al. 2000, Alemu and Mamo 2007).

Doss (2005) gives three micro-level reasons why farmers do not adopt improved technologies:

- The first reason is simply that they are unaware of them or that they are unaware that the technologies would provide benefits for them. Farmers may also have misconceptions about the costs and benefits of the technologies. Negative or positive conceptions arise from the technological frames (terminology coined to reflect perception among actors) that influence actors' technical choices, according to Kaplan and Norton (2008).
- Second, the technologies are not available or are unavailable when needed.
- Third, the technologies are unprofitable given the complex sets of decisions that farmers make about how to allocate their land and labour across agricultural and non-agricultural activities. Also, gender-based constraints act as a powerful force against adoption of technologies. The typically lower asset base of women and their more limited control over benefits act as major deterrents to adoption (World Bank 2001).

Although these micro-level adoption studies have identified important factors, their macro-level application to spur adoption has been limited because they cannot address important political economy issues (Doss 2005). In the context of agricultural innovation systems (AIS), these adoption studies have focused on the technology (product) per se with limited consideration of processes, marketing systems and institutions (Knickel et al. 2008).

This study sought to establish why most of the available proven technologies have very low or no adoption and impact by looking into technology adoption from a systems perspective—involving AIS along with value chains—to bring together the micro-level adoption factors with the main macro adoption issues. In other words, we sought to establish the macro foundation of the micro factors of low technology adoption.

The strength and configuration of bridging institutions across Eastern and Central Africa (ECA) is a product of past and existing political economy forces that determined erstwhile policy formulation and implementation. The study provides ASARECA and its stakeholders with a better understanding of why the technologies and innovations are not widely adopted by intended users. It also provides recommendations for improving adoption including some best practices and promising approaches and methods for scaling-up adoption of technologies and innovations in the ECA sub-region.

1.2 Objectives of the study

The overall objective of this study was to establish the factors constraining adoption of the available and proven agricultural technologies by potential users in ECA, and to recommend how adoption can be enhanced. The specific objectives were:

1. Identify, analyse and establish the causes of the low and/or lack of adoption and scaling out of the available proven technologies and innovations in ECA.

2. Provide analysed examples of best practices including case studies of dissemination and scaling-out approaches, and methods relevant and applicable to ECA that have resulted in high levels of adoption.

3. Recommend strategies that may improve dissemination, adoption and scaling out of proven technologies and innovations.

The rest of this report is organised as follows: Chapter 2 provides the background information to the study while Chapter 3 presents the methodological approach and overview of the country studies. The syntheses of findings with both successful and unsuccessful country case studies are presented in Chapter 4; and illustrative successful adoption stories from China and Zambia are highlighted in Chapter 5. Chapter 6 provides conclusions and recommendations.

2

Background

2.1 Overview

Several reasons exist for low productivity in sub-Saharan Africa. These include: dependence on rainfed agriculture, diverse food crops of low hectarage, poor infrastructure (markets, roads, water and electricity), policy discrimination against agriculture, low investment in technology, and gender-based constraints that reduce technology adoption and effective management. In most societies, women tend to have a limited asset base with regard to land, incomes, knowledge and overall decision making compared to men. These gender disparities directly and indirectly limit economic growth, productivity and welfare (Blackden and Bhanu 1998).

Many resources have been invested in developing agricultural technologies that have the potential to increase yields of crops and livestock. Key among these are new crop varieties, agronomic practices, disease and pest control techniques and natural resource management (NRM) techniques. New varieties of crops number more than 8000 (World Bank 2008) and improved breeding methods for livestock such as artificial insemination, embryo transfer technology and feed formulation are also available. As reported by World Bank (2008) and reflected in statistics in the various ASARECA countries, these productivity-enhancing technologies have not been adopted.

ASARECA is a sub-regional body comprising the national agricultural research institutes (NARIs) of the 11 member countries: Burundi, Democratic Republic of Congo (DRC), Ethiopia, Eritrea, Kenya, Madagascar, Rwanda, Sudan, South Sudan, Tanzania and Uganda. The Association aims to overcome the challenges facing agriculture by developing and implementing strategic priorities that cut across national boundaries. ASARECA serves as an avenue for strengthening agricultural research and relations among national agricultural research systems (NARS) and collaboration with international agricultural research systems. Its vision is: "to be a regional leader in agricultural research and development for improved livelihoods in Eastern and Central Africa". The ASARECA 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 (ECA)".

This study covered 5 of the 11 member countries of ASARECA: DRC, Ethiopia, Kenya, Sudan and Uganda, where between 1997 and 2011 ASARECA supported the development and dissemination of agricultural technology in collaboration with the respective NARS. Scientists in the NARS in the region have developed available and proven technologies. This study focused on the low adoption of these technologies for staples, high value crops, livestock and NRM. It used a SWOT (strengths, weaknesses, opportunities and threats) analysis within a value chain framework with gender and cognitive (sense-making) lenses to elicit constraints in representative enterprises for the four clusters selected. The value chain framework was used as an organising tool to analyse actors, their roles and linkages in the three domains of the innovation systems—agricultural knowledge, agribusiness and bridging institutions.

NARS representatives selected enterprise clusters based on the enterprise's importance in the national

ASARECA Vision

"to be a regional leader in agricultural research and development for improved livelihoods in Eastern and Central Africa"

Mission

"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 (ECA)" economy and agro-ecological zones, and predominance among small-scale farmers. The staples cluster used maize, rice and cooking bananas; the high value crops cluster entailed domestic vegetables; the livestock cluster analysed dairy and beef cattle and indigenous chicken; and chemical fertilisers, organic farming and minimum tillage represented the NRM cluster.

2.2 Technology adoption trends in ECA

According to expert opinion from the ministries of agriculture and livestock, in both Kenya and Uganda adoption of dairy technologies is less than 20%; that of hybrid maize is 40–70%. Adoption of high value domestic vegetables and NRM technologies remains below 20% and is mainly confined to high potential areas. The development of new seed technologies for maize, tomato, onion and cabbage has raised productivity. Maize yields now average 1.7 t/ha (Mbwika 2006), and tomato yields are 10–40 t/ha.

The dairy sector has continued to improve because farmers have adopted better breeds and are using artificial insemination (AI) in breed selection. Among the study countries, Kenya is leading in dairy productivity followed by Sudan, as reflected in the increase in numbers of dairy animals among smallholders in the last 20 years. The main breeds adopted were Friesian and Guernsey which accounted for 62% (Bebe et al. 2003), and Jersey and local crosses at 22%.

In DRC, most farmers do not have access to improved varieties of common beans, groundnut, soybean, cassava, banana, sweet potato, maize and sorghum. Decline in soil fertility and high levels of soil erosion were ranked as the first and second major problems affecting agricultural productivity in South Kivu (Kasereka 2003). Every year an estimated 80 kg/ha of nitrogen, phosphorus and potassium nutrients are lost from the soil in eastern DRC where farming is concentrated (Vandamme 2008). Soil fertility improvement and conservation techniques are limited to the use of simple practices such as crop rotation, incorporating crop residues into soil, mulching, and applying compost, kitchen ash and manure (Lunze 2000). Moreover, manure has been in short supply following the decline in livestock populations in South Kivu in DRC (Lunze 2000).

Use of fertiliser in sub-Saharan Africa has stagnated at very low levels largely because of poorly developed produce markets and high farm input prices. This is one of the main reasons for the region's low agricultural productivity relative to Asia. On average, sub-Saharan African farmers must sell about twice as much grain as Asian and Latin American farmers to purchase a kilogramme of fertiliser, given its high price. Low volumes, high prices, high transport costs, and undeveloped private input markets are major barriers to fertiliser use in sub-Saharan Africa. Soils are degraded as a result of a combination of shorter fallows periods, expansion to more fragile land driven by rapid population growth, and low use of fertiliser in the region. About 75% of the farmland is affected by severe mining of soil nutrients (World Bank 2006). This problem is acute in areas with high population density, which have reduced farm sizes; high soil erosion and mono-cropping is common. For example, the estimated annual productivity loss in the Ethiopian highlands from soil degradation is equivalent to 3% of agricultural gross domestic product (GDP) a year (Berry 2003). Clearly the decline in soil fertility is one of the main reasons for sub-Saharan Africa's low yields; reversing it must therefore be a high priority.

In addition, sub-Saharan Africa governments intervened heavily in markets through price and movement controls which denied farmers remunerative prices for farm produce. Although Kenya, Malawi, Zambia and Zimbabwe initiated maize-based revolutions using hybrid seed and fertiliser, the programmes have been difficult to sustain due to high marketing costs, fiscal drain and frequent weather shocks (World Bank 2008). Negative macroeconomic policies and low public investment in agriculture have also reduced incentives to private agents and limited the supply of public goods such as research and development (R&D), irrigation water, electricity and roads. In this context, this study was commissioned to identify the underlying causes of low technology adoption to help stakeholders and ASARECA develop a better strategy and to scale out technologies.

3

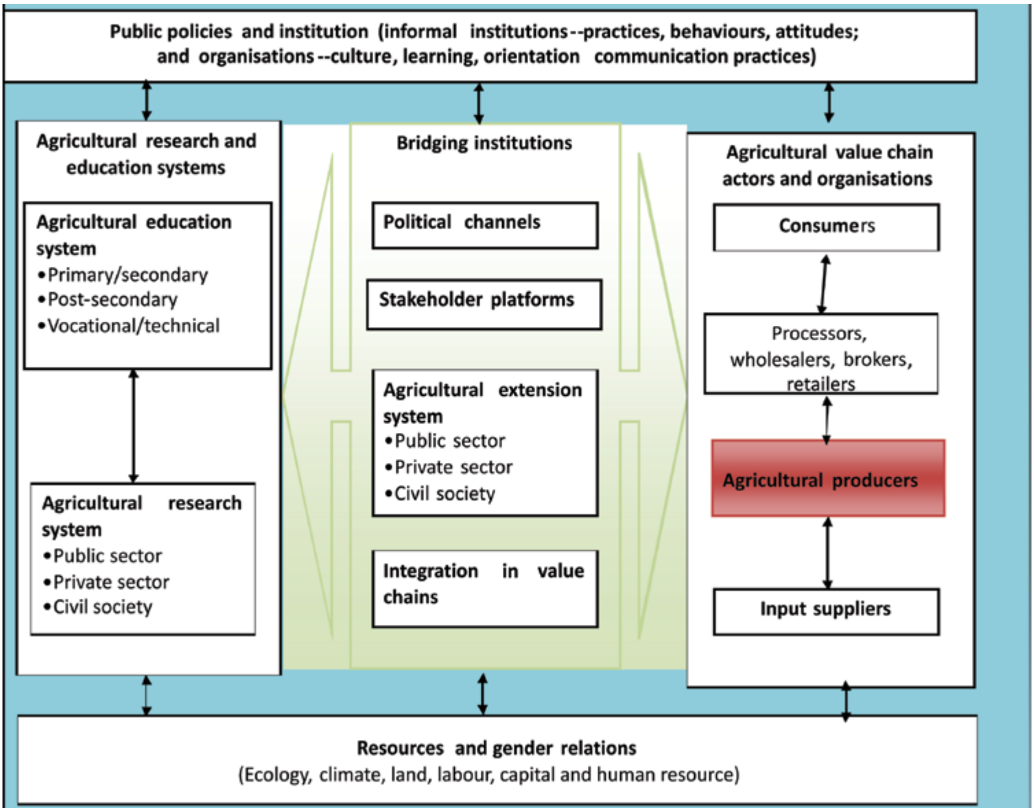
Methodology

3.1 Conceptual framework

The analytical framework used in this study used three approaches: 1) adoption models which were the basis of this study. Review of past adoption studies for prioritised technologies in ECA showed both low and high adoption rates which allowed identification of the successful and missing elements of technology systems; 2) value chain analysis of given agro-enterprise/ commodity clusters was used as an organising tool to track the stages of the technology, actors and their roles, and links in technology delivery and use; and 3) innovation systems approach, which complemented value chain analysis. It emphasises going beyond a narrow focus of the attributes of productive technologies to encompass 'innovation systems'. The main 'qualitative' elements of innovation systems are actors, their roles and linkages, and interactions of producers and other users of technologies and mediating institutions (Hall 2006). This social process is underpinned by sense-making issues including gender relations, and constraining/enabling policy environments.

Most studies on adoption of agricultural technology have, so far, focused on factors related to farm resources and farmer characteristics—education, age, gender, wealth, farm size, labour, credit, tools, etc.; farm systems—cropping system, soil type, climate, etc.; market-related factors—risk, output market, storage, input market, information, etc.); and variables related to access to services—access to credit, membership in cooperatives (Kaliba et al. 1998, Tesfaye et al. 2001, Abay and Assefa 2004, Tura et al. 2010). Similarly, farmer preferences for technology-specific characteristics as factors that significantly influence the decision to adopt have been considered in some studies (Adesina et al. 1997, Sally and Mamo. 2000, Alemu et al. 2007). These micro-level adoption studies have identified important factors, but their macro-level applicability for improved adoption has been a challenging task as they cannot address important macro issues like policies, institutions, infrastructure and the dynamics of technology adoption (Doss 2005). In addition, within the context of AIS these adoption studies have focused on the technology (product) per se (including improved variety, breed or practice) with limited consideration to processes, marketing systems, institutions—as technological, social, and organisational systems (Knickel et al. 2008).

Specifically, this study looked into technology adoption from an AIS perspective along the value chains of selected enterprises/commodities in an attempt to ensure that micro-level adoption factors are analysed within the main macro adoption or systems framework (Figure 1). The main elements within an innovation system are: 1) a knowledge and education domain; 2) a business



Source: Adapted from Spielman and Birner (2008).

Figure 1: Analytical framework.

and enterprise domain; and 3) bridging institutions that link the two domains (Spielman et al. 2008). The knowledge and education domain consists of agricultural research and education systems. The business and enterprise domain comprises a set of value chain actors and activities that use outputs from the knowledge and education domain, and independently innovate. Linking these domains are the bridging institutions—extension services, political channels and stakeholder platforms—that facilitate the transfer of knowledge and information between the domains. These domains are supported by enabling public policy and institutional environment (Spielman et al. 2008). The adapted analytical framework in Figure 1 also provides an additional supportive domain of resources, including ecology, climate, land, labour, capital and human resources and gender relations. Gender and other social dimensions have not been well-integrated into the technology adoption models (Okali 2011), which confines the analysis to technical and economic dimensions. Excluding gender and other social dimensions in the generation, delivery and use of technologies creates a major false start.

From a cognitive (sense-making) perspective, researchers' beliefs about the technology embodied in their evaluation routines influence technical choices (Garud et al. 1994) and this affects their interactions with end users. The interactions among the various actors may eventually construct a collective frame (Porac et al. 2001) and in the process influence the direction of technology evolution. There is need to attain a dominant frame or popular language of framing a given technology from all the competing technological frames harboured by the

The main elements within an innovations system are (Spielman et al. 2008):

1

A knowledge and education domain

2

A business and enterprise domain

3

Bridging institutions that link the two domains

These domains are supported by enabling public policy and institutional environment.

actors in the innovation system for successful adoption. This is because actors in the innovation system are more receptive to technology that is discussed using favourable terminology. The multiple directions of arrows in Figure 1 show the necessary interactions among actors. The presence and prominence of multiple actors in technology production and delivery in a given country depends on an enabling policy environment, infrastructure, favourable institutions and appropriate gender-mainstreaming actions.

3.1.1 Analytical elements

Table 1 summarises the analytical elements defining the five AIS domains used in this study. The domains are: research and education; business and entrepreneurship; extension and advisory services; policy and institutions; and resources and gender relations.

Table 1: Analytical elements of AIS framework

Innovation system domains	Defining elements
1. Research and education	Building innovative capacities of actors in adaptive and joint research in laboratory and on-farm trials for new technologies.
2. Business and entrepreneurship	Commercialisation strategy of linking farmers to market and rural finance, contracting and enterprise development.
3.Extension and advisory services	Learning through market and non-market interactions—and using different actors, approaches and media—including public and non-public, farmer–farmer learning forms.
4. Policy and institutions	Designing and implementing innovation policy: supply side priorities (funding, legal and regulations, taxes and subsidies); and demand side (procurement policies and advocacy).
5. Resource and gender relations	Gendered agro-ecological and socio-economic targeting in using land, labour, investment and infrastructure potential.

3.2 Prioritised enterprises and technologies

To prioritise technologies, the consulting team engaged the NARS of five selected countries to select enterprises based on the importance in national economies and the number of proven and available technologies and innovations. Most countries prioritised one enterprise from each of the four enterprise/commodity clusters: NRM, staples, high value crops and livestock (Table 2).

Table 2: Selected countries and technologies

Technology clusters	DRC	Ethiopia	Kenya	Sudan	Uganda
Natural resource management	Organic farming	Lime and chemical fertilisers	Chemical fertilisers	Chemical fertilisers	Conservation agriculture (minimum tillage)
Staples	Cassava	Hybrid maize	Hybrid maize	Hybrid maize	Maize (Longe series) Bananas (for cooking)
High value crops	Beans	Pulses	Vegetables	Vegetables	Bananas (for dessert)
Livestock	Beef	Dairy	Dairy	Dairy	Serere Agricultural and Animal Research Institute SAARI chicken

3.3 Methods of data collection and analysis

The literature review was based on new thinking on studies of adoption—gender, innovation systems and processes. This helped in assessing the micro and macro-level factors of adoption in addition to identifying issues for primary data collection in the selected countries. Regarding gender, the study sought information on prevailing gender inequalities in the sector, impacts of these constraints on technology adoption and institutional efforts to redress the situation.

Primary data in the selected countries were generated through key informant interviews and focus group discussions (FGDs). The key informant interviews were conducted with national policy makers (see Appendices 1 and 2 on list of key informants) while FGDs brought together representatives of given enterprise/commodity value chain—farmers (male and female), non-governmental organisations (NGOs)/community based organisations, agro-dealers/stockists, extension workers, agro-processors, traders (wholesaler and retail), researchers, and financial institutions. Two FGDs were conducted in each country for the four enterprises clusters. In Sudan, for example, the first FGD examined technologies and innovations in chemical fertilisers (NRM) and vegetables (high value crops); the second FGD focused on technologies and innovations in hybrid maize (staples), and in livestock feed and dairy (livestock).

The FGD process entailed several steps: First, FGD participants identified available technologies, actors and their roles and linkages in the enterprise/commodity value chains from input acquisition, production, processing, marketing, financing and consumption. They also identified key challenges to effective participation for men and women at each stage of the enterprise/commodity value chain, and possible solutions. An example of this step has been provided in Table 3, which summarises the analysis of the supply chain of maize Longe series seed in Uganda.

Overall, data collection involved updating data on actors involved in R&D, stages at which they are involved, human resource allocation, infrastructural support, varieties released, partnerships and sources of funding, outcomes in terms of yield improvement. To guide the discussion, a checklist of specific survey questions was developed and used. In addition, a national resource person from the NARS in each country collected data, assisted in setting up interviews and assembling documents related to the technology in question. Along with the prioritisation of commodities/enterprises in each country, issues identified through the key informants and FGDs were discussed and analysed. The underlying reasons and intervention options were then prioritised and synthesised within the framework of adoption models linked to the innovation system along the value chain of the different enterprises.

Second, using SWOT analysis, FGD participants discussed strengths, weaknesses, opportunities and threats to adopting available technology(ies) along a given enterprise value chain. Third, focusing on identified weaknesses, FGD

Table 3: Key activities, actors and challenges in the Longe maize seed supply chain

Activity	Actors/source	Challenges
Input acquisition (seed, fertiliser)	Stockists, open markets (traders), farmer exchange/ selling, farmer-owned seed NGOs, National Agricultural Advisory Services (NAADS), seed companies, Uganda National Agricultural Research Organization (NARO), etc.	• Fake seed and/or adulterated seed with low viability • Inadequate and untimely supply of some varieties • Some varieties are susceptible to diseases • High cost of seed • Rejection by farmers due to inappropriateness • Poor seed handling by farmers and stockists
Production	NAADS, extension, stockists, farmer to farmer, NARO	• Limited access to information • Information not harmonised (e.g. public extension vs. NAADS) • Farmer resistance to take extension messages • Poor approach: In central region, women attend workshop/training but men obtain information from stockists, but in the east and north, men attend training yet it is women who are involved in production • Women's inadequate compensation for their participation • Women's heavy workloads—competition between productive and reproductive work
Processing/storage	Stockists, extension, NARO/ universities, traders, NGOs, farmer groups/ associations	• Limited and poor storage facilities • Infestation by storage pests and diseases • Fake pesticides
Marketing	NAADS, NGOs, farmer associations, Ministry of Trade, stockists, processors, World Food Programme (WFP), Uganda Commodity Exchange	• Limited market information • Poor transportation • Fluctuating and low prices
Financing	Banks, government, Ministry of Finance, microfinance, etc.	• Lack of credit, particularly by women due to lack of collateral

participants prioritised three to four key factors of low adoption, their root causes and proposed strategic solutions, and responsible actors for improving technology adoption and up-scaling. (See, for example, SWOT analysis of banana technology in Tables 4 and 5.)

Table 4: SWOT analysis of banana technology adoption

Strengths for technology adoption	Weaknesses for technology adoption
• Produce big bunches	• Poor extension service
• Tolerant of diseases	• Unavailability of planting materials
• Generate income	• Poor market systems
• Early maturing	• Have undesirable pale colour after cooking
• Tolerant to drought and perform better on poor soils	• Poor taste, if harvested less than six months to maturity
• Tissue culture plants tend to have uniform maturity	• Timing maturity is difficult
	• High production costs
	• Few women control factors of production: land, finance
	• Low farmer participation
Opportunities for technology adoption	**Threats for technology adoption**
• High demand locally and regionally	• Climate change
• Presence of extension workers	• Competition with other income sources
• Banana leaves and pseudo stems can be used as animal fodder	• Emerging diseases and pests
• Banana is grown almost in every part of the country	• Rural–urban migration affects labour availability
• Gender equity in sharing roles, resources and benefits at household level	• Increasing population affects land availability

Table 5: Key problems, root causes and solutions for low adoption of bananas

Key problems	Root causes	Solutions/responsible actors
1. Poor extension services (clustered under this problem included high production costs, weak farmer–extension–research linkages, low farmer participation, inadequate post-harvest handling technologies)	• Poor facilitation and supervision of extension services • Extension workers poorly motivated • Poor work ethics • Low interest of extension staff, high farmer: extension ratio • Inconsistent policy on extension services • Poor farmer participation • Limited updated information	• Formulate clear policy on extension service delivery and farmer participation • Better communication strategy • Provide incentives to motivate extension staff
2. Unavailability of planting material	• High cost of planting materials • Lack of proper strategy for multiplication and popularisation	• Promote community technology development sites
3. Poor market systems	• Inadequate marketing information • Limited quantities and poor quality of commodities • Unorganised farmers, poor infrastructure	• Organise farmer marketing groups

4

Synthesis of study findings

4.1 Causes of poor/lack of adoption

Findings from key informants and FGDs reveal that the major macro-level factors responsible for low adoption are related to: 1) soil fertility and agro-ecological targeting, 2) seed systems; 3) extension services; 4) livestock technology delivery mechanisms; 5) performance of the released technologies; 6) inadequate attention to gender-based constraints in technology design and delivery; 7) lack of commercialisation of commodities; and 8) the overall political economy processes that influence the creation of an enabling policy environment.

4.1.1 Soil fertility and agro-ecological targeting

Soil fertility is a key challenge for agricultural production in densely populated areas of ECA. The study revealed that in some of the countries, continuous decline in soil fertility is affecting the adoption of technologies. The policy and technical evaluation for DRC and Uganda (Figure 2) showed that soil fertility is poorly prioritised, which may indirectly affect adoption of technologies that thrive on high soil mineral use. Findings of an earlier study show that the decision to adopt soil conserving and/or output-enhancing technologies begins with the perception of soil erosion and soil fertility effects on farm income (Ervin et al. 1982, Norris and Batie 1987, Pender and Kerr 1998, Shiferaw and Holden 1999). This perception is a product of the investment costs of soil conservation, rates of return on investment, opportunity costs, land tenure security, preferred livelihood strategy, interest rates, and market access for the farm products. Perception is also influenced by the education levels and intensity of extension service providers. And this affects the level of awareness of the household about soil and plot characteristics such as plot size, slope, and soil quality (Vandamme 2008).

A recent study in Ethiopia (Zelleke et al. 2010) documents the seriousness of the issues in soil fertility that has necessitated strong government intervention through purchasing and distributing lime. The problem requires approaches that include, but go beyond, the application of chemical fertilisers—one of the few technological practices applied at scale in the country. Although lack of fertile land can be a key constraint to technological adoption, as is the case of planted fallows in densely populated Rwanda, labour is still considered a major constraint especially to 'low external input' technologies. Zelleke et al. (2010) report that core constraints to adoption and to improved productivity include: 1) topsoil erosion; 2) acidity (affected soils covering over 40% of Ethiopia); 3) significantly depleted organic matter due to widespread use of biomass and dung as fuel; 4) depleted macro and micro-nutrients; 5) destruction of soil physical properties; and 6) a rise in salinity.

Without public funding, mitigating such widespread soil degradation is difficult because of the uncertain ownership of land which discourages investment in land development, the low returns to crop and livestock farming and the challenges arising from unreliable weather. Thus, Ethiopia has approached the problem as a national concern to ensure adequate resources are made available to help stem the decline. The rankings made by key informants and group discussions point to policy shortcomings such as poor ecological targeting of technology. This problem is especially apparent with the staple crops being promoted in regions where optimal production of hybrids is not possible.

4.1.2 Seed systems

The role of formal or informal seed systems in each of the ASARECA countries is varied and different, but with considerable influence on adoption levels. Sudan and Kenya have strong formal seed systems where private and public seed companies organise the production and marketing of seed. This is unlike Uganda, DRC and Ethiopia where informal seed systems are dominant. The common weaknesses of the seed systems in the countries visited include: poor demand assessment, poor responsiveness to production risks, poor seed distribution, and the pull–push challenges related to decentralisation and centralisation of seed systems, weak seed regulatory system, and lack of integration of formal and informal seed systems (Figure 3).

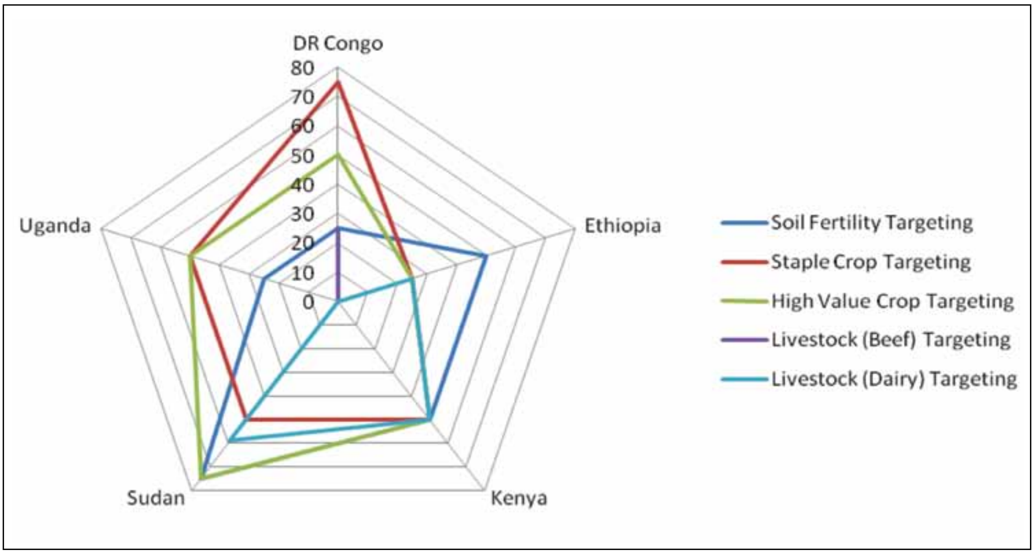


Figure 2: Rating of technology targeting.

Poor demand assessment. Assessing the demand for seed in ECA is poor as reflected in the sector's performance in meeting farmer expectations of seed quality and quantity. The low quality of data available and inability to compile comprehensive data in ECA constrains planning. The wrong demand assessments made by relying on crop acreage grown in previous years creates a mismatch between seed production and use, along with the huge costs incurred due to the leftover seed and storage costs. Farmers are sometimes forced to buy inappropriate varieties. Formal seed systems for vegetative crops do not exist. The few private and public tissue culture banana laboratories in Burundi, Kenya, Uganda and Rwanda lack outreach strategies, and awareness among farmers is low. This problem is due to inadequate adaptive capacity of extension to show benefits of adopting new technologies, especially with respect to price of planting vis-à-vis yields.

Poor responsiveness to production risks. In countries with weak institutions, the capacity to respond to or to plan to mitigate production risks (including unpredictable weather, pest and disease epidemics, soil fertility decline, etc) is lacking. The assessment made for different clusters of technology showed huge gaps in resource availability and institutional arrangements needed to address production risks. As shown in Figure 3, the capacity for managing production risks for livestock AI or use of pedigree bull systems is weak for all countries

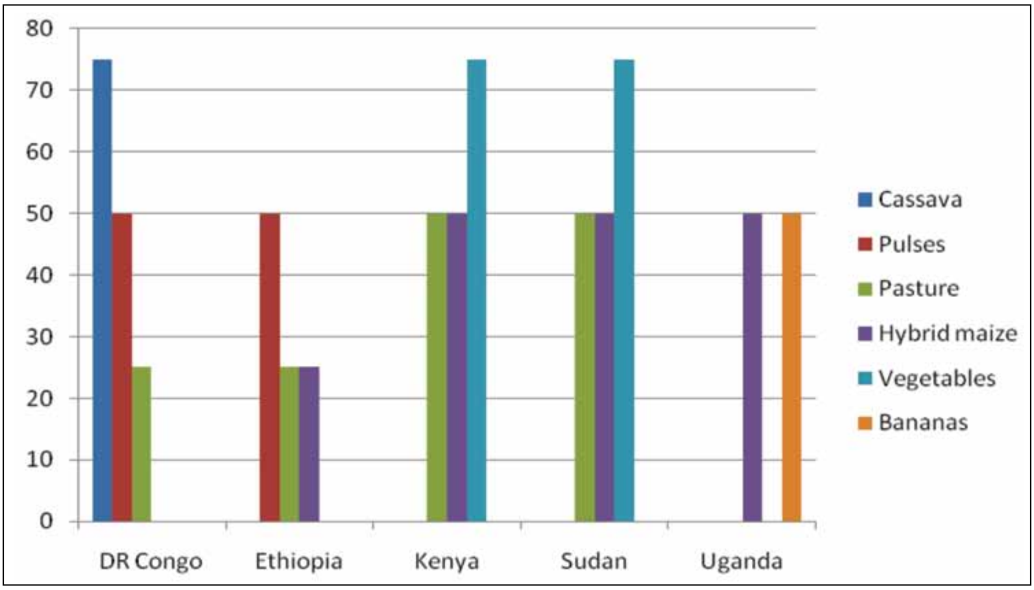


Figure 3: Performance rating of seed systems in ECA.

except in Sudan's dairy sector around Khartoum. The case for staples is about average for most countries, but they remain vulnerable to production risks. The World Bank (2008) argues that that good governance is essential to agricultural development and ongoing processes of democratisation, civil society participation, and public sector management reforms, and that controlling corruption holds great potential for improving agricultural performance. For example, Detre et al. (2007) explored why producer-owned hybrids, which are more investor-driven than previous patron-driven forms of collective action, were increasing as an organisational form favoured by agricultural producers. The resource availability and decision-making process and speed in government systems is sluggish while private companies act expeditiously to avert risks that may cause loss of earnings.

Poor seed distribution. The capacity for seed distribution in ECA was inadequate especially for livestock pastures and staples (Figure 3). But high value crops have good systems in place because multinational companies dominate seed business for these crops. The weaknesses in the formal seed systems are partly explained by the fact that agro-dealers are concentrated in urban centres and the supportive infrastructure is lacking. Efficiency in timing, cost of transportation and storage, drying and packaging, etc., were among the major constraints of the seed system affecting access and ultimately the adoption of demanded technologies in all visited countries. The conclusion is that some new and potentially modern varieties have failed to reach farmers due to the inefficiency of the varietal release and seed multiplication system. Potential investors in varietal release are not well-informed about the costs and procedures while the mainstream seed companies are hampered by outdated business models and bureaucratic processes that are not responsive to market dynamics.

Seed distributors cited three main problems. Low demand for some seeds, risk of ending up with unsold seed and lack of storage facilities. Since the agro-dealers are located mostly in commercial centres, which are far from the farms, only a few farmers voluntarily take the trouble of travelling long distances on bad roads to obtain seeds that may not be suited to their agro-ecological zones. Most agro-dealers lack properly equipped seed storage facilities such as air-conditioning and dehumidifiers, the two very basic pieces of equipment needed to prolong seed shelf life. The most effective distribution system may sometimes require multiple actors as demonstrated in the DRC for cassava when they were faced with the cassava mosaic virus and required an urgent solution to ensure food security (Box 1).

The pull–push challenges related to decentralisation and centralisation of seed systems. Most of the study countries have a decentralised seed system where both public and private seed actors play important roles. However, in some countries like Ethiopia, this process has created a pull-and-push challenge due to an overlap of responsibilities along with challenges in identifying the right roles of the public and private sector. Is decentralisation likely to deliver change for disadvantaged groups? Whitehead et al. (2003) argue that this is unlikely if the institutional issues that underpin social hierarchy are not addressed. The seed system remains weak in ECA, due mainly to: 1) the limited overall coordination for effective use of research resources, both human and physical, among the different actors of the national research systems; and 2) the limited agro-ecological coverage of the breeding programme due to the huge agro-ecological diversity in the countries studied (18 major agro-ecological zones are appropriate for agricultural production [IFPRI et al. 2006]).

Box 1: Case of cassava in DRC: Technology appropriateness and markets trigger high adoption

Cassava is the most important staple food in the Democratic Republic of Congo (DRC), supporting over 70% of the population, and is a source of income for households and the economy. In the mid-1990s, there was severe cassava mosaic disease (CMD) transmitted via the white fly. CMD reduced production by as much as 26% (from 19 million to 14 million t).

A multi-partner group comprising of USAID, the International Institute for Tropical Agriculture (IITA), DRC Institut National pour l'Etude et la Recherche Agronomique (INERA), the Food and Agriculture Organization of the United Nations (FAO), the South-East Consortium for International Development (SECID), and farmers dealt with the challenge. USAID provided funding amounting to $5 million for 5 years (2001–2006); IITA provided implementation leadership and, jointly with INERA, managed the germplasm. INERA was responsible for adaptive research that screened their varieties as well as improved varieties from IITA. SECID multiplied and distributed planting materials preferred by farmers. FAO, SECID and other NGOs multiplied existing INERA improved varieties with good level of tolerance to CMD. Training of technicians and farmers on better post-harvest management and processing techniques to reduce drudgery, yield loss and ensure high-quality cassava flour. Processing equipment consisting of combined cassava graters/chippers and hydraulic presses were introduced into the country for evaluation and subsequent utilisation.

By the end of the project, 11 varieties of improved cassava had been developed. Of these, four varieties contained high levels of vitamin A, an important nutrient for children. By 2004, high adoption rates were registered, with a total of 117,138,500 metres of cuttings distributed to 291,563 beneficiaries. The project worked to ensure that both male and female farmers participated and benefited. Out of 7,295 farmers who participated in cassava variety selection, women formed the majority (72.92%). Household incomes have increased from sale of cassava, enabling families to spend more on education, health and clothing. This case underscores the importance of:

- Considering socio-cultural attitudes and practices in the design of technologies.
- Strong and attractive markets, which ensure good returns on land, capital and labour, and act as a major driver for adoption.
- Appropriateness of technologies for all gender largely influences adoption levels.

Tensions exist between the technocracy and the political system due to the fact that technical designs are sometimes overshadowed by political imperatives, sometimes misdirecting priorities and investments away from the people and places that need them the most. Centralised approaches have also come into conflict with the decentralised political-administrative system which has sought to promote a decentralised seed system, in part due to the emergence of parallel federal and regional state seed R&D initiatives running side by side. These have led to duplication of effort, wastage of limited resources and unnecessary turf battles. Finally, tensions exist between the state and the emergent private sector as the state seeks to liberalise the sector while retaining a strong hold over the market, failing to recognise the contradiction of trying to have it both ways at once (Dawit et al. 2010).

Weak seed regulatory system. The study has identified that some countries like Kenya have a strong regulatory system, while others like DRC, Uganda, Sudan (privatised) and Ethiopia have limited regulatory frameworks along the seed value chain. Belay (2008) reports that the evaluation and release mechanism is not very strict, which may result in the release of poor-performing varieties in Ethiopia. Such an occurrence has been indicated by the recent row among farmers in West Gojjam, the Amhara Board for Agriculture and Rural Development, and a private seed company regarding poor performance of an imported hybrid maize variety from South Africa, which had been officially released. Governments with poor regulatory standards on quality tend to engage in industrial protectionism and levy high indirect taxes on agriculture (Krueger et al. 1991).

Lack of integrating formal and informal seed systems. In most of the countries studied, the informal seed system, which mainly handles the local varieties, plays a dominant role in the overall seed system. For instance, in DRC, Ethiopia and Uganda the informal seed sector accounts for more than 90% of the seed used (IFPRI 2010). Therefore, it is important that the formal sectors integrate the informal system to ensure that improved technologies are also aligned with the informal sector, as demonstrated in the Ethiopia case study in Box 2.

4.1.3 Extension and advisory services

Extension service remains a public good in all ECA nations except for a few export commodities produced by multinationals, and the approaches used are mainly paternalistic and top–down in terms of technical and resource capacities.

The many reforms and changes in extension approaches over the years have not transformed the attitudes of public extension managers despite the constant attempts to de-concentrate resources by adopting grassroots approaches. According to the Strategy for Revitalizing Agriculture in Kenya (Republic of Kenya

Box 2: Case of maize in Ethiopia: Creating enabling environment in maize technology adoption

Technology development and adoption of maize is one of the success stories of NARS, in collaboration with the International Maize and Wheat Improvement Center (CIMMYT). Over the last 4 decades, maize coverage has reached 2 million ha from being a mere garden crop in Ethiopia. Currently, maize is leading in total production and yields per unit area, and is second to *teff* in area among grains. The trends in national maize productivity levels show a small but consistent increase from about 1.5 t/ha in the early 1990s to 2.3 t/ha in the late 2000s, even though yields reaching 8 t/ha under model farmers' fields have been attained.

Collaborative effort among Sasakawa Global 2000 partners, the Maize Commodity Research Team (formerly Institute of Agricultural Research) and the government national extension service in the early 1990s, formulated a maize technology package and undertook massive on-farm demonstrations in the major maize agro-ecological zones, where millions of small-scale farmers adopted the improved maize technology package. Linked with the liberalisation of markets and release of hybrids, more than 10 private seed companies and 4 public seed enterprises are engaged in hybrid seed business. Overall, the success story of maize technology development and adoption in Ethiopia is largely attributed to the supportive government policies and institutional collaboration. Recent trends show that multiplication and distribution of the released varieties is limited to few older varieties of maize, which is mainly linked to the poor performance of the formal seed systems in terms of:

- limited popularisation of newly released varieties and research–extension–farmer linkages.
- low variety multiplication and distribution for their target agro-ecologies.
- inadequate responsiveness of the system to demand shifts due to changes in rainfall patterns.
- limited availability of the required type of seeds at the required time in the required amount
- lack of incentives for increased productivity and production due to huge price fluctuation.

2004), there has been widespread inefficiency in the extension system, hence the need for reforms. Experienced and highly qualified staff remained ensconced in urban head offices, leaving remote and marginalised regions understaffed as reported in: DRC (with only 230 field staff); Sudan (farming concentrated around Khartoum) and Kenya (staff residing in urban offices). Consequently the resource distribution is not responsive to the needs of frontline extension workers, a situation that has been detrimental to service efficacy (Figure 4).

Although extension is supposed to be concentrated in rural areas close to farmers, this is not the case in some ECA countries because of the political influence on staff deployment. For example, the challenges for the Ethiopian extension system include: lack of clarity in policies for both extension agencies and agents; lack of a longer-term strategy, vision and plan; limited role of farmer organisations; decentralisation not matched with capacity and accountability; poor financial, administrative capacity/autonomy of woreda extension offices; absence of monitoring and evaluation indicators; and ICT underdevelopment (Ranjitha Puskur et al. 2006).

Today's understanding of extension goes beyond technology transfer to facilitation, beyond training to learning, and includes assisting farmers to form groups, dealing with marketing issues, and partnering with a broad range of service providers and other agencies. Davis (2004) reports that many people are now using the phrase 'agricultural advisory services' instead of extension, which can imply a top–down approach and may ignore multiple sources of knowledge.

Many infrastructural variables and other factors affect agricultural performance in complex and contradictory ways, hence benefits are difficult to quantify (Birkhaeuser et al. 1991, Anderson 2007). Extension as an input is also difficult to measure, and usually proxies are used (Birkhaeuser et al. 1991). In view of these uncertainties, the limited use of recommended technological changes was attributed mainly to assumed characteristics of the farmers (for example, ignorance, laziness, conservatism), even though poor-quality extension services might be contributing.

Another shortfall is the lack of effective linkage and coordination among organisations engaged in agricultural research, technology development and multiplication, technology dissemination, and extension services. The common problems of the extension services across these countries include: lack of a well-resourced coordination platform; inappropriate extension approaches (methods of dissemination); poor targeting of clients/farmers, poor mobility of extension workers; lack of training facilities and resources; and poor work ethics.

Lack of a well-resourced coordination platform. Researchers and extension workers are considered to be superior to farmers in designing the required technological interventions. Extension services are sometimes ad hoc and preoccupied with more short-term objectives dependent on donor funding for

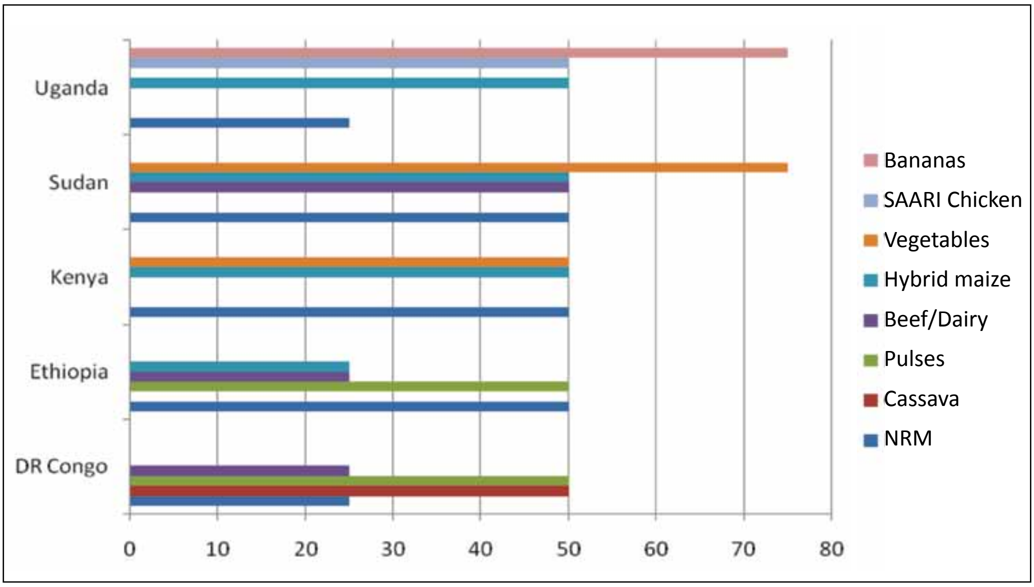


Figure 4: Percentage rating of extension performance client/farmer targeting.

projects; they lack a long-term vision and hide behind paper strategic planning, which is never implemented. Belay (2003) found that extension coverage was biased, mainly benefiting well-to-do farmers and limited to high-potential areas.

Inappropriate extension approaches. The group approaches touted in agricultural extension service planning documents have been found to lack innovative methods to facilitate and coordinate farmers' and their organisations' access to knowledge and information, especially on markets. This confirms what Christapolos (2010) reports that coordination with stakeholders is either very weak or lacking. Extension agents are evaluated based on the number of farmers they have managed to reach, not the impact of the package on farmers' agricultural productivity, incomes and livelihoods.

Poor targeting of clients/ farmers. It emerged from the study findings that in most countries men participate in most extension training yet women undertake most of the farm work, thus undermining the effectiveness of the knowledge and skills gained because of poor communication between spouses. In cases where women receive training, they are constrained by resources and overall decision-making power in male-headed households. The ECA region has many crop and livestock enterprises due to its high variation in agro-ecological zones but extension workers are expected to extend messages on everything without prioritising among members of households, competition for farm resources and land space. The situation is made worse by the unknown demand for these products in the market.

Poor mobility of extension workers. The extension workers cover large geographical areas and high populations of dispersed farmers without adequate facilitation in terms of vehicles, fuel and allowances. In some regions, there is an absence or low numbers of service personnel, as is the case in DRC (which has just 230 agents countrywide!). In some countries, extension personnel are concentrated in politically influential regions, with some operating in semi-urban areas. The study countries have different approaches, actors and priorities in the provision of extension services. Extension staff remain in the old paradigm where they are regarded as 'experts' and farmers are seen as either ignorant in technology matters or just plain anti-development. As shown in Figure 4, client targeting for most technology clusters in all countries ranged from low to average (25–50% rating).

Lack of training facilities and resources. Extension agents lack soft skills, knowledge on group dynamics, marketing and ICT. These agents need to be skilled technicians who are also brokers of sorts, being able to connect farmers to markets and other institutions that farmers demand (Davis 2004).

Poor work ethic. This is reflected in the poor organisation of work, low commitment and misuse of resources. Hall (2006) in a World Bank paper argues that the scope of innovation includes not only technology and production but organisations (in the sense of attitudes, practices and new ways of working), management and marketing changes, therefore requiring new types of knowledge not usually associated with agricultural research, and new ways of using this knowledge. In the same vein, assessing extension services in ECA reveals poor management of the service. This confirms the contention by Rivera and Qamar (2003) that extension organisations must revitalise their management systems and programmes. They suggest four key management functions in extension: good leadership, high-level employee training, increased budgets and salaries, and combating resistance to change by extension personnel.

4.1.4 Livestock technology delivery mechanisms and service management

While the ongoing livestock revolution is likely to result in a rapid increase in the demand for quality livestock services, the policies and institutions in a number of countries are not set up to meet the challenge. The policy priorities and directions for service delivery are often influenced by decision makers. Those trained in veterinary science argue that it is poor animal health that is the main constraint to livestock production. However, nutritionists point to the poor availability of feed and fodder, while breeders point to poor genetics.

The adoption levels of livestock technologies is in general very low owing to the high costs of establishment, poor supply system for improved animal breeds. Other factors include poor forage seed system, poor quality and affordability of feeds, poor artificial insemination services and limited availability of parental stock (as the case of SAARI chicken in Uganda and beef in DRC). Researchers argue that most farmers have not adopted the technologies due to lack of access to requisite inputs, lack of information and knowledge about the technologies, and weak extension–research–linkages (Amudavi et al. 2009). Ability of states in the region to implement and monitor government policies and programmes is also limited and overextended.

The low prioritisation of livestock in DRC means livestock services are not easily available. The same situation was found to be the case in western Sudan. Many governments and donors sought to promote privatisation and decentralisation of services which was never acceptable to professionals in government. In support of veterinary services to ensure ‘safe trade’, the Food and Agriculture Organization of the United Nations (FAO) and the World Bank argued for the formal recognition of veterinary para-professionals and the establishment of statutory bodies responsible for their licensing and registration in each member country. In many ways this is a big step, light years away from the perennial scepticism and professional snobbery among veterinary professionals of only a few years ago (Scoones et al. 2006). However, decentralisation of services creates other conflicts and could undermine disease surveillance efforts, as noted by Kasirye (2005) in Uganda.

The level of coordination and regulatory capacity of state or provincial administrations has been limited, with conflicts arising between down-graded central veterinary authorities and their decentralised counterparts. Such conflicts become particularly problematic when dealing with notifiable diseases that must be reported country-wide. As a consequence, Tanzania and Uganda are currently reviewing their approach to decentralising veterinary services that include ways of bringing disease reporting under centralised control (Kasirye 2005).

4.1.5 The performance of technologies

All ASARECA countries have put in place technology release mechanisms for crops, but have limited promotion mechanisms for livestock and NRM technologies. In Ethiopia, the technology release mechanism has weakness. It fails to ensure that the newly released technologies perform better than those previously released (Alemu et al. 2010). However, this study revealed that the poor performance of available technologies is also attributed to the following factors:

- **Inappropriateness of technology targeting (agro-ecology and socio-economic conditions).** In East Africa, low agricultural productivity is attributed to several constraints including inappropriateness of technology, and poor delivery of agricultural extension services (Amudavi et al. 2009). In terms of technology delivery, the targeting of released varieties for the particular agro-ecologies is limited. A recent study by Dawit et al. (2010) shows that 13 types of varieties cover more than 80% of the formal seed supply for the major crops in Ethiopia. These varieties are mainly targeted at high-potential to intermediate agro-ecology, even though there are a number of varieties released for the three major agro-ecologies (highland, intermediate and lowland areas). Thus, it will be important to promote agro-ecology-based technologies along with their delivery mechanisms.
- **Poor maintenance of released technologies.** According to the World Development Report of 2008, poor maintenance of released technologies can result in serious disease outbreaks. For example, Ug99 that attacked wheat and is spreading to the Middle East (World Bank 2008).

- **Limited effort to boost end-users' technology perception (technology sense making).** Farmer's individual perception of the degree of a given problem may influence their decision on possible solutions. The same situation applies to farmers' preferences for certain technology based on real experience or perceived characteristics. Past findings show that certain taboos, cultural norms or practices in various socio-cultural settings in Africa, influence farmers' perceptions and technology adoption. Indigenous knowledge and local traditional practices may be considered part of this social and cultural framework (Drechsel et al. 2009).

- **High cost of technology itself and heavy investment required.** The introduction of new technologies may increase demand for complementary inputs. When the supply of these inputs is restricted, adoption will be constrained. For example, high yield 'green revolution' varieties require increased water and fertiliser use. The McGuirk and Mundlak (1991) analysis of the adoption of high-yield varieties in the Punjab showed that adoption was constrained by the availability of water and fertiliser. Private investment in drilling wells, private and public investment in establishing fertiliser production and supply facilities removed these constraints and contributed to the diffusion of modern wheat and rice varieties in the Punjab.

- **High production risks and lack of mitigation measures.** When a new technology has a yield-increasing effect (e.g. high-yield variety), and if it is also perceived to have higher risk, poor farmers would rather select low yielding but more drought/pest-resistant varieties unless there are price-support policies that would tend to increase its relative profitability (McGuirk et al. 1991).

- **Poor quality of some technologies.** Some new varieties of maize, like Pioneer, have been found to be highly susceptible to pests and have a low shelf life, which discourages farmers from adopting them. The high biomass of some varieties such as sunflower cause high soil nutrient depletion. Farmers felt the change in yields did not compensate for the deterioration in soils and therefore discontinued their production. Key informants in Sudan and Kenya mentioned that high feed consumption, low quality of milk and meat from Friesian cows discouraged farmers from adopting them despite the breed's high milk production.

- **The long gestation period needed for benefits of conservation agriculture to materialise.** This may serve as a barrier to farmers with short-term planning horizons. However, the political economy matters in the interplay of resources (such as water, land and labour), private entrepreneurship and public support to enhance performance of technologies. This situation is exemplified by fruit and vegetable production in Sudan (Box 3).

4.1.6 Inadequate attention to gender-based constraints to adoption

Gender inequalities are pervasive in all the five study countries and range from women's heavy workloads that create inefficiencies in production, limited access to and control over factors of production (land, finance, skills), and overall control over benefits associated with their inputs. From the FGDs carried out for this study, there was evidence which showed that all ECA countries studied have conducive macro environments for gender mainstreaming, as reflected in the existence of gender and women policies, strategies, work plans and implementation structures. However, both research and extension organisations have not adequately addressed the issue. Ethiopia, Kenya and Uganda had gender-mainstreaming structures. However, in their research and extension organisations while Sudan had made substantial effort within extension. However, DRC had no structures in both research and extension while Sudan had none in research. While acknowledging the efforts by these countries, concern was raised about the inadequate institutions to address gender issues in research, extension and within households where technology adoption decisions are made. This is caused by inadequate gender mainstreaming resources, limited commitment to gender by institutional leadership, low gender mainstreaming capacity in most countries, and absence of accountability mechanisms necessary to hold individuals and programmes responsible for gender mainstreaming. In Uganda, Ethiopia and Kenya, in both institutions and households, the attitude towards gender was found to be negative. This was revealed from key informant interviews. Such attitudes can create bottlenecks to institutional transformation and technology adoption.

Box 3: Case of vegetables in Sudan: Beyond resource potential and private individual efforts in the performance of fruits and vegetables

Many cultivars of fruits and vegetables can be produced year round due to the climatic variation plus available land and water in Sudan. Yet horticulture crops represent only 12% of national agricultural income, compared to 17% for cotton and 29.6% for cereals and oil seeds. This is due to low priority and funding given to fruits and vegetables compared with cash crops such as cotton, gum Arabica and staple food grains. Various vegetables are grown in both irrigated and rainfed plots on an area of about 273,000 ha. This accounts for about 3% of the total cultivated area and produces an average of 3.4 million tons of vegetables. The most important vegetables grown are onion, tomato, potato, okra, egg plant, water melon, cucumber, pumpkin and several leafy vegetables. Vegetables are grown in small plots irrigated with pumped water, including in the national corporation in Gezira Scheme where 30,000 ha are devoted to vegetables. Horticultural production in the Sudan is mainly under irrigated farming along valleys and streams. Other vegetables like carrot, cabbage and cauliflower are grown on the outskirts of the large cities. Vegetable acreage increased tremendously in the last 5 years largely due to increased urbanisation, awareness of their nutritive value and high returns per unit area. At present, horticultural production is a growing enterprise in the country due to relatively high demand locally and abroad. For instance, per capita local consumption of fresh vegetables is 43 kg, and that of fruits is 32 kg.

Despite the increase in the area under vegetable production, productivity (in yields) remains low, indicating high potential for improvement by adopting improved varieties, and pests and disease control. Major constraints to technology adoption for fruit and vegetable production include:

- inadequate financial and credit facilities
- production of poor quality vegetable seed
- inadequate extension service
- low productivity due to dependence on inefficient traditional cultural practices amid high incidences of weeds, pests and diseases
- high costs and improper transportation
- in addition, huge losses occur in the horticultural crops due to poor post-harvest practices

This case study shows that in spite of the huge resource potential (land, water, and climate) and efforts of private individuals in horticulture production, there are only slight increases in fruit and vegetable production for local and export markets. Thus, spurring adoption and upscaling available technologies requires targeted horticultural policies in particular and overhauling agricultural policies in general. Elbashir et al. (2010) conclude that in Sudan: "(An) Agricultural scheme should be adopted and financed, taxation policies should be revised to make the sector competitive in the international market." Yet, priority setting and public funding are political economy issues.

These inequalities cut across institutions, programmes, projects and households that participate in activities along the value chain (Kabutha 2002). Because shifting from subsistence to commercial sector requires the use of market inputs such as fertiliser, seed, credit, skills and knowledge, these inequalities undermine adoption and overall performance of technologies. Women work 13–18 hours a day in most countries, thus reducing their effectiveness in production, processing and marketing (MoARD 2009). An exception was in central and northern Sudan where women operate within the household and are not much engaged in agriculture. Limited access to factors of production and business establishment due to limited access to credit, land, knowledge and skills poses a great challenge to adoption of technologies. To address these issues effectively, there is need strong for commitment from leadership, strong gender capacity, a gender friendly organisational culture that nurtures productivity, and overall institutional accountability to gender. Accountability in gender means holding all staff fully accountable, engendering research programmes as well as outcomes. Investment in gender mainstreaming has great pay-offs:

- The 1998 *Special Program of Assistance for Africa (SPA) status report on poverty in sub-Saharan Africa* examined whether gender-based asset inequality limits economic growth in sub-Saharan Africa (Blackden and Bhanu 1998). The programme compiled micro-level case studies addressing gender inequality in access to agricultural resources and productive inputs and the impact on productivity and growth. The report argued that gender differences in access to assets limit the options of women farmers in the sector; gender differences in labour remuneration lead to conflict and affect labour allocation in households; and gender differences in labour and other factors of productivity limit economic efficiency and output.
- Comparative evidence from Kenya suggests that men's gross value of output per hectare is 8% higher than women's. However, if women had the same human capital endowments and used the same amounts of factors and inputs as men, the value of their output would increase by some 22% (see Table 6). If these results held true in sub-Saharan Africa as a whole, simply raising the productivity of women to the same level as men could increase total production by 10% to 15% (Saito et al. 1994). Considering Okali's (2011) point of view, the gender relational model found persisting

among most respondents in ECA is based on a stereotypical, functionally discrete, nuclear family unit, consisting of husband, wife and offspring.

Table 6: Access to production inputs increases women's productivity

Experiments with food crop farmers in Kenya, 1990	% increase in yield
Effects of giving female farmers men's age, education and input levels	22
Effects of increasing land area to male farmers' levels	10.5
Effects of increasing fertiliser to male farmers' levels	1.6

Source: Saito et al. (1994).

Within this unit, women as wives are presented as primarily family workers whose economic interests are congruent with those of their husbands, and whose work is subsumed under that of the husband. The exception is of course in northern Sudan where Islamic principles delineate gender roles and women enjoy more power and social protection. Innovations are fed through the gendered division of labour and family relations that have far-reaching consequences for women and their ability to work independently and accumulate wealth (Subramanian 1996). Gender relations are embedded in existing social institutions that need to be addressed if change is to occur that would provide advantages to disadvantaged women.

Several issues emerge on gender mainstreaming in ECA. First, gender inequalities are pervasive in all the ECA countries. Gender inequalities include: women's heavy workloads which constrain adoption and effective management of technologies, women's limited access to and control over factors of production—land, information and skills, finance—and women's limited access to and control over benefits accruing from their contribution to family farms, mainly because they have limited decision-making. Second, gender inequalities constrain overall productivity of technologies, as exemplified in Box 1. Third, in most of the ECA countries, macro policy environments for addressing gender constraints have been developed through supportive gender policies and mechanisms for gender mainstreaming. Even in DRC and Sudan, where gender mainstreaming is at formative stages, the macro policy environment is conducive to gender mainstreaming. But mechanisms for enforcing gender mainstreaming are either absent or weak and implementing agencies, among them research, extension and the private sector, have not made decisions on whether or not to institutionalise gender concerns. For example, in Sudan and DRC research on gender is minimal.

Fourth, gender-mainstreaming work in research and extension—even in countries where it has taken root—is fairly narrow. It focuses mainly on capacity building without sufficient investment in other key pillars of institutional gender mainstreaming: (1) commitment and support by leadership who will ensure that gender is reflected in policies, strategies, resource support and visibility; (2) demand for accountability—holding all departments and programmes accountable for gender mainstreaming and ensuring that a monitoring and evaluation (M&E) system is gender sensitive through a proactive citizenry and civil society; and (3) a gender-responsive organisational environment that supports maximum productivity of staff and programmes. Gender capacity must be built up and not assumed to be an automatic by-product of setting up small departments of gender (see also recommendations in Chapter 6).

Fifth and finally, gender mainstreaming is a strategy for making the concerns and experiences of women, men and children an integral part of the design, implementation, monitoring and evaluation of policies and programmes. Furthermore, it enables this to be done in all economic and societal spheres, so that women and men benefit equitably. It also synergises efforts directed at technology adoption and growth in productivity that is inclusive.

4.1.7 Marketing system and commercialisation

Empirical findings show that technologies for commercialised enterprises linked to marketing systems are better adopted compared with enterprises with poor

Other key pillars of institutional gender mainstreaming:

1

Commitment and support by leadership who will ensure that gender is reflected in policies, strategies, resource support and visibility

2

Demand for accountability—holding all departments and programmes accountable for gender mainstreaming and ensuring that an M&E system is gender sensitive through a proactive citizenry and civil society

3

A gender-responsive organisational environment that supports maximum productivity of staff and programmes marketing systems. Evidence from Zambia indicates that price changes following market liberalisation favoured technologically more advanced producers who were able to cope with price and yield variability and deal with the demands of agro-processing (Binswanger et al. 1987, 1993). The following missing market elements in ECA for technology adoption are highlighted.

Incentives for increased production and productivity. The influence of marketing factors on the adoption of agricultural technologies includes the impact of unequal access of farmers to markets, price volatility, low profit margins, high risks, and market uncertainties (Castaño et al. 2001). Reduced price volatility and market uncertainty help extend farmers' planning periods and encourage investments in land productivity (Castaño et al. 2001). Moreover, farmers often need to know in advance their future income if they are to invest in expensive modern marketed inputs. So fluctuations in incomes tend to discourage productivity-enhancing investments, as seen in the case of Ethiopia (Beyene et al. 2008).

Improve links with agro-industries. According to recent evaluations, the effectiveness of value chain interventions remains a concern. Most areas of the ECA lack linkages with agro-industries interested in their commodities and most rely on numerous middlemen to get their produce to the market. The case study (Box 4) highlights some of the reasons for the dairy sector's good performance in Kenya.

Weak market coordination and commercialisation of enterprises. Technology adoption can be highly stimulated by strong market coordination if it improves farm profitability. The ECA region is beset with serious market access and efficiency concerns (Figure 5). Linkages even within regions are poor or lacking due to poor roads, conflicts, lack of trust, high transportation costs, constraining government policies, regional insecurity and information asymmetry. The colonial model of roads from the ocean to the hinterland or from rural areas to capital cities still persists; even regions with high population are not connected to those with high potential for agricultural production within ECA. ASARECA has policies geared towards market-led development of technology in the region through agricultural research for development (AR4D) approach. But markets on their own do not stimulate production due to price fluctuations. For example, whenever there is a glut in maize production, farmers resort to producing low-

Box 4: Case of zero grazing in Kenya: Technology appropriateness, targeting and markets

In 1979, the Kenyan and Dutch governments introduced the zero-grazing system or stall feeding with the aim of addressing the constraints of smallholder dairy farming. These were lack of grazing land, low productivity of dairy cows, low-quality fodder, prevalence of diseases and low income due to depressed markets for cash crops. The technology package consisted of: the zero-grazing unit, improved dairy breeds, artificial insemination/bulls, on-farm high-yielding fodder, and farmyard manure.

Zero-grazing has performed well because of the efficiency and effectiveness of interventions targeting based on agro-ecological potential, delivery systems, and the linkages among research, extension and farmers. Dairy cooperative societies have been set up to provide links among processing, bulking and marketing of produce. Zero-grazing has been accepted by small-scale farmers because it uses fewer, better feed, improved cow breeds, which increased incomes and improved livelihoods.

At the national level, this technology is underpinned by a policy environment with appropriate and supportive dairy policies, targeted research, strategic public–private partnerships and competition in the private sector. Recently, regulations for the informal market, which dominates the dairy sub-sector, have been transformed from being actively hostile to broadly supportive.

Despite the high adoption rate, lack of credit facilities has been the main constraint particularly for the informal milk sub-sector. The initial establishment costs for the zero-grazing units, costs of animal feed and concentrates, artificial insemination, clinical services, farm equipment and labour required to maintain zero-grazing systems are quite high for most small-scale farmers. During the rainy season, milk losses occur because of failure to access markets. Poor road infrastructure inhibits efficient milk collection, access to inputs, access to market information, extension/training/health and breeding services. These result in plummeting milk prices, and the high technology costs of maintenance reduce the incentives to increase production and expansion.

Children and men are usually committed to other activities such as studying or other business and leave the burden of zero-grazing—fodder-cutting, manure application, feeding animals, stall cleaning, milking, fetching water, heat detection, seeking AI services and sale of milk—mostly to the women. Dissemination of this technology has sometimes not targeted women for training. Rural–urban migration is leaving an aging population to take care of the dairy sector.

This case study shows that balancing the successes and challenges of adopting zero-grazing in Kenya will require addressing the dynamics of technology, targeting, market and social issues—including gender and youth.

yielding varieties with multiple use-attributes, especially for the local market. The findings from FGDs revealed that the livestock sector enjoys better access to organised markets across ECA. There is adequate demand for staples locally,

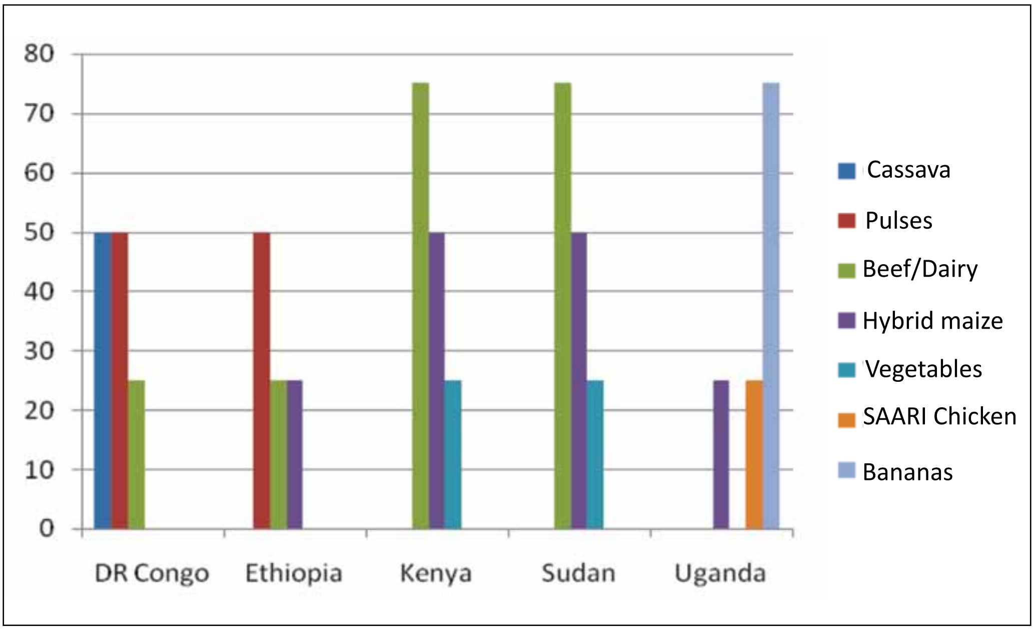


Figure 5: Percentage ranking of access to markets.

but high value crops have difficulties accessing markets, except in Kenya where foreign-led export markets for some vegetables are highly sophisticated.

Without increased demand for products and efficient markets to distribute them, growth in agricultural productivity could quickly run into declining prices. According to key informants and FGDs, consumers in Uganda love their matooke, especially the colour and taste attributes, and they feel that the research products have not incorporated their preferred characteristics into matooke. Even with dessert bananas, research products are not favourable compared with the Bogoya cultivar. Consumers have called for regular market surveys and development of supply chains around smallholder farmers, with complementary investments in all links in the supply chain. However, coordination problems, rent seeking and risks pose serious difficulties in making such simultaneous investments in poor rural areas. Farmers in FGDs expressed the need to understand the costs of marketing to ensure that traders are not earning abnormal profits, and to see the need to trust traders. Market information collection and dissemination was weak across ECA, thus affecting choice of technology and investments in enterprises that capture consumer needs/tastes and make profits.

The problems of small markets, seasonality and lack of economies of scale in production and marketing cut across the ECA region. The exception is in Central Sudan where irrigation and intensive dairy production are practised to a large extent. Commercialisation was noted mainly for dairy in Kenya, Sudan and Uganda but the rest of ECA still lags behind in commercialisation to create incentives for increased production and productivity. Such incentives entail stabilising markets (minimum price, cold chains, value addition, export avenues, etc.), strengthening links between domestic production and agro-industries and empowering the value chain actors through horizontal and vertical integration, establishing mechanisms for accessing markets with premium prices for product quality, and promoting the organisation of markets through group marketing.

4.1.8 Strengthen linkages with finance to ease access to credit

The most critical issue is that financial services do not match economic or agro-ecological realities and lack cross-agency forums that can focus on delivering what regions say they need to succeed. The distribution of loan funds is not rationalised for all eco-zones due to the varying levels of influence in government and ecological zones. Analysis of regional distribution of financial institutions reveals that some regions have better access to credit than others and past policies overemphasised high-potential areas, thus affecting the capacity of technology adoption for neglected regions. It is also important to note that where collateral in

Analysis of regional distribution of financial institutions reveals that some regions have better access to credit than others and past policies overemphasised high-potential areas, thus affecting the capacity of technology adoption for neglected regions.

form of physical assets is required, women and other vulnerable groups will be constrained from accessing such credit. An important question is how much yield increase is required for farmers to adopt a given technology and especially using credit. According to Baum et al. (1999), the net benefit should usually be between 50% and 100%, which corresponds to a benefit-cost ratio of 1.5:2. If the technology is new to the farmer and requires that they learn new skills, a minimum rate of return near to 100% is a reasonable estimate to assume adoption.

Organised markets that can ease the flow of farmers' income and improve repayment capacity are the exception rather than the norm in ECA. Without planned production and increased demand for products accompanied by efficient markets to distribute them, growth in agricultural productivity could quickly turn into gluts and result in declining prices that counteract the benefits of productivity growth for producers and discourage investment, as other researchers have found (Poulton et al. 2006). It is also important to note that male and female farmers have different levels of access to credit, particularly if collateral is required.

4.1.9 Issues related to enabling environment

The adoption of agricultural technologies in the study countries was hindered by the lack of an enabling environment to align the socio-political prioritisation and funding emphasis for technologies in different agro-ecologies, and limited infrastructure for technology adoption. With considerable variability, the ECA countries are endowed with diverse agro-ecologies, but which have very unequal representation among top policy makers. The Ministry of Agriculture in Ethiopia identifies 32 major agro-ecologies (MoARD 2005) whereas Kenya has 7 (Wellington et al. 2007). These agro-ecologies are distinct in production potential and their technology requirements but the differences in political influence are usually assumed away.

Huge challenges arise from the broader mix of crops grown in the region; the agro-ecological complexities and heterogeneity of the region; the lack of infrastructure, markets, and supporting institutions; and the gender differences in labour responsibility and access to assets (World Bank 2008). Governments can use macro-economic policy, trade regulations, input subsidies, regulations or education and extension to alter the decision-making environment in which farmers choose one practice over another. However, many programmes promoting conservation have been relatively ineffective because of contradictory signals and incentives from other policies or subsidy programmes. For example, policies designed to promote sustainable agriculture can be undermined by other, typically richer, policy measures in support of highly erosive cash crops or by weak or slow-to-respond research and extension efforts (FAO 2001). While it is possible to overestimate the influence of policies on farmer decision making (Winter-Nelson and Temu 2002), there is increasing recognition that the provision of public support in the form of guaranteed output prices, input subsidies, deficiency payments, cheap credit, or disaster relief has encouraged and facilitated massive investment by farmers in expanding production capacity.

While neutral dialogue is necessary in policy making, the dialogue does not always lead to rational choices. 'Rules of the game' are often biased against those who are not represented in the rule-setting corridors. The poor are often excluded from policy-making tables, and government departments, international development agencies and research institutions have failed to include the poor in identifying their own needs and policy priorities. Capacity development not only needs promotion of innovations and technologies in clusters in targeted geographical regions but also the interaction of these with institutions (strong ethics, competent ways of working, high moral values and trust etc.).

4.2 Conclusion

The country studies have revealed several issues that have contributed to low technology adoption in ECA. First, there is limited alignment of technology attributes with user preferences, and lack of agro-ecological targeting. Second, the prevailing weak interaction mechanisms (institutions) result in lack of awareness and poor adoption by potential users of technology. This is largely due to weak and disorganised or short-term, project-based education and training of users on technology benefits and markets. Third, technology delivery systems are weak and work ethics are very poor. Fourth, research and extension systems have low commitment and accountability to gender mainstreaming. In particular, gender departments are not well-funded and staffed, and gender is just an added-on issue. Fifth, commercialisation is inadequate because enterprise value chains are not developed, nor are farmers' financial needs in the different stages of supply chain matched with financial conditions. Thus, farmers sometimes fear burning their fingers by adopting technology whose financing, product market and price are unknown or uncertain. Finally, enabling policy and institutional environment are weak in terms of priority setting, funding of technology, regulatory frameworks and the attitude of extension service managers—all constraining technology adoption. These issues are elaborated in the recommendations in Chapter 6 and also draw important lessons from successful technology adoption stories of upland rice in Yunnan Province of China, and zero tillage practice in Zambia in Chapter 5.

5

Lessons from adoption stories in China and Zambia

5.1 Overview

The need to mitigate low technology adoption and solve the problems of food insecurity for millions of people in developing countries through improved agricultural productivity is underscored by the multiple technological approaches adopted in these countries. The generation, production/multiplication, promotion and adoption of technology, where successful, have a history of policy and institutional support through the concerted efforts of governments and international research and development agencies. Support provided to farmers in both Asia and Latin America and allocating adequate resources for research, extension, marketing infrastructure and developing farmer organisations demonstrate the importance of political support in agricultural policy. Although varying in historical and political economy contexts, the importance of these key factors in boosting agricultural technology adoption are exemplified by the adoption stories of upland rice in Yunnan Province of China and zero-tillage in Zambia.

5.2 High adoption of upland rice in Yunnan Province, China

5.2.1 Background

Large parts of the Asian uplands are characterised by a high incidence of poverty, poor physical access to markets, ill-functioning marketing institutions, and subsistence-oriented agriculture with low productivity. These conditions obtain in much of sub-Saharan Africa. And just like in Africa, in Asia the rising population pressure and the consequent intensification of marginal areas for food production food production have contributed to environmental degradation and a further reduction in agricultural productivity. The Chinese government's support to Yunnan Province through institutions (extension and legal enforcement for soil conservation) and technology development for upland rice reflected good enabling policy with appropriate agro-ecological targeting. These upland areas were deliberately targeted because they are in a vicious cycle that perpetuates poverty, food insecurity and environmental degradation (Heidhues et al. 2006). There were concerted efforts to provide the relevant technology and also effective extension services.

Upland rice is dryland rice grown in soils that do not hold rainwater for a long time. After rains, water drains out of these fields fairly rapidly, so that crops grow in soils that are aerobic. Upland rice thus grows in hydrological conditions similar to those of other upland crops such as wheat and maize. According to Heidhues et al. (2006), upland rice is grown on about 14 million hectares worldwide, accounting for about 11% of the world rice area and contributes 4% of the total rice output. The indica type of new upland rice variety was selected for the non-flooded, well aerated soils. It is superior to traditional varieties on infertile soils, with improved lodging resistance, harvest index and input responsiveness (Atlin et al. 2006).

5.2.2 The challenge

The rice farmers in Yunnan Province grow a range of non-rice crops such as maize, millet, yam, beans, and cassava, which reflects a dietary orientation similar to many areas in sub-Sahara Africa. Despite this diversity, a general feature of the upland system is that it is inhabited by very poor farmers who grow food crops mainly for subsistence using very few inputs other than labour. Yunnan areas are remote with poor access to markets, and are generally inhabited by ethnic minorities that tend to be socially and politically disadvantaged.

5.2.3 The solution and results

Since 1995, documented evidence has shown steady yield increases in upland rice in three Yunnan counties. The yield gains have been attributed to improved upland rice varieties developed by the Yunnan Academy of Agricultural Science

(YAAS), which has in turn benefited from International Rice Research Institute (IRRI) germplasm, including a variety released in 2000 as Luyin 46—an improved indica genotype B6144F-MR-6-0-0 developed in Indonesia. Contributing to this productivity gains are increased use of inputs due to deliberate government efforts to improve seed delivery systems, and the mandatory construction of terraces for upland crops on steep slopes. The area under upland rice grown on terraces has been increasing by almost 60% per year, with the yield in terraced fields steadily increasing from about 2 t/ha in 1995 to 3 t/ha in 2003, compared with an average yield on the slopes that has remained below 2 t/ha (Pandey et al. 2005). The author's survey of the 2004 crop in Yunnan found that improved upland rice on terraces out-yielded traditional varieties on slopes by over 1 t/ha. On the slopes, improved varieties out-yielded traditional varieties by 20%. The yield gains were translated into similar increases in net return because markets were available for the crop harvested.

The advantage of upland rice is that labour is spread more evenly over the seasons of the year. It is also harvested early and thus shortens the 'hunger' period before the next harvest, if it is used for subsistence. Institutions and policies play an important role in upland rice farming systems. Policy was reformed to integrate upland systems with the rest of the economy by providing infrastructure and market institutions to improve market integration and competitiveness of agricultural production (Pandey et al. 2004). A parallel is drawn with NERICA rice in Africa, which has succeeded only in Uganda among the ECA countries as explained in "Box 6".

5.3 The success of conservation agriculture in Zambia

5.3.1 Background

Famous worldwide as a copper-producing country, Zambia is increasingly a success story for conservation agriculture, with smallholders adopting it widely. Estimates range from 70,000 to 120,000 farmers who had adopted aspects of conservation agriculture by 2003 (Haggblade and Tembo 2003), or 10% of smallholders in Zambia. Adoption has been strongest in the semi-arid parts of Zambia, with annual rainfall of 650–1000 mm. Farmers in these regions depend


NO SMOKING
SHAKER N-IV
SHAKER N-III

on mixed crop–livestock systems and cultivate mainly maize, groundnut and cotton. Ideally, what we call 'conservation agriculture systems' comprise a specific set of individual practices—reduced intensity of soil tillage, cover crop for the soil surface and diversified crop rotations—combined in a coherent, locally adapted sequence.

Box 5: New Rice for Africa (NERICA)

New Rice for Africa (NERICA) is based on the successful crossing of African *(Oryza glaberrima)* and Asian *(Oryza sativa)* rice. Field tests suggest the new varieties hold great promise with higher yield potential under a variety of soil and weather conditions, produce more protein, and have a shorter growing period, and greater resistance to African pests and diseases. NERICA varieties were developed at the main M'bé Research Center of the Africa Rice Center (Africa Rice), through conventional crossbreeding. Results from a study conducted during the 2004 wet season in 8 countries on 19 sites gave lowland NERICA yield ranging from 5–7 t/ha. Based on preliminary figures from Diagne et al. (2009), it was estimated that the area under NERICA in sub-Saharan Africa was around 700,000 ha in 2009.

Markets for inputs and outputs are not necessarily well-established and the full benefits of the new lines may go unrealised. An immediate problem is the supply of rice seed of the new group of high-yielding and stress-tolerant upland rice varieties. There was high-level commitment by top leadership and development partners in Uganda; this led to 50,000 ha of rice being established due to rapid adoption rates. The effect was a reduction in the annual rice import bill by one-third and decreased household poverty in 5 years. The major benefit was realising more than 50% of farm income (farm income share of total income: 85%). And sharing of benefits and costs is gendered (Lodin 2010). However, producing NERICA is time consuming; in absolute terms it takes 12–13 hours/day for 1 month. Farmers, mainly women and children, run up and down the field, shouting, waving, clapping hands, throwing stones, using rattles and drums to scare away pests. NERICA production is also time consuming relative to other crops: (two or) three weedings instead of one which is labour exhausting/inducing drudgery (backbreaking work), relying mostly on hand and hoe weeding combined. Usually only hoe weeding is required for other crops. Weeding is mainly carried out by women and children. Diagne et al. (2009) report adoption rates of 4% for Côte d'Ivoire in 2000, 20% for Guinea in 2001, 18% in Benin in 2004 and 40% in Gambia in 2006. In Nigeria, Spencer et al. (2006) estimated that up to 30% of farmers in the state of Ekiti, and 42% in Kaduna grew NERICA. Diagne et al. (2009) suggest a range of social, economic and institutional hurdles. Markets played a role; both land availability and participation in land markets boosted adoption. Programmes that increased farmer awareness about characteristics of particular NERICA varieties were important.

Kijima and Sserunkuuma (2008) found that the percentage of households growing NERICA varieties in Uganda increased from 0.9% in 2002 to 2.9% in 2003, reaching 16.5% in 2004. Poorer households in Uganda tend to allocate a larger proportion of their land to NERICA varieties, which may suggest that its adoption has the potential to reduce poverty and improve income distribution. NERICA can bring hope to many small-scale poor farmers on the continent by reducing poverty and income inequality within populations. But this is conditional on its wider dissemination, which can only take place if the seed supply bottlenecks and the enabling policy constraints mentioned are addressed. NERICA will also continue to face challenges from cheap and better-quality imports that are preferred by consumers, and from the development of local value chains that make it more competitive on the market. This calls for strong private sector support in the form of vertical integration along the rice value chain.

Conservation agriculture (CA) is intended to raise crop yields, lower labour use and improve timeliness of field operations, weed control and farm incomes. Many stakeholders from the private sector, government and donor communities have been promoting new conservation farming in Zambia. Chief among them are ZNFU/CFU (Zambian National Farmers Union and Conservation Farmers Union), Institute of Agricultural and Environment Engineering (IMAG), Golden Valley Agricultural Research Trust (GART), Dunvant, Cooperative League of the USA (CLUSA), and Land Management and Conservation Farming (LM&CF)—today (Agricultural Support Programme LM&CF), Ministry of Agriculture and Cooperatives (MACO).

The initial interest of ZNFU began when several of its commercial farmers travelled to Australia and the USA in the early 1980s. Reducing fuel consumption was the principal incentive for these farmers to adopt conservation farming; minimum tillage had the potential to reduce fuel consumption from 120 litres to 30 litres per hectare. A tremendous increase in the number of conservation farming adopters was observed from 1999 to 2003, due to government and donor push. In 2000, MACO formally embraced conservation farming as official policy of the Zambian government (MAFF 2001). The government has supported conservation farming in various ways: policy pronouncements, workshops, demonstrations and field support. The World Bank facilitated training for all extension agents in agro-ecological region II including key staff from MACO headquarters, in 'fast-track technologies' (MAFF 2001). The specific crops grown were chosen according to the requirements of the agro-ecological region.

Such technologies include use of cover crops, agroforestry, live fencing, erosion control, manure and compost. Frontline extension officers, 620 in number, from Central, Eastern, Lusaka and Southern Provinces plus Kaoma District of Western Province were concurrently trained in fast-track conservation farming technologies at four training sites (Chalimbana, Katopola, Palabana and ZCA-Monze). During the season 2002/03, Sida, Norad, FAO and WFP promoted digging permanent basins through the programme Food for Work. At the same time, CARE International, CFU, CLUSA, LM&CF, PAM and World Vision distributed 60,000 input packages to cultivate 1 lima of maize and 1 lima of legume.

5.3.2 Results and outcomes

The success of CA in Zambia cannot be attributed to technical factors alone. First, it was a result of a complex institutional framework, the technical innovation in conjunction with an effective participatory approach to adaptive research and technology transfer that tied farmers to a development strategy suited to their agro-ecological and socio-economic conditions (Derpsch 2001). In particular, institutional support was demand-driven and concentrated on providing training and education that equipped participating farmers with the skills to adapt and refine zero tillage practices on their farms.

Second, close collaboration gradually developed among researchers, extension agents, the

Reasons for success of CA in Zambia

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First, it was a result of a complex institutional framework, the technical innovation in conjunction with an effective participatory approach to adaptive research and technology transfer that tied farmers to a development strategy suited to their agro-ecological and socio-economic conditions (Derpsch 2001).

2

Second, close collaboration gradually developed among researchers, extension agents, the private sector and farmers to develop, adopt and improve CA systems.

3

Third, an aggressive dissemination strategy was launched to provide technical, economic and environmental information through the media, written documents, meetings and conferences, controlled and managed by producer organisations.

private sector and farmers to develop, adopt and improve CA systems. This included on-farm trials and participatory technology development. Over time, special attention has been paid to incorporating crop and livestock in CA systems, including integrating poultry, hog and fish farming. A particular challenge is developing rotational grazing patterns for cover crops that do not jeopardise the sustainability of CA systems. A related key reason for adopting CA farming practices was to incorporate environmental considerations to correct watershed degradation.

Third, an aggressive dissemination strategy was launched to provide technical, economic and environmental information through the media, written documents, meetings and conferences, controlled and managed by producer organisations. Farmer-to-farmer exchange of experiences was also emphasised. Fourth, private–public partnerships and an agro-input company (Dunvant) supported demonstration projects on large and small farms by providing inputs and extension services. Lastly, targeted subsidies played a significant part in supporting small farmer adoption of no-till practices. These subsidies included acquiring manual- or animal-drawn equipment with financial support from the State under development programmes (mainly FAO). Subsidised or free equipment is still made available to groups of farmers. Box 6 highlights important challenges and lessons from this case study.

In summary, the adoption stories of upland rice in Yunnan Province, China, and zero-tillage in Zambia show that successful generation, production/multiplication, promotion and adoption of technology is attributed to a history of policy and institutional support through the concerted efforts of governments and international research and development agencies. The targeted support provided to farmers in different agro-ecological conditions—especially with respect to allocation of adequate resources for research, extension, marketing infrastructure and developing farmer organisations—demonstrate the importance of political support in agricultural policy.

Box 6: Challenges and lessons

Conservation agriculture can improve welfare but major challenges were encountered: adapting some of the equipment, lack of appropriate and sufficient biomass for mulching, lack of regulations to control wild fires, pests such as cut worms destroy seeds and seedlings of germinating plants, and stray animals graze on cover crops. The equipment for minimum tillage were all imported, raising their prices, and there was no means of assuring its availability after project closure because manufacturers are reluctant to produce for a market whose demand is unknown. The main lessons from the Zambian experience are:

- Stakeholders—from policy makers and donors to input suppliers and trainers—united around a simple system. The Ministry of Agriculture and Cooperatives put in place a remarkable policy framework that deserves mention.
- Conservation farming as it stands today in Zambia is a water-harvesting and drought-mitigation technology. It is adapted to arid and semi-arid areas but is not suited to wetter climatic conditions, where in its present form it would lead to water logging. It is at odds with other conservation agriculture techniques that are adapted to temperate or equatorial conditions (but not to dry climates), or to areas receiving a bimodal rainfall distribution.
- Communal grazing is common throughout sub-Saharan Africa and is a major problem in trying to keep soil covered under conservation agriculture. This problem is acute particularly where agricultural productivity is low and climatic risks are high, and where farmers capitalise on livestock (cattle mainly) and frequently overgraze.
- Time is a major deterring factor in efforts to diffuse and adapt conservation farming. The technique requires medium- to long-term investment, especially in terms of labour. Conservation farming implies providing quality training to smallholders, careful monitoring of the system for several years, and maybe economically supporting adopters to share the risk of converting land and practices.

The benefits of conservation farming must also be rigorously demonstrated. Lacking at present are tangible data on the benefits, as shown in impact assessments using control.

6 Recommendations

The study traced bottlenecks to technology adoption along value chains of selected enterprises in ECA in the framework of an innovations system. The findings from literature review, key informant interviews, FGDs and a feedback workshop (Appendix 3) lead to six important recommendations: 1) agro-ecological targeting; 2) Gender mainstreaming; 3) market linkages and commercialisation; 4) linkages with finance institutions; 5) research, extension and farmer linkages; and 6) enabling policy environment.

6.1 Agro-ecological targeting based on politics, ecology and commodity

The agro-ecological targeting can be looked at in terms of the diverse agro-ecologies each country is endowed with but which have competing commodities and varying population densities. The following recommendations are discernible:

- Research systems should target agro-ecologies (for some commodities) and seek to gain political influence on how resources are located regionally to upscale technology dissemination—beyond the typical three major targeted agro-ecologies—highland, intermediate and lowland.
- Policy makers and investors in agribusiness must be encouraged to adapt technology to location-specific agro-ecologies for technologies generated and released in other countries.
- It is important to build the capacity of local researchers and policy makers in adapting technology to agro-ecological zones, in responding to end-user preferences for technology attributes and in allocating resources to facilitate this process.

- NARS need a platform to lobby support for their products from the political class who are influential in resource allocation.
- While recognising the importance of ecological targeting, it is also necessary to appreciate the circumstances, needs and preferences of different social groups within these ecologies in order to provide options for diverse clients—and not 'one size fits all' solutions.

6.2 Gender mainstreaming in agricultural institutions

Gender-based constraints prevalent in all the ECA countries undermine technology adoption, management and overall productivity. While the significance of these constraints is well documented, the response of both research and extension organisations remains weak. This is despite the existence of fairly supportive macro environments provided through national policies, and mechanisms, and endorsement of regional and international gender equality instruments. In summary, this study recommends that institutions involved in research and extension comprehensively adopt gender-mainstreaming strategies that encompass commitment to gender, build gender capacity, create enabling organisational culture and build in mechanisms for accountability to gender mainstreaming. Some of the key elements of these pillars are:

- **Political will:** policies, procedures, resources, support and enthusiasm to support gender policies.
- **Technical capacity:** Knowledge and skills to undertake practical aspects of gender analysis and integration for enhanced programming and institutionalisation of gender-equitable organisational processes.
- **Accountability:** Setting up mechanisms to ensure that organisations walk the talk in terms of gender mainstreaming. Accountability will need to be built into job performance contracts, research and programme design, studies, monitoring and evaluation, among others. Of greater significance is the location of the coordinating office. For it to have voice and respect, the office needs to be high enough, if possible, reporting to the head of the organisation.

- **Organisational culture:** Creating a gender-sensitive culture that values all personnel and maximises on productivity. Developing measures to reduce historical inequalities will go a long way in motivating staff to contribute to results.
- **Gender sensitive analysis:** The analysis is recommended to identify and address gender-based constraints, thus ensuring that men and women participate and benefit at all levels in the different value chains. The analysis should encompass the following phases: 1) mapping gender relations and roles along the value chain; 2) identifying gender-based constraints in terms of conditions of gender disparity, factors that cause gender disparities, how to deal with the laid back attitude among women or men, and formulating cause and effect hypothesis; 3) acting to remove gender-based constraints by using strategic and market-driven solutions; and 4) measuring success by designing and implementing gender-sensitive indicators to monitor the status of men and women and reduce gender inequalities over time. As much as possible, the indicators need to measure outcomes rather than just numbers.

6.3 Promote market linkages and commercialisation of enterprises

Weak links with industry and markets constrain technology adoption in ECA regions due to poor roads (from the ocean to hinterland, rural to capital city mentality persists), lack of information, high transportation costs, constraining policies and regional insecurity. The ASARECA strategic plan has prioritised an agricultural domain (HLL: high potential, low population, low market access), and has policy geared towards collective marketing in research for development:

- One way of strengthening institutions to support technology adoption and economic transformation in the region is through public–private partnerships (PPPs). These partnerships can seek market development funds to build modern warehouses with cold storage facilities to lease to private firms to operate franchises and contracts with farmers and traders.

- Increasing technology adoption requires incentives to stabilise markets, facilitating farmers to access markets with premium prices for quality, market coordination and transparency.
- To facilitate technology adoption that links with markets requires a business incubation fund that provides grants on a competitive basis to innovations selected through peer review by experienced business experts.
- NARS, farmers and intermediaries need capacity building and data on consumer habits and commodity demand and supply levels in regional markets before they can competitively leverage their technology as viable brands for adoption. Indeed, regular and gender-sensitive market surveys, with investments in all links in the supply chain, can enhance how public and private institutions coordinate markets and interact and communicate through ICT platforms.
- Policy makers and managers of NARS need capacity building in PPPs, reflexive thinking and in how to bring on board locally designed technology business systems and processes to catalyse adoption and up-scaling.

6.4 Promote linkages with finance institutions to ease access to credit

The study findings showed that some technologies are expensive to acquire, for example, high-yielding pedigree cows, while some require expensive accompanying inputs. Thus, adoption is constrained by lack of funds. Funds can be difficult to raise by borrowing from finance institutions, particularly for women who may lack collateral demanded by lending institutions. Although ASARECA and NARS have not developed a policy to link with finance institutions, the policy can be achieved through sharing information on the profitability of new technologies in the following ways:

- There is need to negotiate arrangements that will ensure that women farmers, who have traditionally been left out, are able to access credit.
- The distribution of loan funds should be rationalised for all regions and social groups, irrespective of their influence (voting power) and ecological zones.

- Extension, finance institutions and ministries of agriculture should adopt cheap digital technology to harness information on farmers' credit rating, resource capacity and available financial services, procedures and costs, and move to cloud computing to improve services and cost efficiencies.
- Capacity building is required: 1) for policy makers, NARS and technology end users to bridge links with finance companies to facilitate technology adoption and up-scaling; 2) for facilitation to strengthen ethical relations and networking is required; 3) to develop a wide range of financial products to meet the needs of diverse clients, both male and female; and 4) in use of digital platforms that host credit referencing data on technology end users to ease the capability of lenders to assess the credit rating of potential borrowers who want to invest in new technology.

6.5 Enhance extension–research–farmer linkages

Institutional learning and change are vital elements for successful technology dissemination and adoption and should inform the configuration and approach to technology promotion. When implemented in a flexible, participatory and sustainable way, most of the models can lead to improved extension performance and the impact policy makers are looking for in ASARECA countries. Technology developers, disseminators and users need that 'smart way' that allows them to partner and become co-owners of the process and results. Some of the pertinent changes needed are forums for learning and inculcating virtues that stimulate and sustain good performance as follows:

- ECA countries are too highly politicised, tribal and divided to foster healthy competition in technology generation, promotion and adoption. Yet technology development and adoption thrives better in an environment where work ethics are strong, less adversarial and opportunities exist for innovation. The solution lies partly in promoting a multi-cultural environment that is also linked to good markets.
- The extension service and NARS should use process audit firms that can develop metrics to measure service efficacy. These firms should set benchmarks for performance contracting and evaluate them instead of leaving it to employees in research and extension to set their own targets.

- The NARS and extension systems should have region-specific designs that can be used to create partnerships between researchers, extension, stakeholders and end users of technology so that all benefit from the success of locally developed systems for adoption, and returns flow back to extension and research in form of better remuneration and business investments or royalties. Here context specificity and local processes of experimentation and learning are important in the innovation process.
- NARS should ensure there is increased participation of farmers in seed variety development and release. Assessment of seed demand, which relies on extension data from previous years, remains poor in the region, causing inadequate and erratic supply of improved seed. Therefore, seed companies need to identify better methods of forecasting seed demand to ensure adequate quantities of seed are available for distribution to producers when needed.

6.6 Strengthen infrastructure capacity and enabling policy environment

The study found the capacity for seed distribution in ECA inadequate, especially for livestock and staples, mainly because distributors are concentrated in urban centres and supportive infrastructure such as roads and storage facilities are lacking. The following recommendations will address challenges that lead to increased prices of seed and limit accessibility by potential adopters:

- Seed companies should increase their distributorship to reduce distances travelled by farmers to purchase planting material.
- Stakeholders in the industry need to create systems for proper coordination to avoid duplication of roles and ensure high agro-ecological reach of the formal seed system.
- Harmonisation and rationalisation of seed policies championed by ASARECA, which has been successful in some countries, should be fast-tracked in the region.
- In most countries, the informal seed system, which mainly handles the local varieties, plays a dominant role in the overall seed system accounting for

more than 90% of the seed used in some countries. Governments should therefore create policies/ programmes that allow the informal seed sector to integrate with the formal sector to promote generation, dissemination and use of good quality seed of improved non-hybrid varieties.

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Appendix 2: List of FGD participants

Appendix 2(a): List of 1st FGD participants in DRC (cassava and beef)

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Appendix 2(c): List of 1st FGD participants in Ethiopia (chemical fertilisers and lime, hybrid maize, haricot beans and dairy)

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Appendix 2(d): List of 1st FGD participants in Kenya (chemical fertilisers and vegetables)

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Patrick Maina	PO Box 213 Wang'uru	Agro-Dealer	0722 348796	
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Name	Organisation and address	Designation	Telephone	Email address
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Transforming Agriculture for Improved Livelihoods

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