

# Going Beyond Demos to Transform African Agriculture



The Journey of AGRA's  
Soil Health Program





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**Correct Citation:** Alliance for a Green Revolution in Africa. (2016). Going Beyond Demos to Transform African Agriculture: The Journey of AGRA's Soil Health Program. Nairobi, Kenya.

**ISBN No:** 978-0-9980765-0-8

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**Design and Layout:** Conrad Mudibo, Ecomedia Limited, Nairobi, Kenya.

**Printing:** Ecomedia Limited

**Photo Credits:**

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Clinton Development Initiative  
International Centre for Research in the Semi-Arid Tropics (ICRISAT)  
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# Acronyms

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AASR	Africa Agriculture Status Report	ETG	Export Trading Group
AFAP	African Fertilizer and Agribusiness Partnership	FARA	Forum for Agricultural Research in Africa
AfDB	African Development Bank	FFS	Farmer Field School
AFFM	African Fertilizer Financing Mechanism	FAO	Food and Agriculture Organization of the United Nations
AfNet	African Network for Soil Biology and Fertility	FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
AGRA	Alliance for a Green Revolution in Africa	GAP	Good Agricultural Practices
AISL	Agro-Input Suppliers Limited	GBD	Going Beyond Demos
ANAFE	African Network for Agriculture, Agroforestry and Natural Resources Education	GIS	Geographical Information System
APC	Agribusiness Partnership Contract	GLP-LIMS	Good Laboratory Practices and Laboratory Information Management System
AWARD	African Women in Agricultural Research and Development	ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
BAGRI	Banque Agricole du Niger	IFA	International Fertilizer Industry Association
BCR	Benefit-Cost Ratio	IFAD	International Fund for Agricultural Development
BMGF	Bill & Melinda Gates Foundation	IFDC	International Fertilizer Development Center
BNDA	Banque Nationale de Developpement Agricole	IFPRI	International Food Policy Research Institute
BRS	Banque Regionale de Solidarite	IITA	International Institute of Tropical Agriculture
CARD-FNGO	Centre for Agriculture and Rural Development – Financial Non-governmental Organization	INERA	Institut de l’Environnement et des Recherches Agricoles
CDI	Clinton Development Initiative	IPNI	International Plant Nutrition Institute
CGIAR	Consultative Group on International Agricultural Research	ISFM	Integrated Soil Fertility Management
COMESA	Common Market for Eastern and Southern Africa	KCEP	Kenya Cereal Enhancement Programme
CROPNUTS	Crop Nutrition Laboratory Services	KIPPRA	Kenya Institute of Public Policy Research and Analysis
CSHC	Country Soil Health Consortia	MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
EAC	East African Community	MFI	Microfinance Institution
ECOWAS	Economic Community of West African States	MIR	Marketing Inputs Regionally
EPRC	Economic Policy Research Centre	MT	Metric Ton
ESA	East and Southern Africa		

NAIS	National Agricultural Information Service	SOFECSA	Soil Fertility Consortium for Southern Africa
NARS	National Agricultural Research System	SOCO	Soy and Climbing Bean Commercialization Project
NEPAD	New Partnership for Africa's Development	SSA	Sub-Saharan Africa
NFP	National Fertilizer Policy	SUA	Sokoine University of Agriculture
NPV	Net Present Value	TAP	T-Skilled Agricultural Professional
PFRD	Pesticide and Fertilizer Regulatory Division	TFC	Tukula Farming Company
PMG	Producer-Marketing Group	TFRA	Tanzania Fertilizer Regulatory Authority
PPRSD	Plant Protection and Regulatory Services Directory	TTFA	Toyota Tsusho Fertilizer Africa Limited
RF	The Rockefeller Foundation	UNADA	Uganda National Agro-Input Dealers Association
ROP	Rural Outreach Program	USAID	United States Agency for International Development
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture	VCR	Value-Cost Ratio
SADC	Southern African Development Community	WAFP	West African Fertilizer Program
SARI	Savanna Agricultural Research Institute	WHP	World Health Programme of the United Nations
SoilFertNet	Soil Fertility Management and Policy Network	WUR	Wageningen University Resource Centre
SHP	Soil Health Program	ZARI	Zambia Agricultural Research Institute
SHPAN	Soil Health Policy Action Node		



# Foreword

---

**N**orman Borlaug and his colleagues, when developing the Asian Green Revolution, did not have an organization behind them like the Alliance for a Green Revolution in Africa (AGRA). Its founding 10 years ago was a smart thing to do. H. E. Kofi Annan sounded the call for a uniquely African Green Revolution on July 5, 2004, at a meeting of Heads of State in Addis Ababa, Ethiopia. Not long afterwards, AGRA was established. Given the complexity of the challenges involved, AGRA had to be invented from scratch because no such institution existed before.

At its start, AGRA focused on four main components of what a Green Revolution needed most: seeds, soils, markets and policy. How to overcome nutrient depletion and soil compaction so common in most smallholder farms of sub-Saharan Africa is a major challenge in itself – not something that the Asian Green Revolution had to face. African soils are now unhealthy and this has been directly related to unhealthy people. And largely because of that, cereal yields in sub-Saharan Africa hovered around 1 MT/ha, the lowest of any region of the world. AGRA has stimulated what is now an organic movement composed of farmers, farmer associations, NGOs, policymakers, scientists and advocates from the private and public sectors throughout Africa and beyond.

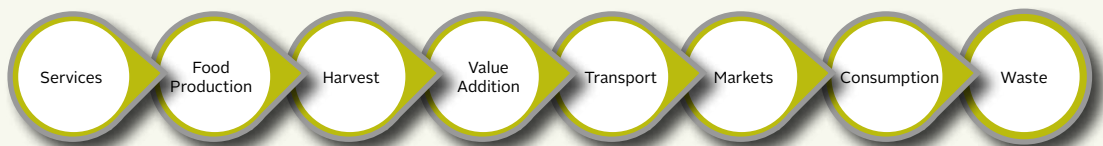
AGRA's Soil Health Program (SHP) started with a bang at the Africa Fertilizer Summit held in Abuja in June, 2006. This gathering created awareness of the need for increased use of mineral fertilizers (from about 8 kg/ha to 50 kg/ha) as the key vehicle for overcoming soil fertility depletion. Commitments made at the Summit and follow-up actions resulted in the average fertilizer use in Africa increasing from 8 kg of actual NPK fertilizers per hectare at that time to the current level of 16 kg/ha, a good first step. Several of us soil scientists attending the Summit felt that, for the first time, people were listening to us.

The Soil Health Program then got to work, training 139 MSc and 43 PhD candidates in soil science at 11 African Universities, replenishing the dwindling pool of African soil scientists. It also set up over 155,000 large and small demonstration plots that showcased “best-bet” soil health practices in 13 countries, in collaboration with several partners in the public and private sectors. The Program then took on the major challenge of developing ways to overcome the myriad regulatory and logistical barriers to which imported fertilizers are subjected – from the port to the farmer inland – which make fertilizers in Africa cost an average of USD 830 /MT, as opposed to USD 200/MT in Vietnam and other Asian countries.

My field experience tells me that most smallholder African farmers can raise their maize yields from 1 to 3 MT/ha by using high-yielding varieties and applying fertilizer, even the blanket fertilizer recommendations that many countries still have. (I use maize yields as a proxy for other crops, as well as livestock and tree products.) Indeed, maize yields in sub-Saharan Africa averaged 1.5 MT/ha in 2015, a 50% increase since 2005 and an important indicator of potential. This yield level is still extremely low compared with 3 MT/ha in Latin America and South Asia, 5 MT/ha in China, and more than 10 MT/ha in North America, Europe and Japan. Certainly AGRA and its partners have contributed to this improvement. Crop yields are a necessary but not sufficient condition for alleviating poverty and hunger, but it is without a doubt the initial step.

To go from 1.5 to 3 MT/ha is clearly possible now, particularly given the high economic growth rates of many African countries. To go the next step after that (from 3 to 5 MT/ha) will require much more farmer access to new technologies, and AGRA is well placed to facilitate this process.

AGRA's new strategy now rightfully focuses on the different links across the food value chain, my version of which is below.



The first link is to provide the necessary services before farmers plant their crops. Seed systems are key, as well as soil testing, IT-based credit, crop insurance, and public and private extension services armed with the knowledge derived from field demonstrations. AGRA’s pioneering work in smoothing over constraints to fertilizer purity and transport is now coupled with making more targeted, on-the-spot fertilizer and organic matter recommendations right in the farmer’s field, using the new SoilDoc technology, crowdsourcing the results, and making more accurate maps, which are being tested with AGRA support in Burkina Faso, Malawi, Mali, Mozambique, Niger, Tanzania and Zambia. While such soil tests are necessary, they too are not sufficient. What is the point in recommending zinc if there are no fertilizers available that contain zinc? This is why AGRA is working closely with fertilizer blending companies to make sure that more precise blends are available to the farmers that need them.

The next step in my view is to bundle services, so farmers and farmer associations can focus on what they do best – grow crops, livestock and trees. It is great to see the beginnings of what might be called “bundling service” companies, created by farmer associations to take care of: purchasing the best seed; buying the right fertilizers; obtaining credit and creating straightforward ways to pay it back; obtaining weather-indexed crop insurance (and also creating transparent ways to pay the premiums and collect the cash when the weather fails); assuring reliable prices for produce in reliable markets; and capturing innovations coming out of research. I just saw the beginnings of such an organization created by a group of commercial farmers in Kenya and understand that progressive county governments are also stimulating the formation of such service companies owned by smallholder farmer associations. Needless to say, these new companies provide jobs for young entrepreneurs that didn’t exist before – for example using SoilDoc kits and charging farmers for the service.

AGRA scientists and their partners must engage more across the remaining links of the food value chain. The old division between seeds and soils made orphans of other components of agronomy, such as rainfall

prediction (especially the planting rains), proper spacing, conservation tillage in situations where it is appropriate, and reducing losses in pre- and post-harvest operations. This is an important gap. When a new technology, such as microdosing (or even using fertilizers in the regular way) was linked with credit it really worked.

Looking forward, the value chain approach needs three overarching dimensions: policy, nutrition, and environment, of which AGRA is currently tackling the first one, policy. The bottom line of hunger elimination is not higher crop yields (that is the first line) but rather the elimination of stunting with adequate access to sufficient calories, protein, and micronutrients. AGRA should open a new front on agriculture-based nutrition with proper measurements of nitrogen (protein), iron, zinc and the precursors of vitamin A.

Then the big elephant in the room: the environment. The effects of climate change are definitely with us in Africa and none of them are good. AGRA and its partners should measure and devise innovations to maximize nutrient cycling, putting the soil biota to work more efficiently, and utilize better soil moisture (“green water”) which accounts for two-thirds of the water used by plants in agriculture. AGRA should also look for ways to help decarbonize our atmosphere. One low hanging fruit is to seriously promote the use of nitrogen-fixing trees in association with crops. The technology is there, but impact has been minimal because of the need to support farmers during the period before nitrogen and other positive impacts take place.

Finally, AGRA and its partners should take the lead and figure out how a 3 MT/ha African agriculture can produce synergies with the environment, including decreasing the carbon footprint of a vibrant agriculture, safeguarding biodiversity, as well as conservation of wildlife, particularly in East and Southern Africa with its spectacular biodiversity, mostly on private lands. There are important issues of nutrient cycling and nutrient transfers between agriculture and wildlife that need to be addressed. As the African Green Revolution moves forward, can African farmers protect this unique and potentially very profitable endowment?



In summary, AGRA's Soil Health Program, and AGRA overall, has made a difference in promoting and supporting the uniquely African Green Revolution that H. E. Kofi Annan called for. Now that a tipping point has been reached, there are tremendous opportunities to help achieve a more prosperous 3 MT/ha agriculture and link it effectively with improved human nutrition and stewardship of our environment.

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**Pedro A. Sanchez**

# Preface

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**I**mproving soil health is essential to reversing the low productivity that has plagued Africa's smallholder agriculture over the past 40 years. During this period, the average yield of maize, a staple food crop in Africa, has stagnated at about 1 MT/ha. Unfortunately, due to continual mining of soil nutrients over time, without sufficient replacement, Africa's soils – particularly on small land holdings – steadily lost their ability to support strong crop growth. In order to transform African agriculture, farmers must start using fertilizers in much greater quantities than currently, and apply it in appropriate ways to ensure environmental sustainability.

This book chronicles the journey of the Soil Health Program (SHP) of the Alliance for a Green Revolution in Africa (AGRA). The Program was established in 2008 to address the problems of declining soil fertility in Africa, with generous support from the Bill & Melinda Gates Foundation and The Rockefeller Foundation. The strongest point of entry for SHP interventions was increasing fertilizer supply and use, with the latter rooted in the application of Integrated Soil Fertility Management (ISFM) practices that align with local knowledge and fit local agro-ecologies.

The term “soil health” is commonly used in this book, although the usual detailed aspects of soil health are not the focus. Our use of the term arises from fact that ISFM practices, which were a central focus of SHP, are a key contributor to the health of living soil. We use “soil health” to convey that soil is not just an inert, lifeless, crop-growing medium, but rather a vital, ever-changing element of our surrounding environment, one that is full of life and deserving of careful management.

This book describes the background against which the Soil Health Program was established, the architecture of the Program, and its key innovation of “going beyond demonstrations” in order to facilitate the scaling up of soil health technologies. The Program learned early on that, while creating awareness of new technologies through on-farm demonstrations was important, more had to be done. We had to find innovative solutions to the systemic challenges that stand in the way of smallholder farmers adopting soil health technologies: access to financing to

buy needed inputs (especially improved seed and fertilizer), access to remunerative markets, access to good extension advisory services, and more effective farmer organizations to capitalize on economies of scale and thus reduce the high transaction costs that come with separate individual actions.

The SHP journey is depicted through the innovations and associated scalable models and achievements presented in Chapters 1 to 12. The last chapter synthesizes major lessons from this journey, relative to three important questions: What worked well? What did not work well? And what are the opportunities that should guide future investments?

We sincerely hope that this book will help all those who are working to take soil health technologies to scale across Africa. We especially hope that those who focus mainly on providing knowledge to farmers will be stimulated to broaden their approach – to do more than create awareness and tackle other major constraints facing farmers.

The SHP journey has taught us that private sector-led crop value chains are key to scaling up and sustaining impact. AGRA has already repositioned its approach to agricultural transformation by integrating soil- and seed-related activities with efforts to improve smallholder access to markets and financial services, to strengthen farmer organizations, and to help countries improve national policies aimed at increasing and sustaining agricultural productivity and incomes.

We thank the authors for their contributions to this book and appreciate their diligence in responding to reviewers' comments. We are thankful to the reviewers for providing critical assessments and suggestions that helped us to improve the chapters. Last but not least, we also express our thanks to the editor.



**Dr Agnes Kalibata**

*President, Alliance for a Green Revolution in Africa (AGRA)*

# Acknowledgements

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It was in early November 2015 when we concretized our plan to write a second book documenting the journey of AGRA's Soil Health Program (SHP) and some of its contributions to transforming African agriculture. The decision to produce this book came a little over a year after releasing our first one, *Investing in Soils*, which documented selected SHP-related case studies and was well received by a wide audience.

Our second book, *Going Beyond Demos to Transform African Agriculture: The Journey of AGRA's Soil Health Program*, is now here and we acknowledge that writing it was possible only because of the dedication of so many people. First, we sincerely thank the grantees and implementation partners of the SHP projects who sacrificed their time to travel to the first and second writeshops, which were held in Nairobi and Naivasha, respectively, in Kenya. We feel greatly indebted to the many farmers who participated in various SHP projects, to the staff of intermediary institutions, and to the many researchers with whom we have worked for the knowledge and experiences reflected in this book.

Also, it would have been a very different book if not for the commitment and openness of AGRA staff and their leadership, as well as our grantees. Thank you all for challenging each other every step of the way. Many people reviewed individual chapters or the entire manuscript at one stage or another and made very useful suggestions. We would like to sincerely thank Pedro Sanchez, Ray Weil, Chris Lambe, August Temu, Charlie Wortmann, Sileshi Gudeta and Bernard Vanlauwe. Thanks also to Tiff Harris

(TH Consulting Ltd.), our chief editor, and Conrad Mudibo (Ecomedia Limited), our graphic designer, who were instrumental in this process.

We also feel greatly indebted to Rebbie Harawa of AGRA, whose leadership, critique and guidance helped chart the way. Special thanks to Marie Rarieya, David Kimani, Asseta Diallo, Zacharie Zida, Abednego Kiwia, Mary Yaodze, and Noordin Qureish, all of whom provided much-needed linkages with the SHP grantees and partners. We also thank the AGRA M&E staff, Jane Njuguna and Samuel Amanquah, who provided input to the background chapter. Special thanks to Dorothy Shivere who provided us with efficient logistical support during the writeshops.

Finally, we would like to acknowledge the Bill & Melinda Gates Foundation and The Rockefeller Foundation for their support to AGRA in general and the Soil Health Program in particular.



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# 1 Taking Soil Health Technologies to Scale: An Introduction

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## Key Messages

- 1 Creating awareness about promising agricultural technologies is a necessary but not sufficient activity for increasing the productivity of smallholder farmers in Africa.
- 2 African farmers are seriously hampered by a number of challenges, ranging from degraded soils and poor access to information and inputs at the start of the crop value chain, all the way to the end, where farmers struggle with post-harvest losses and gaining access to good markets.
- 3 A holistic approach must be taken to improve the livelihoods of Africa's smallholder farmers – one that addresses all major systemic problems in the agricultural value chain.
- 4 Given the right support, farmers can significantly increase the productivity of the crops they grow, lift their yields, realize higher incomes and profits, and dramatically change their lives for the better.

Soils are the reservoir of nutrients and water for plant growth. The physical structure of soils determines how nutrients, water, and roots move through it. In most soils, after five to ten years of cultivation (without using fertilizer), a lack of available nitrogen, phosphorous, and potassium (as well as other nutrients) severely limits crop yields. The missing nutrients need to be replenished.

Africa's farmlands are often low in nutrients, lack sufficient organic matter, and are limited in their ability to hold water. It is estimated that more than 80% of Africa's farmland soils have chemical or physical properties that constrain crop production (Lal, 2010). This soil health crisis has come about from decades of "nutrient mining" – the result of continuous cultivation using little or no fertilizer (organic or inorganic). The pervasive mining of the soil is costing Africa dearly: about 8 million tons of soil nutrients are lost each year, valued at over USD 4 billion (Toenniessen, Adesina & DeVries, 2008). Soil erosion makes the problem even worse. In Kenya, the economic impact of soil erosion is equivalent to reducing the country's gross domestic product by USD 390 million annually, or 3.8% (Cohen, Brown & Shepherd, 2006).

The use of fertilizer across sub-Saharan Africa has been and remains very low compared to the rest of the world (Figure 1.1). Three major challenges contribute to this stagnation:

- 1) All too often, smallholder farmers do not find fertilizers in the marketplace when the time is right for applying them, and even when they do, locally appropriate fertilizer products are usually too expensive for them to buy;
- 2) Farmers often lack the knowledge they need to efficiently combine mineral fertilizers with organic inputs in ways that will give them optimal returns on their investment; and
- 3) Counter-productive policies have corrupted the fertilizer market and decimated the systems needed to deliver knowledge to poor farmers.

For these reasons (and others described elsewhere in this book), African smallholders are simply unable to buy and apply fertilizers in sufficient quantities to offset current levels of nutrient depletion. Average fertilizer application rates in the SSA region are currently about 16 kg/ha, far below the recommended minimum to sustain soil fertility (IFDC, 2015).

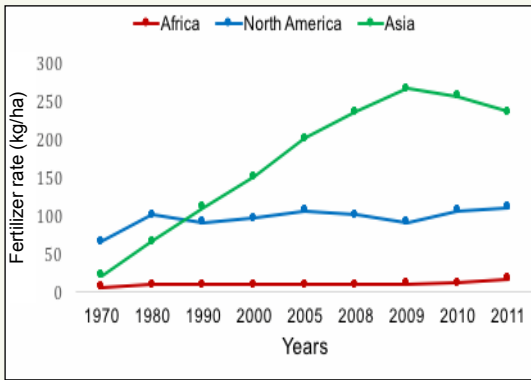
## Introduction

Sub-Saharan Africa is the only major region in the world where staple food production has not kept pace with population growth over the last three decades. Crop productivity has increased slightly, but has been overwhelmed by the region's rapidly growing number of people. Elsewhere around the world, crop productivity and food production have significantly outpaced population growth (FAOSTAT, 2015; World Bank, 2015).

Sub-Saharan Africa (SSA) is just not producing enough food to keep pace with its growing needs. Cereal yields in the region average less than 1.5 MT/ha, compared to average yields in Asia and Latin America of over 5 MT/ha and 8 MT/ha, respectively (FAOSTAT, 2015). One major reason for this difference is the relatively poor health (fertility) of the soils being cultivated by smallholder farmers in Africa.

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2 Islamic Development Bank, 8111 King Khalid St., Saudi Arabia



**Figure 1.1:** Comparative usage of fertilizer in Africa and other parts of the world (Source: IFDC, 2013)

One major effect of soil nutrient mining has been to dramatically slow improvements in crop yields. The potential yields that improved seeds can and do produce in other regions are far from being realized in most parts of Africa. This “yield gap” means that many Africans – especially women and children living in rural areas – still suffer from hunger, malnutrition and severe poverty. Improving the physical, chemical, and biological health of soils has proven to be one of the most difficult challenges to overcome in agricultural development, with efforts to do so limited by the advocacy of “quick-fix” short-term solutions, conflicting ideologies about how best to intervene, and inadequate understanding of market development processes and farmer behavior.

Over the years, soil scientists have developed new approaches and technologies that have been somewhat successful in dealing with Africa’s soil health challenges. Scientists have developed, tested, and popularized – at least to some extent – several promising soil fertility improvement technologies (AGRA, 2016). These include the use of lime to make acidic soils more productive, blended fertilizers that contain missing micronutrients, organic manure to improve soil structure, and rhizobium inoculum for legumes to increase nitrogen fixation.

However, there are major differences between crop yields obtained by farmers and those achieved on controlled experimental plots. This is due, at least in part, to the high variability of soils (Tittonell et al., 2010; Vanlauwe et al., 2015). This difference is also attributed to the fact that under experimental plots, researchers use the maximum level of inputs and implement other agronomic practices in a timely manner, including water management and weeding, which is often not the case at the farm level. Labor is another major constraint facing farmers.

The yield gaps currently being experienced in SSA can be overcome through the use of appropriate fertilizers, good agronomic practices and improved seeds. The high

diversity of soils in Africa means that the application of one technology alone (e.g., fertilizer) is not likely to be the most efficient way to address declining soil fertility. In many places, the physical and biological characteristics of soils need to be improved over time using integrated soil management approaches, which in turn will make fertilizer more effective and agronomically efficient.

In SSA, where large areas of land have been depleted of nutrients (Jama & Kiwia, 2009), droughts, flash floods, and the increased temperatures associated with climate change are reducing the productivity of arable lands, consequently leading to severe food insecurity relative to an ever-increasing population (Ndirangu et al., 2013; Vanlauwe et al., 2010).

## Addressing Low Agricultural Productivity in Africa

Many agricultural research and development organizations are working to improve smallholder agriculture in Africa. Various international and national R&D institutions have produced robust, high-yielding seed and developed clear recommendations for the precise and appropriate use of fertilizer. They have done so in partnership with a large number of public and private development agencies, and worked with them to create farmer awareness about the improved inputs and encouraged their adoption to increase farm-level productivity. Even with all that, however, many of these new technologies never reach a commercial scale, in part because markets are not developed well enough to make them available to farmers when they need them and at prices they can afford. These challenges are widely acknowledged and a number of attempts have made to address them, both in terms of market accessibility and financial inclusivity, but these efforts still fall well below the threshold for sustaining an agricultural transformation in Africa.

Governments have called for efforts to improve soil fertility in order to increase productivity, such as in the June 2006 Abuja Declaration on fertilizer that recommended Africa increase its average use of fertilizer to 50 kg/ha. At the time, average fertilizer use was only about 8 kg/ha; today, 10 years after that Declaration, average fertilizer use has indeed increased, but it must increase much further. In addition, when and if this goal is achieved, it will still comprise just one factor within the agricultural value chain that, by itself, is not likely to overcome the productivity challenge. Other important government agreements include the 2003 Maputo Declaration and the 2013 Malabo Declaration, under which governments agreed to allocate at least 10% of their national budgets to agricultural development (NEPAD, 2016). While several countries have followed through on this commitment, many others are falling

well short of the agreed target, meaning that their agriculture sectors are still underfunded. And even where funding has been increased, comprehensive measures that address the problems of smallholders are still inadequate (NEPAD, 2009).

## AGRA's Focus on Addressing Farmers' Needs

The Alliance for a Green Revolution in Africa (AGRA) shares the consensus view among African agricultural specialists that increasing the productivity of smallholder farms is essential if the sector is to be transformed. Success will require improved and timely access to more affordable production inputs, especially improved seed and appropriate fertilizers. This will need to be coupled with better access to affordable financing, effective extension advisory services, stronger farmer groups, as well as remunerative market opportunities.

AGRA aims to ensure that smallholder farmers have what they need to succeed: improved seeds and healthy soils; access to markets, information, financing, storage and transport; and policies that provide them with comprehensive support. Catalyzing an agricultural transformation in Africa will require innovation-driven and sustainable productivity increases, combined with access to markets, affordable financing, and better policies that improve the livelihoods of smallholder farmers.

AGRA and its partners have created a number of high yielding, locally adapted staple crop varieties capable of delivering a step change in farm yields. AGRA has nurtured a pool of local scientists, as well as indigenous businesses and service providers that can together deliver an agricultural transformation. Building partnerships with governments and regional institutions can help leverage the impacts of appropriate interventions and lift barriers that currently block markets. With a refocused strategic direction, AGRA now has the opportunity to better harness its expertise and resources, and to ensure consistent delivery on its goals through stronger implementation.

In seeking to catalyze an agricultural transformation, AGRA has leveraged a number of strategic advantages (and will continue to do so):

- Unparalleled regional and country-specific knowledge, providing a unique ability to engage with others to meet development challenges and capitalize on new opportunities;
- The ability to deploy local capabilities and deep, crop-specific knowledge;
- Activities that span the entire agricultural value chain;

- A focus on Africa's smallholder farmers and their greatest needs;
- A network of partnerships with donor organizations, governments, implementing organizations (NGOs, CBOs), and universities, with AGRA acting as a natural hub for agricultural activities across the value chain; and
- An ability to enable more effective coordination of regional efforts and the sharing of best practices across borders.

With initial funding from the Bill & Melinda Gates Foundation (BMGF) and The Rockefeller Foundation (RF), AGRA established its Soil Health Program (SHP) in 2008. The Program became a core component of AGRA's efforts to improve soil fertility on smallholder farms in 13 target countries<sup>3</sup> across Africa. The SHP theory of change rests on the idea that integrated soil fertility management (ISFM) practices<sup>4</sup> are essential for ramping up agricultural growth in Africa, and in order for farmers to adopt and use these practices, inefficiencies in the value chain must be reduced. The Program applied intervention models that were best suited to deliver on its core objectives. These were to create physical and financial access to appropriate soil nutrients and fertilizers; to improve access to locally appropriate ISFM knowledge, agronomic practices and technology packages; and to strengthen the capacity of national institutions.

Dealing with soil fertility problems typically requires farmers to adopt a technology package (as opposed to a single product) that includes improved agronomic practices together with organic and inorganic inputs. For this reason, AGRA's efforts to improve soil health have focused on fertilizer supply and use – provided they are rooted in ISFM practices that reflect local knowledge, practices, and agro-ecologies. The objective was to give priority to the development of systems that allow smallholder farmers to intensify production through access and appropriate use of fertilizer and other inputs as part of locally adapted ISFM practices.

ISFM practices, including the use of both inorganic and organic fertilizers, have significant potential environmental benefits, in part because they can increase the productivity of land already being cultivated and potentially reduce the amount of new land brought under the plow. Similarly, ISFM improves the physical,

<sup>3</sup> Burkina Faso, Ethiopia, Kenya, Ghana, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Uganda, Tanzania and Zambia

<sup>4</sup> ISFM entails a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at optimizing agronomic use efficiency of the applied nutrients and improving crop productivity (Vanlauwe et al., 2015)

biological and chemical properties of soils, as well as general environmental resilience.

The key challenge that AGRA's SHP has faced is how to achieve wide dissemination of existing ISFM practices, and adapt them to local conditions in commercially and environmentally sustainable ways. This challenge includes a political dimension. The potential for taking proven ISFM practices to scale – which is critical to achieving the objective of sustained improvements in household productivity and incomes – depends largely on the existence of national and regional policies that are conducive to sustainable farmer access to, and use of, fertilizers in target countries.

Household-level dissemination requires a strong, competent cadre of experts across the entire fertilizer chain. The Program has therefore also focused on both medium- and long-term research capacities in Africa, plus training for practitioners, in particular soil scientists and agronomists, extension agents, agrodealers, and laboratory technicians. These are the people who are not only the conduit of knowledge and information on inputs to farmers across the SSA region, but who also package existing technologies to suit local environmental and socio-economic conditions.

In order to achieve scale in the use of ISFM practices, AGRA's SHP supported a range of activities, including:

- 1) Value chain approaches that brought in novel approaches to agricultural finance, such as financial guarantees aimed at leveraging commercial bank lending to key actors in the input supply chain, and financial grants to innovative or nascent businesses that would improve the functioning of the fertilizer value chain;
- 2) Policy advocacy, which enabled national governments and other stakeholders to engage on policy issues regarding fertilizer quality;
- 3) Capacity building, including support for training of PhDs and MScs in soil science, as well as vocational training to laboratory technicians, extension workers, and agrodealers; and
- 4) Strengthening extension advisory services that support NGOs, farmer organizations, and other public and private organizations involved in disseminating and scaling up the use of appropriate ISFM practices that promise wide-scale impacts on smallholder productivity and incomes.

## Going Beyond Demos: AGRA's Institutional Innovation

Africa's soil health crisis cannot be addressed in isolation, or by using the traditional approach of setting up demonstration plots to show farmers how they can increase their yields through various agronomic practices. Even though demonstration plots are important for creating awareness and for encouraging the adoption of new technologies, it became clear that this approach would not lead to the scale of adoption that AGRA's Soil Health Program was targeting. In order to do that, several systemic barriers to increasing productivity and profitability had to be addressed simultaneously, and in close collaboration with AGRA's other programs and its many partners.

In practical terms, this meant designing a comprehensive initiative that would lead to:

- Greater uptake of improved seed of staple crops;
- Better access to affordable credit, to more cost-effective storage and transport services, and (especially) to input and output markets;
- Stronger farmer organizations that operate collectively, and thereby exert greater influence at various key points along the agricultural value chain; and
- Greater availability of relevant production, processing and marketing information to smallholder farmers.

This innovative and holistic approach is referred to as "Going Beyond Demos" (GBD). The GBD initiative takes a value chain approach to improving the productivity of specific crops, and involves engaging with public and private sector organizations to develop and refine input and output markets. The GBD initiative was implemented through soil health projects funded by AGRA over a 3-5 year period; these projects targeted between 10,000-50,000 farmers each (AGRA, 2014).

The GBD concept was a paradigm shift among stakeholders that helped them think outside the box to resolve the systemic problems that have held farmers back in adopting new technologies. It is meant to trigger new thinking and change mindsets among traditional practitioners as to how farmer adoption and scaling up of new technologies can best be accomplished.



## Conclusion

Catalyzing an agricultural transformation in Africa will require innovation-driven and sustainable productivity increases, combined with access to markets, affordable financing, and better policies that improve the livelihoods of smallholder farmers. Dealing with soil fertility problems typically requires farmers to adopt a technology package (as opposed to a single product) that includes improved agronomic practices together with organic and inorganic inputs.

The ISFM scale-out approach evolved from increasing farmer awareness of soil health technologies through demonstrations to building farmer organizations and linking them to affordable finance, and to agricultural input and output markets, in what became to be known as “going beyond demos” (GBD).

In scaling up and enhancing the performance of the GBD framework, issues related to gender, youth, climate change and climate-smart agriculture, sustainability, nutrition, and policy need to be incorporated into planning, design and implementation activities. The underlying principles and methods for implementing the GBD approach are referenced throughout this book, but serve as the main focus of Chapter 2.

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PRACTICE BRIEF Climate-smart agriculture

# Integrated Soil Fertilizer Management: Contributions of framework and practices to climate-smart agriculture



**Overview**  
Integrated Soil Fertilizer Management (ISFM) is a set of practices aimed at increasing fertilizer use efficiency, local production, and specific crop productivity to realize climate-smart agriculture.



**BLENDED FERTILIZERS FOR RICE**  
PKS 12-20-20-4.8 + Zn B Cu (0.3-0.2-0.2)



FERTILIZER  
CONDUCTED BY R  
OTHER PARTNER

# 2 Going Beyond Demos – An Institutional Innovation

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## Key Messages

- 1 Demonstrations of new agricultural technologies, especially when done in farmers' fields, are an effective and commonly used technique for showcasing the potential benefits of good farming practices.
- 2 “Going Beyond Demos” is an institutional innovation by AGRA which recognizes that, while such field demonstrations are a vital activity, by themselves they are not enough to produce the kind of wide-scale adoption by smallholder farmers that Africa needs to transform its agriculture.
- 3 In practice, Going Beyond Demos (GBD) is a much broader approach to encouraging adoption, one that does more than show the benefits of new technologies and addresses systemic constraints that slow farmer uptake, including:
  - Limited access to input and output markets;
  - The high cost of credit needed for buying inputs, especially fertilizers, which are very expensive in Africa;
  - A general lack of high-quality extension advisory services; and
  - Anemic or fledgling farmer organizations that are often unable to meet the needs of their members.
- 4 GBD takes a broad value chain approach in order to sustainably scale up the use of good farming practices. This requires forging strong and enduring public-private partnerships that ensure the timely availability of affordable, high-quality inputs to smallholders, as well as access to output markets where production surpluses can be converted into money in the pockets of farmers
- 5 For holistic, value chain-based approaches like GBD to be effective and sustainable, policies are needed that enhance public-private partnerships.

## Introduction

Through its Going Beyond Demos (GBD) innovation, AGRA demonstrated its commitment to improving soil health by focusing on the critical nexus between soil fertility management and productive agriculture. The need is for creating solutions and moving beyond traditional demonstrations into the realm of enabling farmers in sub-Saharan Africa (SSA) to adopt integrated soil fertility management (ISFM) practices for increased food security, good nutrition, and higher incomes.

Making this move required nothing less than a paradigm shift for the soil scientists and agronomists engaged by AGRA's Soil Health Program (SHP). They had to move out of their comfort zone and facilitate actions that address the systemic problems limiting adoption of ISFM technologies. The task required “thinking outside the box” and building public-private partnerships that could put in place the missing pieces to the puzzle. It required them to learn new techniques, to do things differently, and to take some bold risks. As is made clear in this book, the GBD approach has paid off handsomely in many countries and regions (AGRA & IIRR, 2014), and should continue to do so in the coming years.

Smallholder farmers' adoption of ISFM practices increased remarkably and so did their yields, thanks to the GBD innovation. The approach also helped agrodealers, and the fertilizer and seed companies that supply them, respond to increased demand and expand their sales of needed inputs. This positive response by suppliers and retailers was made possible through effective public-private partnerships that the GDB innovation facilitated.

In addition, GBD helped financial institutions to come up with unique credit facilities for smallholder farmers, most of whom did not even have bank accounts. The financial institutions benefited in turn, through increased engagement and turnover of loan facilities for farmers (AGRA & IIRR, 2014).

The GBD innovation also revolutionized capacity building at universities and in technical colleges dedicated to, for example, training extension staff, with students being trained to become value chain and knowledge chain practitioners and facilitators. This chapter describes how the GBD innovation was developed and operationalized, what makes it unique, and the benefits it brings to smallholder farmers in Africa.

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## Evolution of an Innovation

### Seeing is indeed believing – AGRA's Soil Health Program started with demos

As defined in Vanlauwe et al. (2015), ISFM is “a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm, combined with the knowledge on how to adapt these practices to local conditions, aimed at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed in accordance with sound agronomic principles.”

SHP embraced the definition of ISFM by Vanlauwe et al. (2015), and the Program emphasized the use of demonstration plots to create awareness and encourage adoption of ISFM technologies. Two types of demonstrations were established in collaboration with selected smallholder farmers – so-called “mother and baby demos”. The mother demos, which are usually large in size (10 square meters), are designed by researchers but managed by participating farmers. These are used to host field days, and hence act as learning centers for the community. The baby demos are smaller (usually 5 square meters) and are designed and managed by farmers themselves on their own fields after seeing the technologies used in the mother demos. Best-bet practices were demonstrated on research stations and in farmers' fields.

The demonstrations generated a lot of excitement among farmers. Remarkable yields were achieved. For example, maize yields of 5 MT/ha were realized in some farmer-managed demos, compared to their usual 1 MT/ha. In addition, the yields of pigeonpea and soybean reached 4 and 3 MT/ha, respectively, as compared to farmers' normal yields of 0.8 and 0.6 MT/ha. Farmers were very interested and began asking the hard question: how do we take these technologies to scale, on our farms and in our communities?

### Doing more and more demos was not the answer!

SHP realized that showing farmers a better way would not, by itself, result in the adoption of new practices. Farmers had been doing demos for a long time and they needed institutions and projects to help them overcome the dual problems of high cost and unreliable supply of inputs, especially fertilizers and improved seed. In addition, visits to project sites and talking with farmers and other stakeholders revealed several important realities:

- As a result, many of these stakeholders were not keen on making additional investments in demos.
- Still, the farmers who hosted demos were happy because they received free inputs and a good crop, especially if the demos were large. In fact, farmers who had not yet hosted demos were anxiously waiting for their turn to do so.
- Yet extension staff often selected those who hosted the demos, rather than community members, and that gave rise to resentment in some quarters. In addition, some demos were challenging to establish as they involved a number of treatments other than “best bet” practices.
- Farmers could not easily access the improved seeds and fertilizers being demonstrated, as they were costly or not readily available at the local village level.
- Demonstrations were still relevant, however, especially as part of farmer field days that brought farmers and service providers together, including output marketing companies, input dealers, and financial institutions.
- There was need to link all players in the value chain with what was being demonstrated if farmers were to enhance adoption and uptake.

Demonstration plots had been done in AGRA's target areas by many other organizations and projects in the past without much impact, unless other constraints were also addressed (AGRA, 2016). The problem was that farmers could not afford and/or gain access to the inputs required (AGRA & IIRR, 2014). This was particularly the case with fertilizers and improved seeds, the key components of ISFM.

Fertilizers in SSA are very expensive, costing anywhere from USD 800-1200/MT at the farmgate (Jain & Jha, 2015; Jayne et al., 2013). Due to the high cost of credit (with interest rates commonly exceeding 25% per year), most farmers could not afford fertilizer without subsidies (Hanjra & Culas, 2011; Harrigan, 2008; Kerr, 2012). Access to improved seed was often another problem (AGRA, 2014; 2016). This was especially true for soybeans and other legume crops that SHP was promoting in association with cereals. The legumes were necessary for successful scaling out ISFM practices because of their ability to capture nitrogen from the air and fix it in the soil, and the added food and nutritional security they brought to households (AGRA, 2014; 2016).

Market access was fragmented and profit margins were eaten up by high transaction costs and other factors. Farmers were often not well enough organized to take advantage of input and output market opportunities through economies of scale. Extension and other advisory

systems were often dysfunctional and farmers did not have good access to appropriate production and market information.

These realities made it clear that SHP could not stick with “business as usual” if it was to achieve its target of sustainably improving the yields of food crops produced by 4 million smallholder farmers across 13 countries<sup>3</sup> through ISFM interventions, the uptake of improved seed, and use of good agronomic practices.

To address these production and marketing challenges, the GBD approach was initiated in many cases midway through project implementation. This meant that grantees had to adopt GBD’s unique value and knowledge chain approach to improving the lives and livelihoods of smallholder farmers. The essential change was to start helping farmers overcome systemic input and output challenges that were limiting the uptake of ISFM technologies. It was no longer sufficient to show farmers a better way of doing things. It meant they had to find ways to help farmers get access to affordable credit so they could buy inputs. It meant they had to help farmers organize themselves to get better access to input and output markets, and to take advantage of economies of scale. Achieving agricultural transformation using the GBD framework required reorienting and further integrating AGRA programs that were dealing with improved seed, markets, and policy issues.

<sup>3</sup> Burkina Faso, Ethiopia, Kenya, Ghana, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Uganda, Tanzania and Zambia

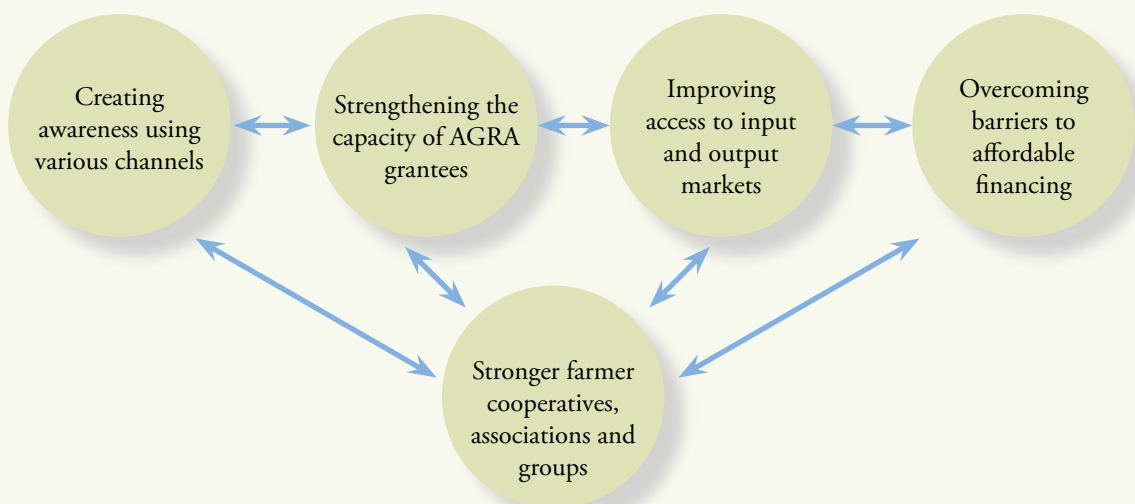
## Conceptual framework of GBD

SHP and its partners developed the GBD innovation to enhance farmer access to fertilizers, seeds and markets. This was made possible through projects that AGRA’s SHP was funding in 13 African countries that targeted between 10,000 and 50,000 farmers over 3 years, depending on the perceived level of complexity (AGRA & IIRR, 2014). Based on lessons emerging from our first year of implementation, five main interrelated interventions were identified as necessary to operationalize the GBD innovation.

As conceptualized in Figure 2.1, the GBD approach has to do with rapid uptake of ISFM technologies where the following value and knowledge chain interventions have come together well (AGRA & IIRR, 2014).

### Creating awareness using various channels

Creating greater awareness has involved the use of baby and mother demos, radio programs, videos (some of which have even been mounted on tri-cycles to reach more remote communities), lead farmers, and emerging ICT applications such as mobile phone applications (AGRA & IIRR, 2014). Although conducting demos and participatory adaptive research has played a central role in operationalizing the GBD innovation, the emphasis on baby demos was reduced in order to free resources to broker input credit facilities with fertilizer suppliers and local financial institutions. This required redesigning existing grants so that projects could address several such constraints using the value chain and knowledge chain approach.



**Figure 2.1:** The conceptual framework of Going Beyond Demos



## Strengthening the capacity of AGRA grantees

In operationalizing the GBD innovation, it became evident that there was need to strengthen the capacity of the project teams to better manage projects, the scope of which were now wider than soil fertility improvement alone (AGRA & IIRR, 2014). New requirements being placed on grantees included managing partnerships, monitoring and evaluating progress (including mapping farmer uptake of technologies), and documenting challenges faced, lessons learned, and emerging issues (AGRA & IIRR, 2014). In addition, technical backstopping of grantees was improved through strengthened country soil health consortia (see Chapter 12) to improve access to ISFM knowledge (AGRA & IIRR, 2014). Moreover, extension workers were trained and retooled through “hands-on” short-term training events and access to information through radio and print media, as well as e-extension (AGRA & IIRR, 2014). In addition, project impacts were more effectively monitored, evaluated, and documented, and subsequently better communicated to all stakeholders. This led to great improvement in monitoring progress, assessing risks, documenting lessons learned, and using those lessons to continuously to improve the GBD innovation.

## Overcoming barriers to affordable financing

In order to overcome the challenge of input financing, SHP tested many options, including:

- Out grower contractual arrangements with commercial farms;
- Contractual schemes with produce buyers that could finance farm inputs;
- Supporting agrodealers to provide inputs on credit;
- Revolving funds managed by farmer associations or by microfinance institutions that could provide farm inputs; and
- Credit guarantees through banks.

## Improving access to input and output markets

Strengthening farmer access to markets required engaging and forging strong partnerships with a number of public and the private sector organizations and agribusinesses. This process started first within AGRA itself, with the Soil Health Program working more closely with the programs that deal with constraints related to the availability of quality seed of improved varieties, access to more efficient and remunerative markets, and the development of more effective and appropriate agricultural policies. This closer collaboration took the form of project co-funding, as well as technical input into designing new projects and ongoing participation.

Sustainable partnerships with private agribusinesses were also essential, especially with growing networks of agrodealers, and with fertilizer and seed companies, to ensure that sufficient inputs of good quality were available to smallholders on a timely basis. Off-takers and aggregators of produce were also engaged to ensure that farmers had the economic incentives and the confidence needed to support adoption.

In some instances, farmer organizations were used to produce needed legume seed when seed companies could not do so. Seed companies often were not interested in producing the seed because farmers can and do recycle their seed for several seasons (AGRA & IIRR, 2014). Attempts to improve the supply of *Rhizobium* inoculum for legumes being promoted, which significantly boost yields, were made through private fertilizer companies as well as national and international agricultural research centers (AGRA & IIRR, 2014). In some cases, funding was provided to improve inoculum production and distribution, which amounted to the brokering of working capital for village-level agrodealers (AGRA, 2015; AGRA & IIRR, 2014).

## Stronger farmer cooperatives, associations and groups

Strengthening the collective efforts of farmers was deemed critical for success of the GBD innovation and taking ISFM technologies to scale. It was therefore given a great deal of effort by the project teams (AGRA & IIRR, 2014). This required expanding the support base available to project teams so that advice and guidance could be provided on: issues related to the governance of farmer associations of different types; best production practices; and marketing skills, among others. This expanded base of support was achieved largely through partnerships with other AGRA programs, and in some cases by hiring outside consultants. Farmers were involved, through their associations, to help develop practical mechanisms for repaying the more

affordable credit they were now receiving from financing institutions (AGRA & IIRR, 2014). In addition, farmer organizations took responsibility for the selection of mother demos and the hosting farmers, in addition to having an active role in managing the demonstration plots.

## Challenges and Opportunities

- 1) The 3-year duration of AGRA projects was too short to implement full value chain and knowledge chain interventions that targeted numerous farmers, and that involved many partners (AGRA & IIRR, 2014). This is particularly so in countries and regions where there is only one cropping season in a year. It takes time to organize a seed production system, for example, and this is particularly difficult for grain legumes that are not readily available from seed companies. It also takes time to put together appropriate partnerships and to build the trust among partners needed to work together. These projects should, at a minimum, be 5 to 6 years long. The “spillover” effect of a second phase project could benefit many more farmers in communities neighboring target geographies.
- 2) There can be considerable variation in the performance of the GBD approach within and across countries, depending on project leadership and the partnerships they are able to pull together (AGRA & IIRR, 2014). A lot of effort needs to be put into strengthening the capacity of project staff, including building confidence in their abilities to take on tasks that fall beyond the normal range of soil scientists! Towards this end, study tours to other successful projects have helped a great deal, as have workshops that allowed project managers and staff to exchange experiences and lessons learned.
- 3) Notwithstanding these challenges, the ‘*Going beyond demos*’ initiative has opened up new opportunities, and provided important lessons that can be applied to similar efforts (AGRA & IIRR, 2014). The main ones include: strong partnerships between institutions must be developed for the different value chain interventions to succeed; efforts to strengthen farmer knowledge of ISFM practices are essential if smallholder producers are to effectively deal with market forces; there is now a growing list of examples of “good practices” on how address challenges related to accessing inputs (including financial services) for smallholder farmers; and there is evidence of increasing commitments from governments and their development partners to improve smallholder agriculture in Africa.

## Lessons Learned

As will become evident from examples provided throughout this book, a number of important lessons have been learned about the GBD approach, including the following:

- 1) The contribution of demonstrations to the enhanced uptake of ISFM practices by smallholder farmers can be accelerated when input and output market incentives are provided along with good agronomic practices. This is an important reason why AGRA’s Soil Health Program created its flagship ‘*going beyond demos*’ initiative.
- 2) GBD is anchored by the activities of different partners, including farmer organizations, private agribusinesses, and development programs. GBD enables them to bring on board their innovations and additional resources to help link farmers to input and output markets. There is, therefore, no standardized approach. This brings with it the challenges of standardizing data collection and generating cross-site learning using similar approaches. The result is rich case studies, which in some cases have common interventions across countries and locations.
- 3) The absence of adequate supplies of grain legume seed is challenging the scaling up of ISFM practices, given that seed companies seldom market such seed. This requires exploring alternative approaches (e.g., farmer groups, public institutions, CGIAR centers) at least until demand grows to a point where private companies may be willing to engage more effectively.
- 4) The participation of women as project beneficiaries remained high (on average, over 50% of the target number of farmers), but varied from project to project. High numbers were achieved when farmer organizations were strong, and when the leadership was dominated by women. Project staff and field extension staff can and do play a big role in this process.
- 5) Microfinance institutions and warrantage systems can help jumpstart access to more affordable credit for purchasing fertilizers, which are especially expensive for most farmers. Besides funding, they provide other useful services, such as storing and selling the produce when market prices are good. Farmers can also pay for credit using produce instead of cash. However, the scope of these organizations is limited in terms of the number of farmers they can support. For the longer term, financing from banks and major financial

institutions is necessary. And for such financing to happen successfully, the facilitation role of a service provider (in this case the project team) is necessary. As the Malawi Clinton Development Initiative (CDI) case demonstrates (see Chapter 3), such facilitation includes identifying a reliable buyer of the produce, strengthening the governance of participating farmer organizations so that they can realize economies of scale in sourcing inputs and selling outputs, and ensuring that their members are financially literate and can honor contracts.

- 6) While private sector-led value chains are key to scaling up and sustaining impact, facilitation is needed to make sure smallholders are fully involved and committed. If this facilitation is lacking, private companies could quickly drop smallholder farmers from the mix because of the high transaction costs involved, especially in extension and in organizing farmers into functional groups.
- 7) Sustaining the GBD initiative over the longer term requires:
  - a) Gathering the evidence and presenting to policy makers on the impact of GDB and mainstreaming the innovation in the planning and implementation strategies of line ministries;
  - b) Policies and interventions that will support private sector adoption of the GDB approach; and
  - c) Future grant making that rests on an integrated model akin to GBD.

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# 3 Scaling Out Maize/Soybean Production Systems in Sub-Saharan Africa

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## Key Messages

- 1 Yields of maize and soybean under smallholder farmer conditions are very low (< 2 MT/ha for maize and < 1 MT/ha for soybean). This is due to diverse constraints, including low soil fertility, pests and diseases, climate change, and limited use of good agronomic practices.
- 2 With good management – including appropriate use of improved varieties, fertilizers and rhizobium inoculants – it is possible to double yields and profitability of maize/soybean cropping under smallholder agriculture.
- 3 New financing mechanisms and better, more supportive policies are needed to increase smallholder access to input and produce markets.
- 4 Strengthening of farmer advisory services (extension) is essential for effective flow of information to farmers and agrodealers.

## Introduction

On a global basis, soybean is a very important food, feed and oil crop (Hartman, West & Herman, 2011). The estimated global demand of over 300 million MT exceeds the current supply of 276 million MT (FAOSTAT, 2015). Africa has the potential to help close this demand-supply gap by expanding production and increasing

yields. In fact, less than 7% of the African cropland suitable for growing soybean is currently allocated to its production (Masuda & Goldsmith, 2009; Hartman et al., 2011; FAOSTAT, 2015). Sub-Saharan Africa (SSA) currently produces about 2 million MT of soybean per year, but production is projected to rise at annual growth rate of 7.5% per year, which would increase production to about 5 million MT by 2025 (FAOSTAT, 2015). This growth will be driven by increased demand for processed oil and animal feed in urban areas. Southern Africa, which has large areas that are environmentally similar to the South American soybean frontiers, is one of the prime candidate sub-regions for expansion (Gasparriet et al., 2015).

Increasing soybean production in sub-Saharan Africa will strengthen nutritional security in the region, as well as improve both household and national incomes. Women and children in this vast area are all too often malnourished, with their diets lacking sufficient calories and protein and/or essential vitamins and minerals. Soybean contains about 40% protein, which is comparable to the protein content of animal products and 20% higher than the protein content of common beans. By some estimates, soybean could thus be used to increase dietary protein for more than 40% of African households that currently cannot afford adequate animal protein (WHO, 2008; Hartman et al., 2011).

Soybean plants “fix” atmospheric nitrogen (N) in the soil with estimated amounts ranging from 44 kg/ha up to as high as 300 kg N/ha. This nitrogen-fixing property improves the yields of other crops that are intercropped with soybeans (grown at the same time and in the same fields), or that are grown in seasonal rotations with it (Giller et al., 2011; Sanginga et al., 2003). Other important benefits of crop rotation systems include increased organic matter, and improvement in physical and biological properties (e.g., better water infiltration and water holding capacity, and increased microbial populations and soil fauna). These rotation effects commonly result in higher yields of the following crop compared to growing the same crop on the same land season after season (Giller et al., 2011; Peoples & Craswell, 1992). For example, growing soybean in rotation with maize can increase maize yields by 0.5-3.5 MT/ha, relative to yields from cereal-cereal cropping

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4 Kenyatta University, P.O. Box 43844, Nairobi, Kenya

5 International Institute of Tropical Agriculture (IITA) c/o ICIPE, P.O. Box 30772, Nairobi, Kenya

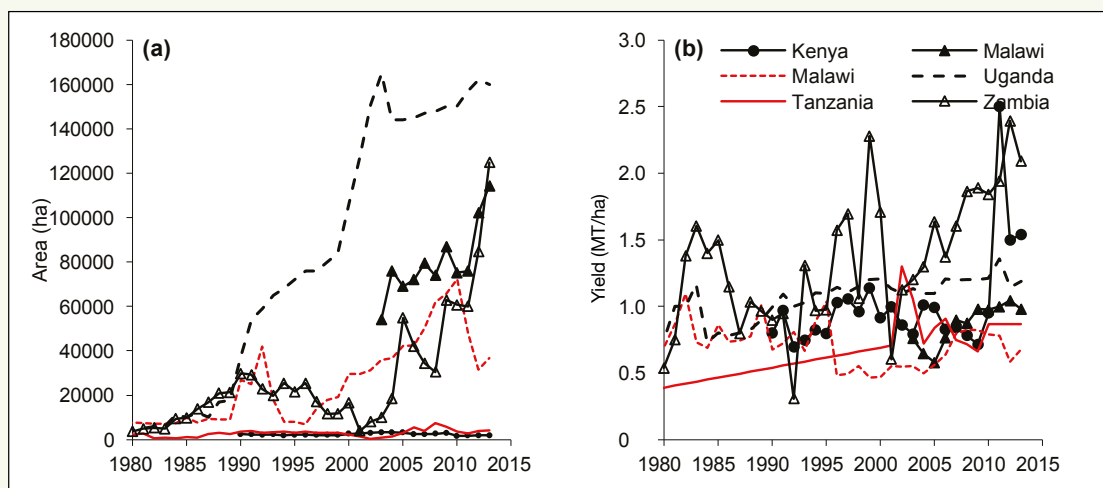
6 International Institute of Tropical Agriculture (IITA), P.O. Box 34441, Dar es Salaam, Tanzania

7 Rural Outreach Program Africa (ROP), P.O. Box 29086-00625, Nairobi, Kenya

8 Clinton-Hunter Development Initiative, Private Bag 68, Lilongwe, Malawi

9 Kenya Agricultural and Livestock Research Organization (KALRI), Kakamega, Kenya (HQ: P.O. Box 57811-00200, Nairobi, Kenya)





**Figure 3.1:** Soybean yields selected countries in sub-Saharan Africa (Data from FAOSTAT, 2015)

(Peoples & Craswell, 1992). The financial payoff of rotating maize and soybean crops can be 50-70% relative to those practicing continuous cereal cropping (Sanginga et al., 2002). Additional benefits include the control of witch weed (*Striga* spp.), a parasitic weed that constrains cereal production in much of sub-Saharan Africa (Carsky et al., 2000).

Biological N-fixation can be enhanced by inoculating soybean with rhizobium and applying 10-20 kg of Phosphorous fertilizer (P) per hectare (Sharma et al., 2011). In addition, soybean yields in the six countries shown in Figure 3.1 (as in most SSA countries) are typically less than 1.5 MT/ha, while its yield potential is over 3 MT/ha.

The SSA region could benefit considerably from soybean production. First, the crop can grow anywhere maize is grown and there is an estimated 20 million hectares of land in the region that is suitable for the production of either or both of these crops (FAOSTAT, 2010). Second, the market conditions and potential returns on farmer investments are also favorable. Demand for soybean is increasing from both the feed and food industries in most countries, and on average, soybean prices are 2-3 times higher than those for most cereal crops. Globally, soybean is the third most heavily traded crop, with almost 75 million MT traded in 2007 (Hartman et al., 2011). The prospects for either stable or increasing prices are also high due to increasing demand. Soybean cake for the expanding poultry industry, and dry seed and oil for human consumption are the dominant drivers of this growing demand.

A key challenge that must be addressed, however, is the low and variable yields of soybean under smallholder agriculture in the SSA region. For example, Rwanda produces on average less than 1 MT/ha, while Malawi produces an average of about 2.5 MT/ha (Figure 3.1). The generally poor yields in the region are due to the use of low-yielding varieties, and the limited use of fertilizers (especially P), rhizobia inoculants, and good agronomic practices (Giller et al., 2011).

In addition, knowledge about soybean production is limited among smallholders because the crop is relatively new to the region. The absence of strong farmer advisory services is a major constraint to educating farmers about the benefits of growing soybean. Maize is generally the farmers' crop of choice, because they know it well and consider it to be absolutely vital in providing food security for their households. Yet soybean holds great potential for improving soil fertility when grown in rotation with maize or as an intercrop, and it can significantly increase maize yields.

It is against this background that AGRA's Soil Health Program invested in promoting soybean production in sub-Saharan Africa's maize-based production system. This chapter details the approaches, achievements and lessons learned from these investments, and highlights the effects of soybean on soil fertility, increased productivity, improved nutrition, and household incomes.

## Target Countries

AGRA addressed constraints to soybean production in Ghana, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, and Zambia. Details on the sites used in seven of these countries are presented in Appendix 3.1; also see Table 3.1.

At least 30,000 farmers in each of these countries were targeted to benefit from strengthened extension services, improved seed, and fertilizer information. The majority of the beneficiaries were poor households unable to afford sufficient food, quality education, and health care without external interventions. Neither could the majority of these households afford to purchase the fertilizer and apply the good agronomic practices needed to significantly increase crop yields. The result: poor crop performance, food insecurity, and continued poverty.

## Approaches Used

In all eight countries, a value chain approach was taken to scale out ISFM practices for maize/soybean cropping systems. Four core interventions were implemented: 1) creating awareness about ISFM; 2) strengthening farmer organizations; 3) improving access to finance for agricultural inputs; and 4) improving access to commodity markets.

### Creating awareness about ISFM

In order to create awareness among farmers, demonstration plots were established in several sites across the eight countries between 2009 and 2013. AGRA grantees used demonstration plots to showcase the appropriate use of fertilizer and rhizobium, the use of improved soybean seed, and the application of good agronomic practices. The project used “Mother demos” and “Baby demos” adapted from the Mother-Baby trial model – an upstream participatory research methodology designed to improve the flow of information between farmers and researchers about technology performance and appropriateness under farmers’ conditions (Snapp, 1999). The Mother demos featured good agricultural practices (GAP) as well as farmer practices, and were at least 10 m x 10 m in size. Baby demos included a subset of the treatments contained in the Mother demos (usually one GAP along with farmer practices) and were small in size (5 X 5 m). In the Mother demos, comparisons were made between: i) uninoculated soybean seed planted and managed with no inputs [referred to as the “farmer practice” (FP)]; ii) uninoculated soybean seed planted with 20 kg P/ha (referred to as “P alone”); and iii) inoculated soybean seed planted with 20 kg P/ha (referred to as “P + inoculant”). Soybean was either rotated or intercropped with cereals.

Field days were organized around the demonstration plots so that farmers could learn about and evaluate ISFM practices. Grantees also trained lead farmers and private extension systems to improve advisory services. In addition, ICT-based communications practices, including local radio, mobile phones, and video documentaries were used to help create awareness and understanding.

## Strengthening farmer organizations

To facilitate the provision of needed services to farmers, projects worked with existing farmer organizations to strengthen their ability to effectively deliver information and knowledge to their members, as well as improve members’ access to input and commodity markets. Where farmer organizations did not exist, the projects facilitated establishment of new ones. Strong farmer organizations are more attractive to financial institutions than individual farmers because of the collective collateral they can offer; the loan repayment rate is also high for strong farmer organizations. Farmer groups can be very important for enhancing commercialization and marketing of smallholder crops by aggregating their produce and reducing transaction costs. In some instances for example, in central Kenya – several farmer groups came together to form larger commercial groups that coordinated the bulking and collective sale of produce. Farmer organizations were thus natural entry points for the Going Beyond Demos approach. In addition, the efforts of extension staff to provide technical assistance to farmers became more effective when they were able to work with farmer associations or cooperatives than when working with individual farmers.

### Improving access to finance for agricultural inputs

Farmers often have very limited access to credit and other financial services, and financing is often prohibitively expensive for subsistence growers. The cost of credit from commercial banks, for example, is typically in the range of 20-30% per annum, and few farmers can afford to borrow at this rate. And yet access to credit, especially for purchasing seed of improved varieties, fertilizer, and other farm inputs, is essential for transforming smallholder agriculture. AGRA’s Soil Health Program supported five different approaches to increasing smallholder access to credit, and hence to farm inputs: 1) outgrower contractual arrangements, in which commercial farms serve as “nucleus production units”; 2) contractual schemes with produce buyers to finance inputs; 3) enabling agrodealers to provide inputs on credit; 4) revolving funds managed by farmer associations or by microfinance institutions that provide production inputs; and 5) setting up credit guarantees with commercial banks.

### Improving access to commodity markets

Poor linkages to remunerative markets pose major challenges to smallholder farmers in rural areas. To address these challenges, the projects organized private sector buyers such as processors and marketers to purchase the grain.



Soybean is a good alternative source of protein for rural families and can be consumed at home in various forms. In addition, any surplus production can be sold to other consumers, as well as to agroprocessors for income. The main obstacle to direct household consumption of soybean is the need to pre-process the beans in order to denature the Trypsin enzyme they contain.

AGRA and other stakeholders invested in enhancing soybean processing and utilization by helping farmers purchase needed equipment. For example, in western Kenya, Rural Outreach Africa (ROP) bought three soybean processing machines using a USD 13,900 grant from the Kenya Commercial Bank Foundation. The machines were used to produce various products, such as flour and animal feeds, that fetched a higher price than raw soybean. Promoting utilization also involved training and demonstrations of various soybean recipes, such as soy nut and beverages. These investments in value-adding equipment helped to attract more farmers to growing soybean because of the higher profitability that comes from selling processed products. Added value margins range from 100-300% per kilogram of soybean. Women and youth benefitted greatly through new employment opportunities.

## Achievements

### Dissemination and capacity building

The AGRA Soil Health Program-supported projects successfully created ISFM awareness among more than 450,000 smallholders in the 8 focus countries – far more than the original target of 300,000 farmers (Table 3.1). This was achieved using field days organized around demos, combined with delivering key information using leaflets, posters, and radio. In addition, a total of 12,062 lead farmers and 549 extension staff were trained across

the focus countries. This was a very important milestone for knowledge dissemination because these lead farmers operate as para-extension staff and help fill the gaps resulting from under-resourced public extension systems. The current extension staff-to-farmer ratio in most African countries is about 1:1000, which does not compare favorably with the internationally recognized standard of 1:400.

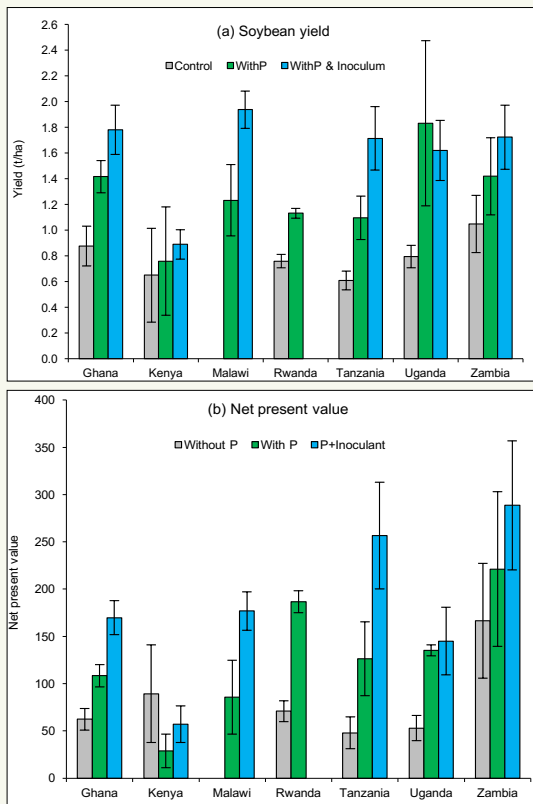
A good example of this kind of gap filling was a project in Malawi, led by the Clinton Development Initiative (CDI), which strongly depended on lead farmers for dissemination of ISFM practices. Neighboring farmers were encouraged to work in groups or “clubs” of 10-20 people, each led by a farmer identified by the group. CDI staff trained these lead farmers, who in turn trained their fellow club members. The lead farmers hosted demonstration plots that were used for field days to showcase the effects of crop rotation, good cultivation practices, the use of fertilizers, and improved varieties of soybean and maize.

### Soybean productivity

The P + Inoculant treatment produced significant gains in soybean yields and returns to investment (Figure 3.2) compared to the farmer practice across all countries except Kenya. In the case of Kenya, yields did not improve, due in part to low plant density and to moisture stress caused by a prolonged drought, especially in Embu. The poor genetic yield potential of the variety used was also a factor. The average yield increases over the control were 86% and 88% with P alone and P + inoculant, respectively. Net present values (NPVs) were positive in all countries, indicating that investments in P fertilizer and inoculant would generate profits over time. On aggregate, NPV was USD 135/ha with P alone and USD 190/ha with P + inoculant over a 5-year time horizon.

Country	Farmers aware	Farmers using ISFM	Number of lead farmers trained as advisors	Number of extension agents trained	Mother demos established
Ghana	170,800	117,000	2,612	235	529
Kenya	97,509	77,809	857	168	325
Malawi	25,384	14,164	1,348	76	120
Mozambique	22,255	11,829	173	66	232
Rwanda	39,500	24,000	4,482	15	90
Tanzania	67,200	29,945	200	36	1,054
Uganda	75,655	48,809	1,768	13	1,016
Zambia	22,197	14,302	393	12	344
<b>Total</b>	<b>520,500</b>	<b>337,858</b>	<b>11,833</b>	<b>621</b>	<b>3,710</b>

*Table 3.1. Accomplishments of maize-soybean Going Beyond Demos in eight countries (as of 2014)*



**Figure 3.2:** Effect of phosphorus and inoculants on soybean yields (MT/ha) and profitability in terms of net present value (NPV in USD/ha) across sites and years (2010-2013) in various countries; error bars represent 95% confidence limits (CL)

The value-cost ratio (VCR) across sites and seasons was greater than 2 in all cases (except in Kenya), representing more than a 100% return on the money invested in inputs (P fertilizer and rhizobium inoculant). In most cases, soybean was profitable where yields exceeded 1.5 MT/ha. This implies that if the variety being grown lacks high yield potential or does not respond to phosphorus fertilizer, producing soybean may not be profitable for smallholders. This is well illustrated by the low profitability achieved in Kenya.

In western Kenya, ROP supported dissemination and capacity building by training a total of 310 lead farmers in agricultural extension delivery, so as to help farmers select robust varieties appropriate for their locations. To ensure that farmers could get the ISFM inputs they needed – seed of well-adapted, high-yielding varieties and appropriate fertilizers – the project strengthened the capacity of 12 local agro-input dealers, enabling them to have the right inputs in stock when farmers needed them.

To sustainably address knowledge gaps about ISFM in public extension systems, AGRA has also invested in selected universities and colleges, helping to improve advanced curricula and produce training modules designed to strengthening the skills of graduate students. For example, in Tanzania three agricultural colleges (Uyole, Igurusi and Illonga) were supported by AGRA in developing ISFM extension modules for students. These modules focus on a number of advanced topics and skills, including how to establish and make the best use of demonstration plots, in order to empower extension providers with the tools they need to disseminate ISFM practices.

## Input financing

In all eight countries, farmers have limited access to microfinance services. Sixty-eight percent of the farmers that participated in projects supported by AGRA took up ISFM practices, an achievement facilitated by linking them to input and commodity markets. And to improve farmer access to inputs, the projects entered into partnerships with banks and microfinance institutions (MFIs). In Ghana, for example, a project led by Savanna Agricultural Research Institute (SARI) supported a cashless credit facility in partnership with the Center for Agriculture and Rural Development in Tamale, a local NGO that works on microcredit. This made it possible for 3,466 farmers to get loans worth USD 300,000 to buy fertilizer and seed of improved varieties at an interest rate of 12% per year. The loan repayment rate was 100% in two subsequent years. To make fertilizer more widely available, the project linked with an agrodealer network in Ghana organized by the International Fertilizer Development Centre (IFDC) so that the dealers could stock the products promoted by the project. The project trained the dealers on fertilizer types and their use, the characteristics of improved varieties, store organization, the safe handling of chemicals (such as pesticides), and how to extend knowledge to farmers. In Malawi, the Clinton Development Initiative acted as a broker between farmers and banks. The farmers raised a 15% deposit in order to qualify for a loan to pay for inputs. CDI worked with two local banks whose agents collected loan deposits and repayments. Farmers did not receive cash; instead, the loans came via agrodealers in the form of fertilizers, seed, and other inputs. The agrodealers in turn obtained their supplies from seed and fertilizer companies.

In Mozambique, agrodealers supplied inputs on a credit basis. This worked where agrodealers had previously established strong relationships with farmers and were confident that they would repay the loans. Projects supported the establishment and strengthening of farmer groups and cooperatives to enable them to access farm input loans, given that peer pressure from group members contributes to loan repayment by individuals.

These farmer groups also helped farmers to aggregate their surplus and negotiate with buyers for more profitable prices.

## Development of partnerships along the value chain

Bringing various partners together required the creation of successful relationships between the value chain actors involved in soybean production. Each of the eight country projects attempted to build such partnerships. The big challenge was to identify relevant stakeholders and partners who could commit to supporting farmers with capacity building, strengthening farmer organizations, improving marketing skills, and creating linkages between commodity and input markets.

In Zambia, the partnership effort succeeded, thanks to a great deal of partner profiling, defining of stakeholder roles, and several consultative meetings. The signing of MoUs at the beginning of the project also contributed to success. The Zambia Agriculture Research Institute (ZARI), which led the project to scale up maize/soybean production, offered ISFM technical capacity as a major strength. Still, it was imperative that they bring other stakeholders on board to help them implement the project (see box, “Partnership Model in Zambia”).

In Kenya, partnerships were strengthened through joint planning and definition of stakeholder roles. In addition, continuous consultations and sharing of project outcomes and outputs contributed to achieving objectives. This was facilitated by ROP in western Kenya, the Soy and Climbing Bean Commercialization project (SOCO) in central Kenya, and the ISFM partnership.

Another challenging aspect of the partnerships was to find buyers who were willing to enter into contracts with farmers. Most buyers cited unpredictable commodity prices as the reason keeping them from entering into contracts with farmers. Other buyers did not want to sign contracts because of farmers deciding to not honor signed agreements and selling their produce elsewhere. The absence of contracts between farmers and buyers was an impediment to farmers accessing credit. In order to overcome this challenge most projects supported processing of the produce locally. Most lending institutions have confidence to lend to smallholder farmers if there is a guarantee for selling the produce at a profitable price. In some countries, such circumstances led to the development of the anchor farm partnership model, one that is working well in Malawi.

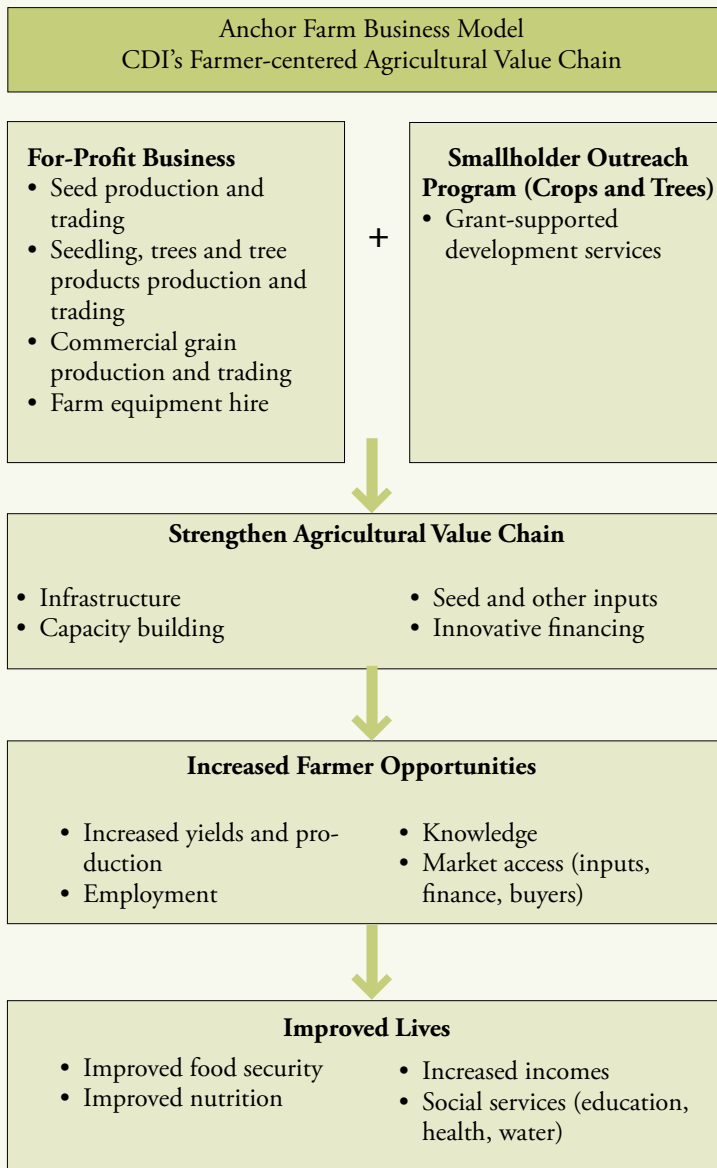
In Malawi, the Clinton Development Initiative of the Clinton Foundation began using the anchor farm business model (Figure 3.3) in 2008 in an effort to take farmers beyond demos. The for-profit anchor farm involved is a locally registered commercial farming business, known as Tukula Farming Company (TFC). TFC currently has a total of 3,166 hectares of farmland, and is owned and operated by CDI as a “social enterprise”. Part of its profits are reinvested in the business to help grow and sustain it, and the remainder is invested in target project communities to create social and economic impact, i.e., improving people’s livelihoods and prosperity, hence “anchoring” the communities.

The anchor farm provides support services to smallholder farmers, including: training lead farmers and public extension workers on ISFM and good agronomic practices to increase crop productivity; facilitating linkages to markets; and helping farmers form and strengthen farmer organizations, ranging in size from small farmer clubs of 10-20 members to much larger umbrella organizations (associations and cooperatives).

### Partnership Model in Zambia

A project for scaling out the maize/soybean value chain brought together stakeholders involved in production and in marketing. Zambia Agriculture Research Institute (ZARI) partnered with Zambian Fertilizers to ensure the supply of fertilizer; with ATS Agrochemicals to supply herbicides; and with ZAMSEED, Stewards Globe, and Indigenous Seed Company to supply seed of improved varieties. This partnership developed what is called the “Soypack”, which contains 50 kg of soybean seed, 100 kg of Soymix fertilizer, 0.7 liters of Panther® herbicide, and 125 g of rhizobium inoculant. NWK Agri-services (formerly Dunavant) marketed this product, and farmers were able to access the inputs in good time and at a lower price compared to getting them from Lusaka, 80 km away from the project area. In addition, the project partnered with such buyers as ZAMBEEF and Mt. Meru Millers to ensure that farmers had access to a good soybean market. Participating farmers signed contract agreements with these companies. In collaboration with extension providers, the project used demos, field days, radio and TV to disseminate knowledge. Using these approaches the project has successfully reached over 100,000 smallholder farmers with ISFM knowledge, out of which 21,000 are now using ISFM on at least 0.5 hectares of their land.





**Figure 3.3:** The anchor farm business model for reaching smallholder farmers

The anchor farm business model is an evolving one (Figure 3.3; also see box on Anchor Farm Model). Key partners and stakeholders in the anchor farm business model include smallholder farmers, social investors, and government agricultural extension teams and researchers, including CGIAR centers

Local farm input suppliers are also critical to making this model work: they partner with leading seed companies to grow seed for them; they work with Universal Chemicals Industries of India, which established a customized

agrodealer business called 'Farmers Hub' for supplying farm inputs in the CDI anchor farm catchment at the right price, in the right place, at the right time, and of the right quality; and they have also partnered with other agro-chemical suppliers, financial service providers, local agroprocessors; large commodity exporters; and agricultural commodity exchange platforms (such as the Agricultural Commodity Exchange Africa Ltd.) on establishing warehouse receipt systems.



## Anchor Farm Model

In 2010, CDI received support from AGRA to improve soybean and maize production by 21,000 smallholder farmers participating in the anchor farm model in Mchinji District, Malawi.

- 1) ISFM increased maize yields from an average of 1.3 to 4.6 MT/ha, and for soybean from 0.7 to 1.3 MT/ha, over the three-year AGRA project. These increases have been realized by ~40% of the beneficiary farmers. In addition, there is evidence pointing to the diffusion of ISFM practices to other smallholder farmers not directly reached by the project.
- 2) The number of farmers receiving training expanded from 168 (the baseline) to 24,088, of which nearly 50% were women. CDI's business plan is to increase the number of participating farmers to 100,000 by 2016.
- 3) A total of 8,945 hectares was put under ISFM during the AGRA three-year project period.
- 4) The project facilitated farmer access to input loans. In the 2012/13 cropping season alone, a total of 3,216 farmers obtained soybean farm input loans valued at USD 213,636 from New Building Society Bank. Of these farmers, 1,341 were women, who comprised 42% of total borrowers. Instructively, all farmers who accessed soybean farm input loans applied MEA Biofix inoculants to their soybean crop.
- 5) A total of 76 agricultural extension workers were trained on ISFM over the three year AGRA project period.
- 6) CDI anchor farms contribute significantly to the availability of improved seed, which farmers access through various mechanisms, including the government's subsidy program and agrodealer networks. For instance, in the 2013/14 cropping season, CDI anchor farms produced a total of 676 MT of seed, of which 98 MT was soybean seed.
- 7) AGRA's support for outreach to smallholder farmers strengthened the capacity of project implementation through several capacity building initiatives, increased the visibility of the CDI anchor farm project, and helped the Clinton Foundation to further leverage resources for scaling up in Malawi and replicating the model in other countries, including Tanzania (with Dutch support beginning in 2013) and Rwanda. Other new partners supporting the CDI anchor farm project include the Eranda Foundation and Innocent Drinks (UK).

## Farmer Testimonial

Divencio Chaduka is one of the farmers in the Chief Mlonyeni area in Mchinji District who has benefitted from the anchor farm model. The farmer's story:

The baseline national average yield for soybean was in the range of 0.60-0.80 MT/ha. In the 2011/12 season, Mr. Chaduka produced 22 bags (1,100 kg) from his one acre of soybeans. This yield translated to 2.75 MT/ha. From this harvest, he sold 21 bags. His total revenue was about USD 864. With a total expenditure of less than USD 120, his net farm income from soybean was over twice the GNP per capita for Malawi. Asked what he did with the money,

Mr. Chaduka smiled and said: "I improved my home with a tin sheet roof. I also bought a modern dining set. And that's not all. I used part of the money to send two of my children to school."

The tin roof means that the family can now sleep through rainy nights rather than struggling all night to keep their bedding dry. In 2012/2013 he managed to buy a motorbike from the soybean proceeds.

When asked about his future plans, Mr. Chaduka replied: "Now I know that money lies in modern soybean farming. I plan to increase the land to be planted to soybean in the next season to at least 3 acres. I want to buy livestock and open a grocery store in the future."



*Mr. Divencio Chaduka, of Gumulira Village in the Mlonyeni area, posing on the motorbike he purchased with money from soybean sales and in front of his brick home that he roofed with tin sheets bought using soybean money.*



## Lessons Learned

- 1) The approach used was instrumental in generating evidence on crop productivity and profitability and highlighted new challenges to be addressed through research.
- 2) Farmer empowerment: The lead farmer approach (when farmers were trained well) was more effective and efficient than public extension systems (e.g., in Malawi). Use of various dissemination approaches and the participation of policy makers in selected events increased awareness and use of ISFM practices. Thus lead farmers are a key driver of scaling up. However, incentives are needed to retain them in a service delivery role and sustain their status as progressive farmers in the area. The partnership between CDI and Farmers Hub tested the use of lead farmers as “commission agents”, selling farm inputs from Farmers Hub on consignment basis and receiving a commission on sales. The pilot program was successful in the 2014/15 season and is currently being scaled up.
- 3) The response to applying P fertilizer is not even across sites. Response to P on some sites was poor because of several factors, including soil type, pH, the variety used, and climate. Thus there is a need to target the application of P in soybean systems.
- 4) When productivity increases, harvesting becomes a big challenge for the majority of farmers who manually harvest. Laborsaving technologies and/or mechanization for planting, harvesting, and processing are needed for scaling-up, and service providers are required to operationalize the process.
- 5) Strengthening of partnerships in the soybean value chain is important both for research and development. Inclusion of diverse stakeholders in the maize-soybean system is essential for scaling up ISFM practices; extension staff, agrodealers, farmer groups, NGOs, and seed and fertilizer companies all need to be involved. Private sector-led value chains are key to scaling up and sustaining impact, but they need facilitation to ensure that smallholders are on board.
- 6) Resolving constraints related to the availability of rhizobium inoculant and the distribution of high-quality soybean varieties will improve use of ISFM.
- 7) AGRA investments have helped in leveraging resources from other partners, including governments, CGIAR centers, social investors, and farm input suppliers (seed, agro-chemicals, fertilizers). These resources have been in the form of cost sharing in implementing project activities, coordination, and increased communication and sharing of experiences and lessons learned. The anchor farm business model has been effective in developing partnerships, leveraging resources, promoting ISFM, and creating significant social and economic impacts, and it has robust built-in mechanisms for sustainability. This is why the Malawi government has fully embraced the anchor farm business model in its programming. It has adopted the model in its poverty and hunger initiative, and recently in the context of its export processing zone project.
- 8) Combining women, business, and employment in the ISFM project in Kenya, which was largely dominated by women farmers, provided training on soybean processing for value addition and improving nutrition at the household level. Activities and training in value addition attracted more farmers to growing soybean. Processing and marketing of soybean is also opening new employment opportunities for women and youth in areas where the crop is produced.

## Conclusions

The use of improved seeds, fertilizers and inoculant (in the case of soybean), coupled with good agronomic practices, increases the yields and profitability of maize/soybean cropping systems.

Soybean production needs to be augmented with the application of Rhizobium inoculum in order to optimize N fixation and crop yields.

Enhancing access to improved legume seed and fertilizer is critical for scaling up ISFM practices. The GBD model proved effective in reaching and encouraging a large share (at least 68%) of the target farmers to take up ISFM practices. GBD can serve as a good project exit strategy and ensure sustainability.

Financing arrangements that give farmers access to affordable credit are essential for ISFM uptake. The high cost of fertilizers and seed of improved varieties are a major limitation in many African countries. Successful partnerships along the value chain helped to reduce the cost of inputs and increase access to them.

The process of identifying relevant stakeholders and partners who can commit to supporting smallholder farmers should include partner profiling, defining stakeholder roles, and the signing of MoUs at the beginning of the project.

Finally, when farmers use ISFM practices, they are able to achieve significantly higher yields, which translate into household food and nutrition security and, when surpluses are produced, higher household incomes through marketing.

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**Appendix 3.1: Project locations across seven countries**

Country	District/site	Soil type	pH	Available N	Available P	SOM
Ghana	Bwaku	Plinthosols	5.5	0.43	4.0	1.10
	Bimbilla	Lixisols <sup>1</sup>	5.4	0.054	6.0	1.20
	Binduri	Plinthosols	5.5	0.04	7.5	0.65
	Chreponi	Lixisols	5.6	0.04	7.0	0.60
	Gushegu	Lixisols	5.7	0.04	7.0	0.60
	Karaga	Lixisols	5.6	0.04	7.0	0.60
	Kpachi	Plinthosols	4.7	0.02	4.0	0.60
	Nyankpala	Lixisols	5.3	0.045	4.0	0.90
	Saboba	Lixisols	5.5	0.43	5.0	0.70
	Salaga	Plinthosols <sup>2</sup>	5.3	0.03	4.0	0.80
	Savelugu	Plinthosols	5.3	0.05	3.8	0.90
	Talensi-Nabdam	Plinthosols	5.4	0.04	4.0	0.95
	Tolon	Plinthosols	5.1	0.04	3.0	0.68
	Wa	Plinthosols	5.2	0.03	3.5	0.85
	Walewale	Plinthosols	5.3	0.04	3.8	0.80
	West Gonja	Plinthosols	5.1	0.03	3.5	0.60
	Wulensi	Plinthosols	5.3	0.04	4.0	0.80
	Yendi	Lixisols	5.4	0.05	5.0	1.00
Zabzugu	Lixisols	5.6	0.04	7.0	0.90	
Kenya	Embu	Nitisols <sup>3</sup>	6.0	0.60	10.0	3.50
	Busia	Acrisols <sup>4</sup>	4.9	0.15	10.2	1.13
Rwanda	Gisagara	Ferralsols <sup>5</sup>	5.3	0.16	6.6	3.80
	Gatsibo	Acrisols	5.4	0.60	9.0	3.40
	Kayonza	Acrisols	5.4	0.30	9.8	3.70
	Kirehe	Acrisols	5.5	0.20	6.0	3.10
Tanzania	Bukoba	Cambisols <sup>6</sup>	5.3	0.37	12.0	2.50
	Muleba	Cambisols	5.2	0.18	12.0	1.60
	Mbinga	Acrisols	5.6	0.16	9.0	2.44
	Misenyi	Leptosols <sup>7</sup>	5.8	0.18	9.2	2.50
	Morogoro	Ferralsols	5.7	0.19	9.0	2.80
Uganda	Bulenge	Plinthosols	5.6	0.15	5.5	3.40
	Namutumba	Plinthosols	5.7	0.18	4.4	3.40
	Nsinze	Plinthosols	5.6	0.19	4.1	3.80
	Dokolo	Ferralsols	5.9	0.20	8.0	3.40
	Iganga	Plinthosols	6.0	0.19	11.0	3.30
	Kumi	Plinthosols	5.8	0.16	11.0	1.40
	Lira	Plinthosols	6.0	0.16	11.0	1.30
	Tororo	Plinthosols	6.2	0.14	6.0	1.30
	Wakiso	Plinthosols	6.0	0.12	8.0	1.80

Country	District/site	Soil type	pH	Available N	Available P	SOM
Malawi	Kasungu	Lixisols	6.0	0.04	9.0	1.20
	Mchinji	Lixisols	5.2	0.042	9.0	1.30
	Mzimba	Leptosols	5.7	0.03	5.0	0.60
Zambia	Chibombo	Acrisols	5.3	0.04	10.0	1.40
	Chipata	Luvisols	5.0	0.05	12.0	1.40
	Choma	Acrisols	5.4	0.06	11.0	1.30
	Mumbwa	Luvisols	5.5	0.07	10.0	1.55
	Mazabuka	Luvisols	5.6	0.03	12.0	1.22





# 4 Scaling Out Cereal/Pigeonpea Production Systems in East and Southern Africa

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## Key Messages:

- 1 The productivity of cereal and pigeonpea is very low under smallholder farm conditions due to low soil fertility, use of low yielding varieties, and diseases and pests.
- 2 Scaling up ISFM practices for improving yields requires a value chain approach.
- 3 Cereal/pigeonpea intercropping, coupled with the application of Phosphorus fertilizer, has the potential to increase yields of both pigeonpea and maize by at least 50%.
- 4 Enhancing access to improved legume seed through innovative seed production and delivery is critical for technology dissemination.

## Introduction

Pigeonpea is one of the most important grain legume crops in sub-Saharan Africa. It is typically intercropped or rotated with such cereals as maize and sorghum, and contributes to food and nutritional security for about 6-7 million smallholder farmers – and more specifically for women farmers in Eastern and Southern Africa (ESA). Women farmers often refer to pigeonpea as ‘our beef’, a reference to the crop’s high level (18-26%) of easily digestible protein; pigeonpea is also rich in calcium, magnesium and potassium, and thus helps in controlling malnutrition in children. However, pigeonpea consumption varies according to local preferences. Pigeonpea farmers in Kenya market about 62% of their dry grain and about 10% of the fresh peas harvested are

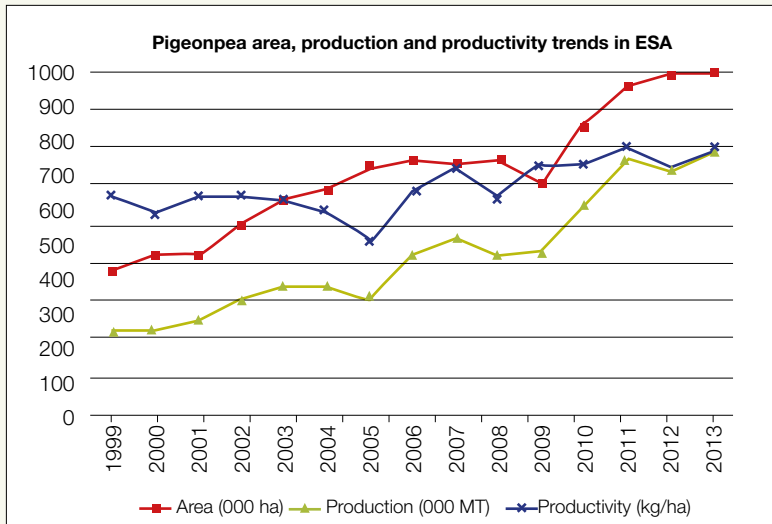
marketed (Shiferaw, 2008). In southern Malawi, households consume 65% of the pigeonpea produced (Orr et al., 2015). In Tanzania, 35% of the total production is consumed on-farm (Lo Monaco, 2003), but a good share of the surpluses produced find its way to market. The crop’s capacity for generating cash income has enabled thousands of farmers to purchase farm animals and diversify production, thus spreading risk and increasing profits.

Pigeonpea is a drought-tolerant and climate-resilient crop, thanks to its deep root system. In addition, pigeonpea improves soil fertility through high biomass productivity and soil nutrient contribution. It has the ability to fix up to 235 kg/ha of atmospheric nitrogen (Peoples et al., 1995), which is more than for many legumes. In maize/pigeonpea intercropping systems, the amount of biologically fixed N (BNF) ranged from 37-117 kg N/ha/year in Malawi and 6-72 kg N/ha/year in Tanzania (Adu-Gyamfi et al., 2007). Although a lot of this fixed N leaves the field with the harvested grain and fuel wood, about 30-40 kg/ha is left in the soil, which can benefit companion or succeeding crops. A study in Tanzania (Myaka et al., 2006) demonstrated that the yield of unfertilized maize/pigeonpea intercrop generally equaled the yield of moderately fertilized maize when grown on its own. The litter fall, which under a good pigeonpea stand could be 1-2 MT/ha, plays a significant role in the recycling of nutrients and improving soil organic matter. Pigeonpea also provides fodder/feed for livestock, as well as fuel wood (Adu-Gyamfi et al., 2007)

The value of pigeonpea to household energy needs can be significant, providing as much as 3 MT of fuel wood under good management practices. Pigeonpea production has been successfully integrated with energy-saving stoves in Malawi, and this has reduced the frequency of buying and collecting fuel-wood (Orr et al., 2015). This can cut the time women and children must spend looking for fuel wood and also help reduce deforestation.

Over 98% of pigeonpea production in Africa takes place in Malawi, Mozambique, Tanzania, Uganda and Kenya, which together have about 990,000 ha under the crop (Figure 4.1). India is the biggest pigeonpea trading partner for ESA, purchasing over 90% of the exported grain (with an estimated market value of USD 300-350 million). India generates an annual demand for pigeonpea of about 3.2 million MT, but produces only about 2.7 million MT locally, leaving a shortfall of about 500,000 MT.

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**Figure 4.1:** Trends in the area of pigeonpea harvested, production and productivity in Eastern and Southern Africa (ESA)

The yields achieved by smallholder farmers are typically under 1.0 MT/ha. These yields can, however, be raised to 1.5 to 2.5 MT/ha under improved management. In order to optimize production, ESA farmers need to use P fertilizer, coupled with high-yielding varieties that are resistant to fusarium wilt disease.

Maize is the most important cereal crop in East and Southern Africa (ESA), occupying 75% of the area under cereal production. The crop provides more than 50% of the calories consumed by ESA residents, and in Malawi and Kenya per capita maize consumption is among the highest in the world – 100 kg/year and 94 kg/year, respectively (Smale & Jayne, 2003). Despite its importance, average maize productivity is very low among smallholder farmers (~1.2 MT/ha) compared to yields of 6-7 MT/ha on commercial farms. Low soil fertility and the limited use of fertilizers and improved varieties contribute to this low productivity.

Sorghum has also become a significant cereal in the region due to its adaptability to drought. It is the fifth leading cereal in terms of global production, and an increasingly important coarse grain cereal crop in rainfed semi-arid areas (Pushpamma, 1993; Dendy, 1995).

## Objectives and Scope

AGRA's Soil Health Program (SHP) has invested in closing the yield gaps of maize/pigeonpea-based cropping systems in Tanzania, Malawi, Mozambique, Uganda and

Kenya, beginning in 2010. Each country implemented one project, except for Mozambique, which implemented two. All projects focused on improving the productivity of pigeonpea through P microdosing, good agronomic practices, and the use of improved varieties. The projects also linked pigeonpea farmers to output markets. Altogether, these initiatives aimed to reach at least 150,000 smallholder farmers, and were backstopped by ICRISAT to ensure that farmers planted improved varieties and used good agronomic practices. This chapter highlights: the approaches that the six projects used to scale up pigeonpea intercropping with maize and sorghum; the yields and economic benefits realized from various interventions; testimonies from project beneficiaries; and the main challenges faced and lessons learned.

## Site Descriptions

The sites in Kenya, Uganda, and Tanzania are characterized by a bimodal annual rainfall cycle with the major rainy season (the long rains) occurring during March to June, followed by the short rains during October to December. In contrast, Mozambique and Malawi are characterized by a unimodal rainfall pattern (annual rainfall of 500-1200 mm) and a single growing season from November to April, followed by a dry season that lasts for seven to eight months (Table 4.1).



**Table 4.1:** AGRA project sites with soil types, rainfall and agro-ecologies

Country	Region/Province	Districts	Soil type	Rainfall (mm)	Agro-ecology
Kenya	Eastern Kenya	Nzau, Kathonzweni	Sandy loam	500-800	Semi-arid
Mozambique	Manica	Manica, Vanduzi Sussundenga, Barue	Red clay loam	800-1200	R10, R4, R6*
	Tete	Angonia, Moatize Tsangano	Yellow clay loam	600-1200	R10, R6, R7*
	Sofala	Gorongosa	Yellow clay loam	800-1200	R4*
Tanzania	Arusha	Arumeru	Clay loam	500-1300	Sub-humid
	Dodoma	Kondoa	Red loam	300-800	Semi-arid
	Kilimanjaro	Hai, Siha, Moshi	Deep volcanic	400-1200	Sub-humid
Malawi	Central region	Lilongwe, Salima, Kasungu	Red-clay loam	500-1100	Semi-arid
Uganda	Northern region	Apac, Oyam, Gulu, Amuru	Red-clay loam	800-1200	Sub-humid

\* Agro-ecologies: R4 = mid-elevation; R6 = Dry semi-arid; R7 = interior central and North; R10 = High altitude

## Approaches Used for Going Beyond Demos

### GBD with improved finance, input supply and marketing

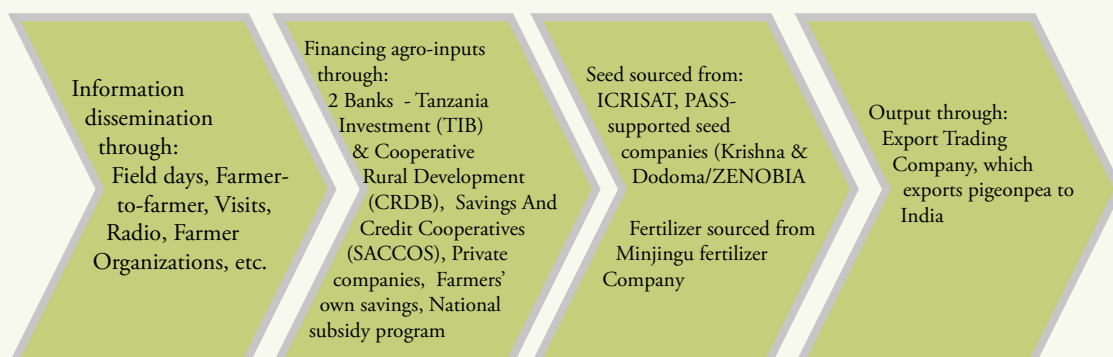
The approach used by the projects to scale up maize/pigeonpea technologies involved Going Beyond Demos (GBD) described in Chapter 2, and entailed four core interventions: 1) providing ISFM knowledge; 2) increasing access to finance for purchasing fertilizer and improved seed; 3) establishing or strengthening farmer organizations; and 4) improving smallholder access to commodity markets. The Tanzania project, for example, involved extensive sensitization (using field days and news media) and the formation of facilitation teams responsible for extending agronomic support to farmers, increasing fertilizer use, and strengthening

seed production systems. To enhance the availability of improved inputs, the project engaged with those involved with the national input voucher system, agrodealers, farmer associations, and seed companies; it also negotiated better access to credit through village banks, both by way of farmer cooperatives and using farmers' own resources (Figure 4.2).

### Demonstrations for informing farmers

Sorghum/pigeonpea<sup>7</sup> demonstrations were established in Kenya during 2012-2014 on 85 farms in two districts of Makeni County. The demonstrations showcased sorghum/pigeonpea intercropping with four different levels of nutrients: 1) full fertilizer rate (20 kg P/ha); 2) half-fertilizer rate (10 kg P/ha); 3) farmyard manure, applied at 5 MT/ha; and 4) the control, which represented no added nutrients. Maize was top-dressed

<sup>7</sup> cv Mbaazi 2, an indeterminate variety of 220 days to maturity



**Figure 4.2:** Going Beyond Demos model for scaling up pigeonpea in Tanzania



with nitrogen at 60 kg/N/ha in all treatments except the control. Di-Ammonium Phosphorus (DAP) fertilizer was used as a source of P, and urea as the source of N.

In Tanzania, 430 on-farm demonstrations were implemented across 7 districts during the 2010-2012 period. This project demonstrated the benefits of maize/pigeonpea intercropping and the application of P to pigeonpea. The demonstrations involved four treatments: 1) maize/pigeonpea intercropping without fertilizer as representative of the farmers' practice; 2) maize/pigeonpea intercropping with P supplied from DAP; 3) maize/pigeonpea intercropping with P supplied from Minjingu granular (a locally produced P fertilizer); and 4) maize/pigeonpea intercropping with P supplied from Minjingu Mazao (a phosphorus fertilizer blended with 10% nitrogen). For maize, 60 kg/ha of nitrogen was top-dressed (using urea as the source). The P was applied at a rate of 20 kg/ha. The pigeonpea variety used was Mali (ICEAP 00040), which is a long-duration maturing variety.

In Mozambique, project demonstrations were conducted during 2012-2014 in Angonia, Barue, Gorongosa, Moatize and Tsangano districts using pigeonpea<sup>8</sup> and maize<sup>9</sup>. The treatments were: 1) maize with full fertilizer [250 kg/ha of NPK (12-24-12) + 150 kg/ha of urea (46%)]; 2) maize with half-fertilizer (125 kg/ha of NPK + 75 kg/ha of urea); 3) maize intercropped with pigeon pea; 4) maize after pigeonpea (rotation); 5) pigeonpea alone; and 6) maize alone with no fertilizer applied (control).

In Malawi, the demonstrations that were implemented compared five treatments or cropping systems: 1) maize alone; 2) pigeonpea alone; 3) within-row intercropping of maize and pigeonpea; 4) strip planting maize and pigeonpea at a ratio of 2:1; and 5) planting pigeonpea on the foot of ridges planted with maize. The within-row spacing of 90 cm x 90 cm was included as a

farmer practice – the prevailing recommended spacing of intercropping. The pigeonpea variety used was of medium duration (ICEAP00557).

Field days were organized around the demonstration plots at all project sites, and farmers came to learn about and evaluate the demonstrated ISFM approaches and good agronomic practices. The projects also trained lead farmers and private extension systems to improve advisory services to fill extension gaps. In addition, the use of ICT-based communications was also promoted, including radio, mobile phones, television, and video documentaries.

## Data collection and analysis

Data was used to identify trends, and for economic analyses (partial budgeting, cost-benefit analyses, and sensitivity analyses). The key sources for additional secondary data included the FAOSTAT database (FAOSTAT, 2015).

## Achievements

### Dissemination and capacity building

The AGRA-supported projects managed to successfully create awareness among 122,468 smallholders out of the target of 150,000, representing an 82% reach (Table 4.2). This was achieved using various approaches, including field days organized around demonstrations, leaflets, posters, and radio. These results are in line with the findings from a survey conducted by the Natural Resources Institute (UK) that showed high levels of awareness about various good agronomic practices, including the use of inorganic fertilizers and legumes to improve soil fertility, particularly among beneficiary households targeted by AGRA's Soil Health Program. Of the farmers who were aware of the technologies, about 71% took up one or more good agronomic practices. The projects provided training to lead farmers, in addition to extension agents, enabling them to fill the knowledge gaps resulting from the under resourcing of extension, a common scenario in many sub-Saharan African countries.

<sup>8</sup> cv ICEAP 0557 intermediate maturity

<sup>9</sup> cv PAN 53, short to intermediate maturity

**Table 4.2:** Uptake of improved maize-pigeonpea technology

Country	Farmers aware of technology	Farmers using technology	Lead farmers trained	Extension agents trained	Mother demonstrations established
Tanzania	27,880	18,000	1,080	350	430
Malawi	30,000	21,872	56	609	160
Kenya	17,058	14,750	375	79	85
Uganda	14,000	3,350	245	59	134
Mozambique	33,530	22,820	537	61	385
<b>Total</b>	<b>122,468</b>	<b>80,792</b>	<b>2,293</b>	<b>1,158</b>	<b>1,194</b>

## Yields and profitability of cereal/pigeonpea systems

Tables 4.3-4.6 show fertilizer responses and profitability trends across the target countries. In Tanzania, maize yields were 32% higher with intercropping compared with maize alone when fertilizer was applied, 75% higher with N and P applied compared to no fertilizer, and 50% higher with a Minjingu rock phosphate product applied compared to no fertilizer. Intercropped pigeonpea yields

were as much as 260% higher with the application of N and P compared to using no fertilizer, and 143% higher with the application of a Minjingu rock P product compared to no fertilizer (Table 4.3). Similar trends were observed for Kenya (Table 4.4) and Mozambique (Table 4.5). Benefit cost ratios and net present values indicate that intercropping pigeonpea with cereals and applying at least half of the recommended fertilizer gives comparable returns to investment as fully fertilized sole maize (Table 4.3 and 4.5; Appendix 4.1).

**Table 4.3:** Effect of fertilizer in maize/pigeonpea intercropping in Tanzania

Treatment	Maize yield (MT/ha)	Pigeon pea yield (MT/ha)	Benefit-cost ratio
Intercrop, no fertilizer	2.0	0.35	1.05
Intercrop + DAP	3.5	1.26	1.75
Intercrop + Minjingu granule	2.9	0.74	1.32
Intercrop + Minjingu Mazao	3.1	0.97	1.52
Maize alone + fertilizer	2.4	NA	1.37

**Table 4.4:** Effect of fertilizer in sorghum/pigeonpea intercropping in Kenya

Treatment	Pigeonpea yield (MT/ha)	Sorghum yield (MT/ha)	Benefit-cost ratio
Intercrop, no fertilizer	0.90	1.23	1.27
Intercrop + full fertilizer	1.19	2.10	1.41
Intercrop + half fertilizer	0.97	1.92	1.40
Sorghum alone, no fertilizer	NA	0.68	0.53
Sorghum + full fertilizer	NA	0.86	0.49
Sorghum + half fertilizer	NA	0.76	0.50

**Table 4.5:** Effect of fertilizer in maize/pigeonpea intercropping in Mozambique

Treatment	Maize yield (MT/ha)	Pigeonpea yield (MT/ha)	Benefit-cost ratio
Control	1.82	0.25	1.0
Intercrop + Full fertilizer	3.17	1.38	1.1
Intercrop + Half fertilizer	2.62	1.30	1.4
Maize alone + Full fertilizer	3.27	NA	0.7

Across sites in Malawi, maize intercropped with pigeonpea produced slightly lower yields than when grown alone (Table 4.6). However, gross incomes were higher under intercropping.

**Table 4.6.** Grain yield (MT/ha) and gross incomes (USD/ha) from maize-pigeonpea cropping in Malawi

Treatment	Maize yield	Pigeonpea yield	Gross income (USD)
Maize alone	4.74	n.a.	802.3
Pigeonpea alone	NA	0.41	186.8
Within-row intercrop	3.27	0.36	773.0
Strip cropping	3.98	0.17	820.3
Pigeonpea on maize ridge	3.82	0.35	869.5

On aggregate, net present values over a 5-year period were: USD 134/ha with intercropped maize receiving the recommended fertilizer; USD 104/ha with intercropped maize receiving half of the recommended fertilizer; and USD 5/ha with intercropped maize grown without fertilizer. Sensitivity analyses indicate that use of the recommended dose of fertilizer in intercropping will continue to be profitable even if maize and pigeonpea prices fall by 10%.

Applying fertilizers substantially improved cereal and pigeonpea yields across the sites used by the AGRA-funded projects. However, it is important to note that using half of the recommended fertilizer improved maize yields almost as much as the fully fertilized treatment – pointing to a better option for farmers. This is particularly important to resource-poor farmers, who can still achieve a high benefit-cost ratio (BCR) without investing in the fully fertilized treatment. Cereal/pigeonpea intercropping and/or rotation are the most effective sustainable crop intensification options available for the semi-arid agro-ecologies of ESA. Integration of legumes into cereal-based cropping systems (through intercropping or rotation) helped to improve maize yields by 20-50%.

Phosphorous microdosing for pigeonpea significantly increased productivity, which was expected because P is deficient in many parts of East Africa (Sánchez, 2010; Vanlauwe et al., 2015) and its omission has been shown to depress the attainable yields of maize by 1.0-1.7 MT/ha (Kihara et al., 2015). In addition, P fertilizer is crucial for growth and N fixation in legumes, and the fertilizer applied on maize and sorghum may have also benefitted the pigeonpea. The increase in yields is expected to diversify food and income sources for households, which is critical in this era of climate change. When one crop fails, farmers can rely on the second crop. An additional benefit of intercropping with pigeonpea is the wood biomass it produces, which can be used as a domestic energy source and lessen the drudgery that women and girls face in fetching firewood.

## Community level seed systems (institutionalized revolving seed practices)

The challenges of accessing seed from companies led the projects to come up with innovative ways of multiplying seed. One of the successful models stories in seed delivery systems comes from Mozambique (see box: “Pigeonpea revolving seed approach in Mozambique”).

Most of the time seed companies are reluctant to produce pigeonpea seed because farmers often just plant seed saved from previous harvests. This makes the informal seed sector particularly important for legumes such as pigeonpea. Over the years, ICRISAT has invested in the development of informal legume seed systems, i.e., developing “Quality Declared Seed” systems for various legumes, which has facilitated farmer access to legume seed of reasonable quality when needed. AGRA, on the other hand, has worked to develop the formal seed sector, mainly through investments in private seed companies (start-ups as well as existing businesses). These investments have led to the production of 475,805 MT of certified seed by African-owned and operated companies, a significant increase over the 2,400 MT being produced when AGRA was started (AGRA, 2015). These investments were made simultaneously with the development of agrodealers, which are instrumental to ensuring that certified seed reaches farmers.

## Access to farm input financing

The high cost of fertilizer (over USD 800/MT in many rural areas, if it is not subsidized) requires appropriate financing mechanisms in order for smallholder farmers to access it. The AGRA-supported projects explored a range of different approaches, organizing farmers into groups and working with agrodealers and/or microfinance institutions to increase farmers’ access to needed inputs (fertilizers and improved seeds).

### Successful Model: Pigeonpea Revolving Seed Approach in Mozambique

A revolving seed approach was introduced in Mozambique, under which each participating farmer received 5 kg of pigeonpea seed (cv ICEAP 00557), which is enough to plant at least 0.4 hectares. After the harvest, farmers returned twice as much seed as they started with, to be made available to other farmers. At the end of three years, the number of farmers using seed of improved varieties increased from zero to 12,000. More than 90% of the farmers receiving seed were able to return

twice as much as they had received, benefiting other farmers during the next cycle. This approach gave a “first time” opportunity to farmers to use seed of an improved variety, instead of local saved seed of low productivity. However, over time special attention should be paid to the quality of seed being revolved. Still, this approach is working well and represents an innovative way to strengthening seed delivery systems at the community level.

## A Tanzanian Success Story

In Tanzania, the AGRA-supported project reached 30,000 farmers (40% being women) with new pigeonpea technologies. More women are picking up the pigeonpea crop because it helps solve important household problems: food and nutritional security, the need for cash income, and the need for fuel wood.

Yulia Sehaba, in Kilosa District, Tanzania, is a farmer who has benefitted from a pigeonpea project implemented in the Morogoro Region by Selian Agricultural Research Institute (SARI), in



collaboration with Ilonga ARI and with support from AGRA. The project built on efforts by previous partners, such as ICRISAT, which supported the breeding of improved pigeonpea varieties. Yulia is 60 years old and married with 3 children. She fully depends on agriculture for the livelihood of her family. Through adoption of improved pigeonpea and ISFM practices, she managed to nearly triple her pigeonpea yield, from 500 kg/ha to 1,300 kg/ha. As a result, she says her income has increased and food security has improved. She has used some of her extra income to buy dairy cows and goats that provide additional income and help sustain her household.

In Tanzania for example, the project strengthened linkages among farmers, agrodealers, SACCOs, and financial institutions. However, the lenders required farmers to have an established market for their produce. The project therefore partnered with Export Trading Group (ETG) as the key grain buyer, as well as with other actors in the maize/pigeonpea value chain. ETG also provided seed and fertilizer to farmer groups in contractual arrangements where farmers who received the inputs sold their grain to ETG. In addition, about 18,000 farmers benefited from subsidized inputs through the government's subsidy program.

In Mozambique, one of the projects developed a revolving fund that helped 900 farmers to access fertilizers. However, the rate of repayment was less than 30%. This low repayment rate was due to the fact that a public institution led the project and inputs were directly distributed to farmers, who tended to see the inputs as free government support. The lack of private sector engagement in the revolving fund also obviously contributed to its poor performance. As a result the revolving fund was discontinued.

In Malawi, high interest rates on loans (30-40%) totally prevented the farmers from getting loans. The project thus used a revolving seed approach to help the farmers' access improved cultivars, and fortunately farmers were also able to access government-subsidized fertilizers.

## Access to commodity market opportunities for pigeonpea

Information on market opportunities and pigeonpea value chains as a whole is needed, particularly on how smallholder producers can access commodity markets and how local processors can create entrepreneurial opportunities that contribute to the emerging end-user markets for pigeonpea in the country, the region, and abroad. Almost all pigeonpea produced in ESA is marketed within the region and abroad (e.g., as mentioned earlier, in India) thanks to a network of intermediaries and informants. These intermediaries include agrodealers that received special training in agribusiness, and local financial institutions that provide financial support (credit). In order for farmers to get fair prices, farmer groups in all countries were trained in collective action and joined forces in producer-marketing groups (PMGs). These PMGs resulted in the delivery of better products, which in turn commanded price premiums of 25-40%. Large traders, such as Rab, Transglobe, ETG, and Mulli Brothers, are buying grain for export to India and Europe. Recently, there has been a trend towards value addition through making and marketing dhal, and 12 such value-adding processing plants are now operating in ESA.



## Lessons Learned

- 1) Innovations in seed systems, such as revolving seed, play a significant role in ensuring that farmers have access to improved seed. Legume seed production is usually not an attractive venture for seed companies, especially where there is limited demand due to a lack of awareness among farmers. The revolving seed approach could also be a conduit for popularizing the use of improved varieties, which could lead to greater demand and eventually entice seed companies to produce certified seed.
- 2) Microfinance institutions can help jumpstart access to finance for fertilizers, especially those that are too expensive for most farmers. However, for this to happen, facilitation by a service provider (in this case the project team) is necessary. This facilitation includes, as the Tanzania case demonstrates, identifying effective and affordable financing mechanisms, such as local banks and SACCOs, engaging with reliable produce buyers, and strengthening farmer organizations to increase their efficiency and economies of scale in sourcing inputs and accessing commodity markets, as well as ensuring that their members are financially literate and willing to honor contracts.
- 3) While private sector-led value chains are key to scaling up and sustaining impact, smallholder participation in them needs to be facilitated. Experience has shown that if external efforts to organize farmers into functional groups are inadequate, smallholder participation in such value chains may fail because of high transaction costs.

## Conclusions

Maize/pigeonpea intercropping, coupled with P fertilizer application, increased yields of both pigeonpea and maize by at least 50% across all project sites. These results have important implications for household food security, especially in years of failed rains – an increasingly common phenomenon due to climate change. Farmers practicing cereal/pigeonpea intercropping harvest two crops. Additionally, a surplus of one MT of maize and one MT of pigeonpea can boost household financial returns by about USD 1,000/year.

GBD is critical to scaling up good agronomic practices (GAP) and enhancing access to improved legume seed and appropriate fertilizers. The AGRA supported projects in ESA led to at least 70% of participating farmers taking up ISFM practices and GAP, which is far above the typical adoption rate of 20-30%, especially in the first three years. Innovative financing measures that enable farmers to access affordable credit are essential

for technology uptake. For wide-scale adoption and the realization of benefits from cereal/pigeonpea intercropping, government policies need to support farmer access to seed of improved pigeonpea varieties, fertilizers, and profitable markets. Policy makers should support farm input subsidies and/or financial services for smallholders, especially if linked with the private sector in a public-private partnership fashion.

Finally, while improved production systems could potentially reduce the effects of drought, these systems need to be supplemented with other measures, such as weather-indexed crop insurance. Extension-based interventions that enhance farmers' soil and water management skills also need to be scaled up.

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**Appendix 4.1:** Net present values and benefit-cost ratios (BCR) for intercropping with and without fertilizer

Country	Cropping	N	NPV-5 year	BCR
Aggregate	Maize alone + Full	355	-53.7 (-71.8 – -35.60)	1.0 (0.9 – 1.1)*
	Intercrop + 0	145	5.2 (-11.4 – 21.8)	1.1 (1.0 – 1.2)*
	Intercrop + Half	124	104.7 (48.3 – 161.1)	1.4 (1.2 – 1.5)
	Intercrop + Full	454	133.7 (118.4 – 148.9)	1.5 (1.4 – 1.6)
Mozambique	Maize alone + Full	222	-133.9 (-156.0 – -111.7)	0.7 (0.6 – 0.8)*
	Control	110	4.5 (-16.7 – 25.8)	1.0 (0.9 – 1.2)*
	Intercrop + Full	41	53.9 (-1.0 – 108.7)	1.1 (1.0 – 1.3)*
	Intercrop + Half	27	104.7 (48.3 – 161.1)	1.4 (1.2 – 1.5)
Tanzania	Intercrop + 0	127	9.4 (-7.7 – 26.5)	1.1 (1.0 – 1.1)*
	Maize alone + Full	133	80.1 (68.2 – 92.1)	1.4 (1.3 – 1.4)
	Intercrop + Full	384	142.2 (126.5 – 157.8)	1.5 (1.4 – 1.6)
Kenya	Intercrop + 0	12	80.9 (-21.3 – 183.1)	1.3 (0.9 – 1.6)*
	Intercrop + Half	12	139.1 (47.8 – 230.3)	1.4 (1.1 – 1.7)
	Intercrop + Full	12	162.6 (67.1 – 258.1)	1.4 (1.2 – 1.7)

\* When the 95% CI encompasses 1, BCR is not significantly different from 1 and thus the intervention is unprofitable





# 5 Taking Fertilizer Microdosing to Scale in the Sahel

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## Key Messages:

- 1 Fertilizer microdosing, coupled with inventory credit schemes, is a promising strategy for increasing fertilizer use by smallholder farmers.
- 2 While farmer awareness of microdosing is critical, the poorest farmers need enabling conditions to adopt the practice.
- 3 Microdosing with both mineral and organic fertilizers can help sustain crop productivity and soil health.
- 4 Scaling up fertilizer microdosing could sustain farmers' resilience to climate change.

## Introduction

The semi-arid regions of West Africa are characterized by low and stagnating agricultural productivity resulting from declining soil fertility, low and erratic rainfall, and limited use of inputs, especially fertilizer and improved seeds. If farmers are to benefit from the high yield potential of improved seeds, however, restoring soil fertility is critical. Farmers in sub-Saharan Africa (SSA) have long disregarded recommended fertilizer rates, not only because recommended rates are generally too high, but also because fertilizers are expensive and often not available when and where they are needed. Blanket fertilizer recommendations fail to consider rainfall uncertainties in drought-prone areas. Furthermore, they do not reflect any variability in farming objectives, the focus of smallholder farmers on achieving food security with limited resources and at minimal risk, and relative returns and opportunity costs.

In the Sahel, average yields of most food crops are often low, less than 500 kg/ha. To address the problem of low fertilizer use in the region, “microdosing” was developed as a way to increase fertilizer use efficiency and reduce costs to resource-poor smallholders, thereby increasing crop growth and productivity (Bationo et al., 1998; Twomlow et al., 2011). This approach emerged from collaborative research efforts between various national and international agricultural research institutions operating in the region. Microdosing involves the application of small amounts of fertilizer, usually about 60 kg/ha for compound fertilizer (NPK) or 20 kg/ha of DAP, placed in the planting hole at sowing or at the base of the plants two weeks after planting, instead of the conventional method of broadcasting, which often results in fertilizer being unevenly spread in the field.

Studies have shown that fertilizer microdosing can increase crop yields by 43-120% (Tabo et al. 2007; Ibrahim et al. 2015). The concentration of nutrients in the rooting zone helps the plants' roots to grow more quickly and profusely, which in turn helps plants to capture more of the native soil nutrients (i.e., those not added with the application of fertilizer during the current season). This more vigorous rooting also helps to counteract late-season drought (Ibrahim, et al. 2015) and adapt to climate variability. Cost-benefit ratios of 8-9 have been recorded when microdosing was used on millet and sorghum, i.e., every dollar invested returns between USD 8.00 to 9.00 to the farmer (Tabo et al., 2007). The combination of these effects significantly increases both the agronomic and the economic efficiency of nutrient and water use, and consequently, raises crop grain yields.

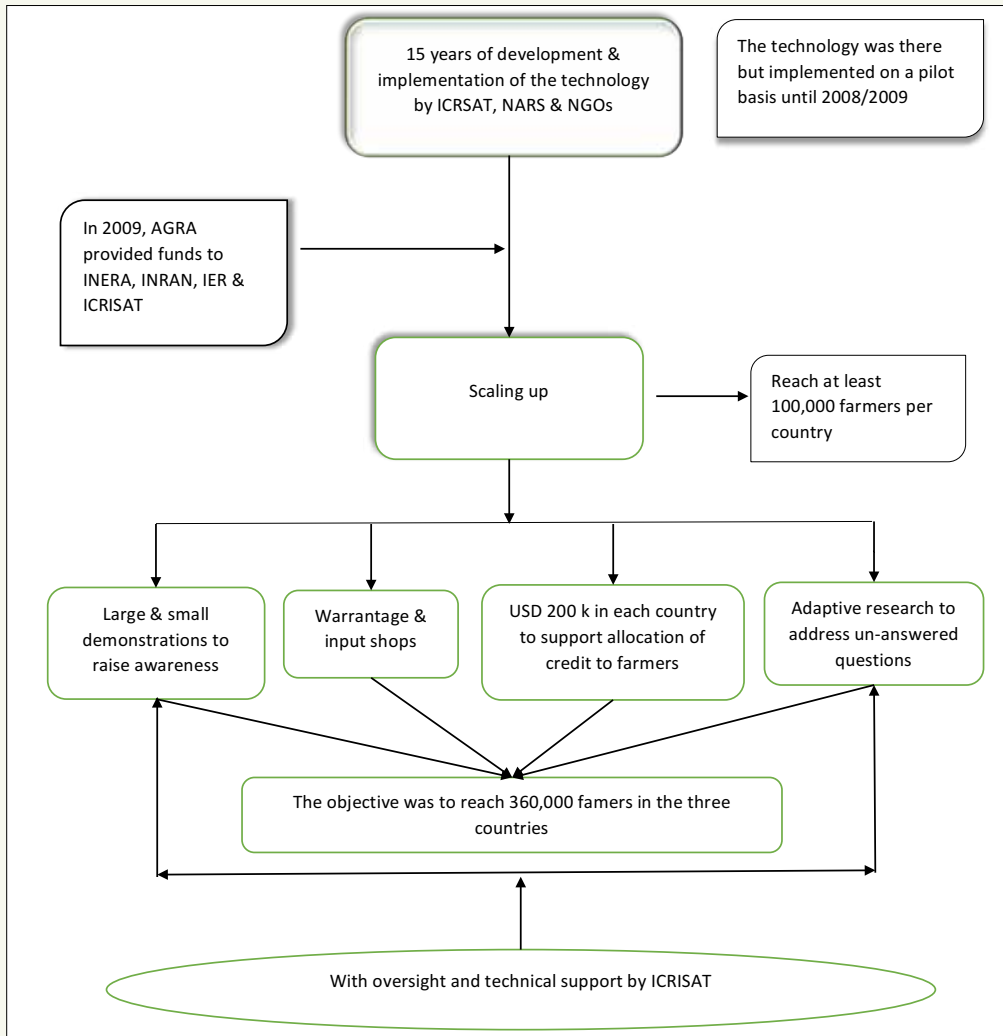
The successful application of microdosing technology requires an average rainfall of 400-600 mm in the Sahelian zone and 600-900 mm in the Sudanian zone. If microdosing is done at planting time (the most desirable option), an optimal amount of soil moisture is needed in order to avoid seed burning; sowing before the first rain of the season is not recommended. However, research shows that microdosing within 15 days after planting produces the same yields as microdosing at planting (Hayashi, et al. 2007). Considering the workload of farmers during planting, mechanizing the process of seeding and microdosing would facilitate adoption of the technology.

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Efforts to scale out microdosing began in 1996 in Niger and involved a group of partners led by ICRISAT. The technology was extended to Burkina Faso and Mali in 2002 and to Northern Ghana in 2005. However, most of these attempts took a pilot project approach and focused mainly on raising farmer awareness of the practice, which was done through demonstrations and farmer field schools. To increase the number of farmers using the technology, and thereby contribute to improving smallholder livelihoods in the drylands of West Africa, in 2009 AGRA's Soil Health Program began supporting the scaling up of fertilizer microdosing in Burkina Faso, Mali and Niger – working closely with, respectively, the Institut de l'Environnement et de Recherches Agricoles (INERA), the Institut de l'Economie Rural (IER), and the Institut National de Recherche Agronomique (INRAN) (Figure 5.1).

The teams in these three countries implemented the project, with technical backstopping from ICRISAT. Scaling up of fertilizer microdosing in West and Central Africa is now possible due in part to the experience gained over the years, and in part thanks to decision-making and communications tools that were produced, including policy briefs, student theses, demonstration videos, and instructional leaflets in local languages. The number of households that were reached, and the number of those that adopted the new technology, indicate that if governments and other funding sources provide the necessary means, additional beneficiaries in this region can be reached, which in turn can improve farmers' resilience in the face of climate change.



**Figure 5.1:** A model for scaling up microdosing technology

## Site Descriptions and Approaches to Scaling Up Microdosing, Warrantage Systems, and Input Shops<sup>6</sup>

### Focus countries

In Burkina Faso, the project focused on the Sudanian zone (600-900 mm annual rainfall), covering 5 provinces and involving a total of 200 villages (Table 5.1). Farmers in this agro-ecological zone depend on sorghum, millet and maize as their major staple foods, yet the productivity of these crops is very low<sup>7</sup> due to unreliable rainfall, low soil fertility, and socio-economic constraints such as limited access to credit and to inputs (mainly fertilizer and seed of improved varieties).

6 Input supply shops are input-selling units created at the community level and owned in principle by local farmer organizations. Their purpose is to bring inputs closer to the farmers and provide them in affordable packages. Instead of 50 kg bags of fertilizer, for example, it is re-packaged in smaller containers of 1 kg or less. The same thing is done for seed

7 300-500 kg/ha for millet; 500-800 kg/ha for sorghum; and 1,500-2,000 kg/ha for maize

Table 5.1: Details of project implementation in the three countries

Country	Number of provinces/regions	Number of departments	Number of villages
Burkina Faso	5	21	200
Mali	4	12	200
Niger	7	35	175

In Mali, the project covered four regions – Koulikoro, Ségou, Mopti and the northern part of Sikasso (Figure 5.2) – and was meant to target at least 200 villages involving 130,000 households.

In Niger, the project covered 7 regions in the Sudano-Sahelian zone (mean annual rainfall of 300-800 mm) (Figure 5.2). The selected zones are characterized by low rainfall and predominantly sandy soils with low organic matter content and low inherent fertility. Farmers in the 175 selected villages are predominantly millet and sorghum growers.

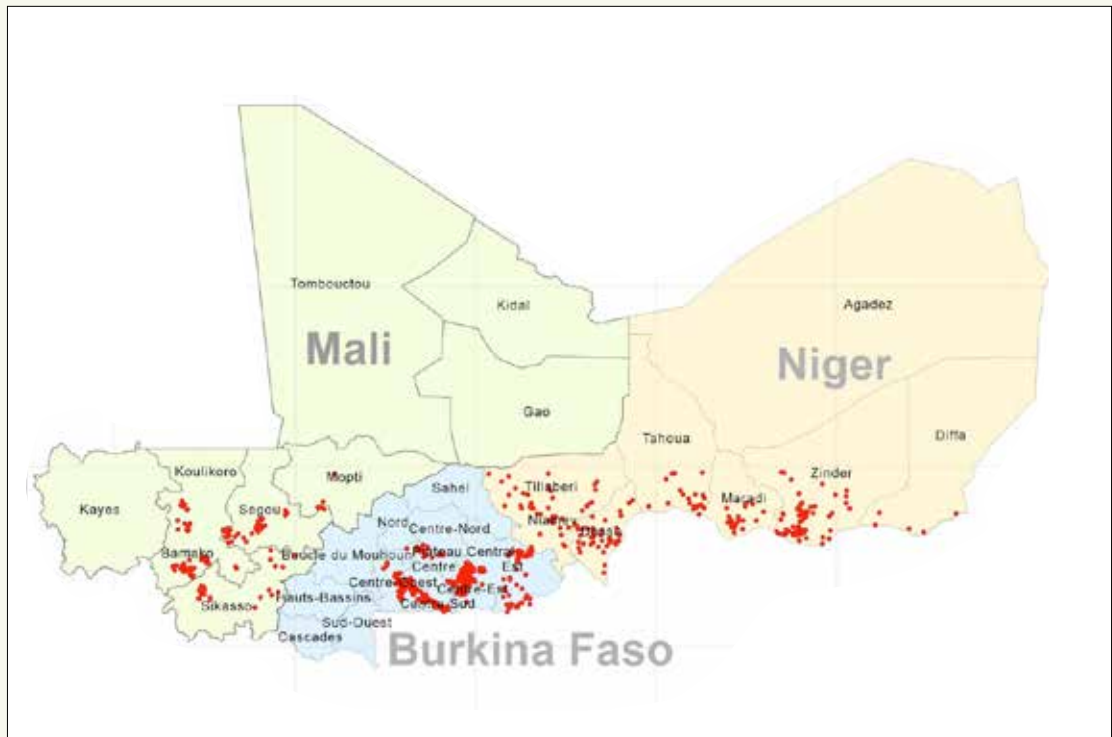


Figure 5.2: Project intervention sites in the three focus countries

## Soil characteristics

The soils of the pilot villages in Burkina Faso are moderately acidic, and have low soil organic matter and low available P. In Mali, soils in the Sudan Savanna are acidic, but have a higher pH in the Sahel. In Niger, the soils in the target sites are moderately acidic, but some alkalinity is encountered in the region of Zinder and Maradi. Overall, soil pH was commonly between 5 and 6; soil organic matter was less than 1%, with some occurrence of higher levels in Burkina Faso; available P was less than 5 mg/kg; and exchangeable K was higher in the soils of Niger compared to Mali. Appendix 5.1 provides additional details on soil characteristics.

## Approaches to implementation

Demonstration plots and farmer field schools<sup>8</sup> (FFS) were used to inform farmers about the benefits of using good agricultural practices, including microdosing and improved varieties. In the demonstration plots, similar treatments were tested across the three countries. A control treatment (no applied fertilizer) was compared to mineral fertilizer NPK applied using microdosing (microdose 1) and to the standard recommended application rate. In Niger, however, different microdosing options were compared (such as NPK, NPK + urea (microdose 1 & 2) and NPK + organic manure (microdose + OM). Millet, sorghum, maize, groundnut and cowpea were used in the demonstrations in all countries, with exception of Niger where maize was not included. Plot size was not uniform across countries, varying from 100 m<sup>2</sup> to 625 m<sup>2</sup>. In order to increase farmer access to credit and farm inputs, warrantage warehouses and input shops were created. The warrantage<sup>9</sup> (inventory credit) is a system by which, groups of producers (farmer organizations and/or unions of farmers organizations) obtain credit by using their stored produce as collateral, produce that is likely to increase in value later in the year. Credit equivalent to the stored produce (based on actual market prices) is provided to farmers, who use it to acquire inputs for

8 Farmer Field Schools are structured groups of 25 to 30 people (farmers and/or herders) who meet regularly during the cropping season in their own field (training site) to learn how to solve problems related to the management of their environment and farm, based on a program developed by them with the assistance of a facilitator; farmer field schools use tools and methods appropriate for non-formal adult education. They are schools without walls, where the land and the environment are the textbook.

9 The warrantage system was introduced in Niger in 1999 with 'FAO Projet Intrants' (a project funded by FAO within the Ministry of Agriculture in Niger). It designed and initiated the establishment of a network of input shops and inventory credit schemes to: increase farmers' access to fertilizers at affordable prices; improve the financial liquidity of farmers so that they could engage in a range of income-generating activities during off-seasons; and improve farmers' income from sales of their produce.

the next cycle, such as fertilizer and seed of improved varieties, but also for other income-generating activities, including the fattening of small ruminants, horticulture, trading, and groundnut oil extraction in the dry season. These sources of income enhance farmers' access to the fertilizers they need for microdosing their crops in the next season.

Five thousand demonstration plots were implemented in both Burkina Faso and Niger, and 2,500 were established in Mali. Fifty warrantage warehouses were developed and implemented in each of the three countries. In addition, 50 input shops (agrodealers) were established or renovated in both Mali and Niger, and 25 in Burkina. The differences in levels of activities between countries were due to country-specific factors, such as the high number of regions covered in Niger for example.

## Achievements

### Demonstrations

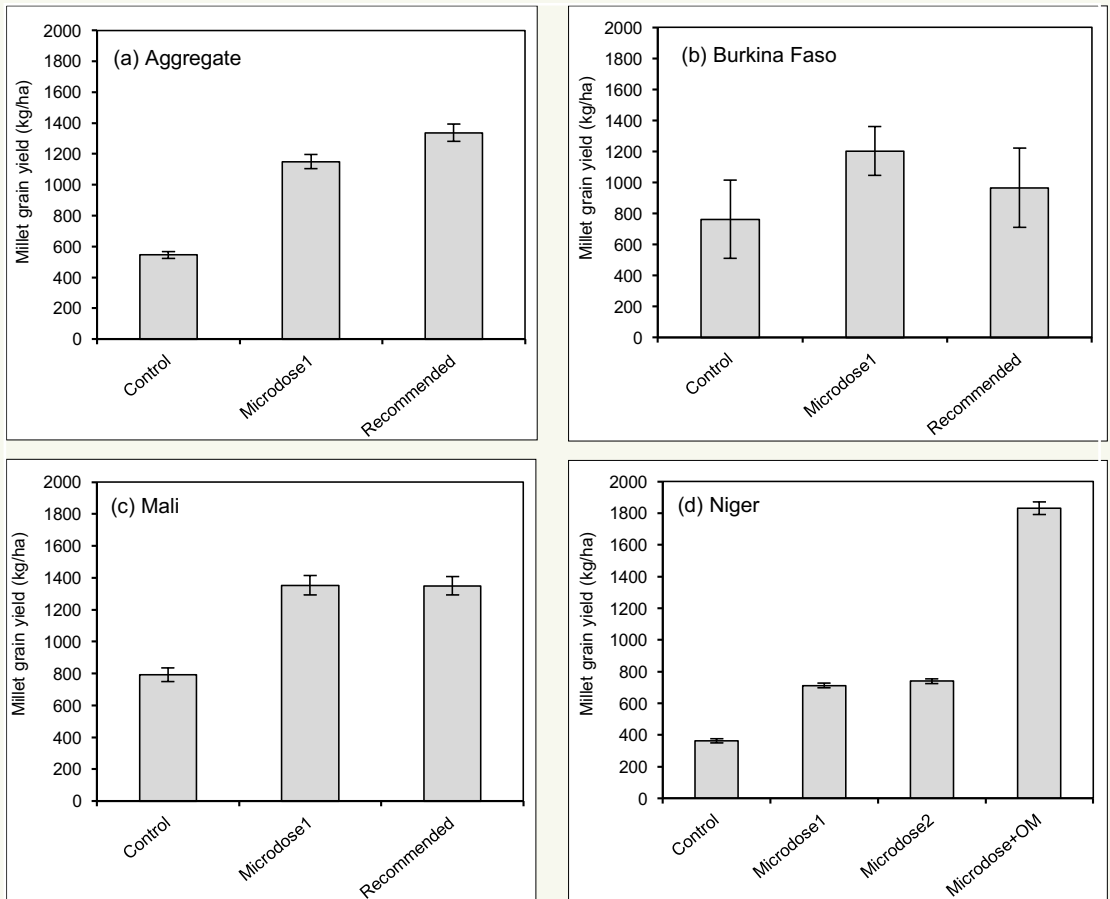
The objective of this activity was to use a "learn-by-doing" approach to raise the awareness of farmers about the new technology. Where possible, men, women and youth were involved. In Burkina Faso for instance, in the Kouritenga zone during the rainy season 2011, 3,013 farmers were involved in the demonstration activities; of these, 39% were women and 61% were men, and young women and men were well represented. However, participation of women as demonstration plot owners was country specific. In some of the Sahelian countries, such as in Niger, women can participate in field activities but they are not entitled to own land (unless they are widows and/or heads of households).

Data on millet aggregated across the three countries show that the recommended fertilizer application rate outperforms microdosing at this level (i.e., when aggregated). However, millet yield response to microdosing was significantly higher or equivalent to the recommended fertilizer application rate within each country (Figure 5.3). Region-level analyses of the data in each country show that in Burkina Faso, the lowest performance of microdosing in terms of millet production is in Boulgou, a region with potentially high rainfall. Higher yields were recorded in the Oubritenga region, which has potentially lower rainfall. The soil data show that organic content in the Oubritenga zone is two times that of the Boulgou region.

In addition, the high rainfall in the Boulgou zone may have leached nutrients below the rooting zone before the crop could absorb them. This could explain the low yields observed in this zone. In Mali, the technology performed better in the dryer agro-ecological zone of

Mopti, whereas the poorest performance was in the region of Koulikoro, where the potential for rainfall is higher. While the amount of available P in areas with higher rainfall is greater than in the dryer zones, organic matter content in the dryer zones was high compared to the other zones. In the dryer zone of Mopti, flooding of the Niger River may have contributed to improve soil organic matter content, which in turn had positive effects

on crop performance. In Niger, overall performance of microdosing without adding organic manure was low. Soil data from Niger indicates that organic matter content is uniformly low in all of the project's regions. In general, project results show that the level of soil organic matter content in the three counties strongly affected the performance of microdosing technology.

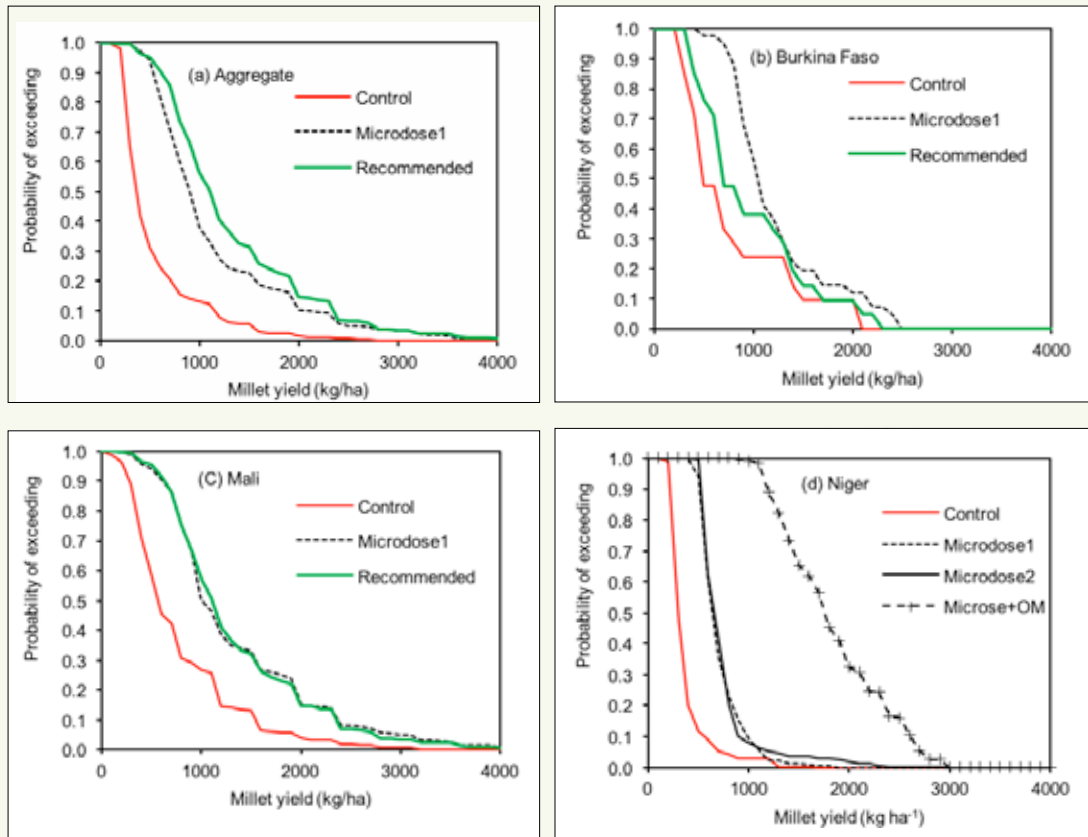


**Figure 5.3:** Variation in millet yields with fertilizer microdosing within Burkina Faso, Mali and Niger. The vertical bars represent 95% confidence limits. If 95% CLs overlap, treatments are not significantly different.



The probability of millet grain yield exceeding 500 kg/ha under the control (no fertilizer) was 31%, while this probability was > 94% under microdosing and under the recommended rate of fertilizer application.

The probability of yields exceeding 1,000 kg/ha under microdosing was 38%, while under the recommended application rate the probability is increased to 57% (Figure 5.4).

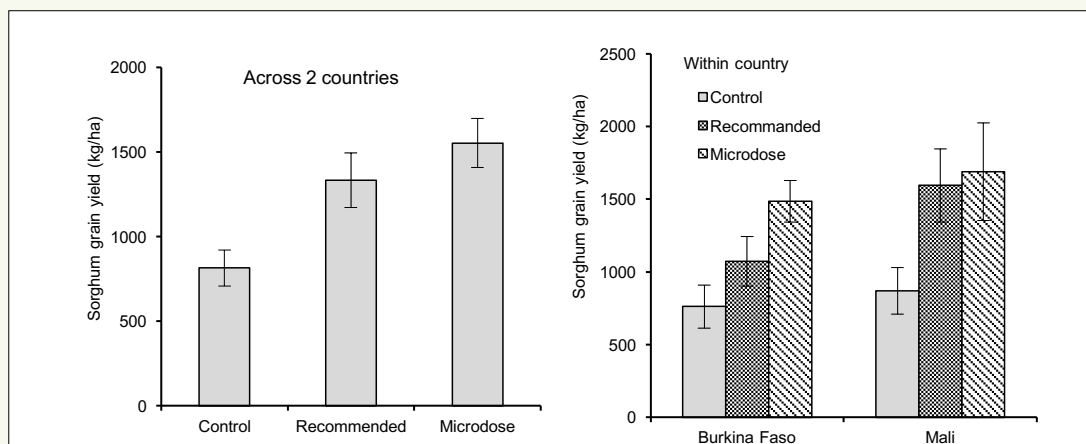


**Figure 5.4:** Probability of millet yields exceeding a given level with fertilizer microdosing and the recommended rate of fertilizer application

In Burkina Faso and Mali, the probability of yields exceeding 1,000 kg/ha under microdosing was over 50%. On the other hand, in Niger the probability was only 10%. However, when fertilizer microdosing was integrated with organic inputs, as in Niger, this probability increased to 99% (i.e., the risk of yields being less than 1,000 kg/ha is only 1%). Increasing the fertilizer rate in microdosing from 9 to 13 kg of N/ha did not significantly improve yields. The probabilities of yields in Burkina Faso and Mali exceeding 1,000 kg/ha

under microdosing with 9 and 13 kg of N/ha were only 3% and 4%, respectively.

When aggregated across Burkina Faso and Mali, microdosing produced slightly better yields of sorghum than the recommended application rate of fertilizer, although the differences were not statistically significant. The within-country trend is similar in Mali, whereas in Burkina Faso the hill application of fertilizer to sorghum produced significantly higher yields than the control and the recommended rate (Figure 5.5).



**Figure 5.5:** Variation in millet and sorghum yield with fertilizer microdosing in the Sahelian countries (Burkina Faso, Mali). The vertical bars represent 95% confidence limits. If 95% CLs overlap, treatments are not significantly different.

Economic analyses using yield data collected on millet and sorghum from the demonstration activities in Mali (2009-2011) revealed that for both crops the cost-benefit ratio is higher for microdosing compared to the recommended application rate, even at harvest time when the benefits accruing to farmer was less due to the large supply of grain in the market (Table 5.2). The study also revealed that millet was more profitable for farmers than sorghum.

### Farmer field schools (FFS)

This approach was used to build the decision-making capacity of participating farmers in the management of their fields, factoring in their own agro-ecological and

socio-economic conditions. In addition, the FFS approach created groups of resource persons in target communities that were able to assist neighboring farmers not directly involved in project activities, helping to raise their awareness and to answer questions about applying the technology. A total of 358 farmer field schools were established in the course of the project (Table 5.3) with a minimum of 20 trainees per school. As a result, at least 7,160 resource persons were trained, who can in future help to set up new field schools in target communities and beyond in the three countries.

**Table 5.2:** Cost-benefit ratios of microdosing and the recommended rate of fertilizer application for millet and sorghum in Mali

Treatments	Millet		
	Yield (kg/ha)	Cost-benefit ratio (at harvest)	Cost-benefit ratio (period of shortage)
Control (no fertilizer)	796		
Microdose	1,428	9.06	17.56
Recommended rate	1,879	0.75	1.34
Sorghum			
Control	720		
Microdose	1,141	3.45	6.63
Recommended rate	1,142	0.65	1.15

**Note:** Fertilizer rate in microdosing was 32 kg/ha NPK. The recommended rate was 100 kg/ha NPK and 50 kg/ha urea

**Table 5.3:** Number of households reached, FFS and demonstrations implemented, and warrantage systems developed in the three countries

Country	Number of farm households	Number of Farmer Field Schools (FFS)	Number of demonstrations	Number of warrantage systems
Burkina Faso	130,000	50	5,100	50
Mali	168,000	60	2,351	79
Niger	100,000	248	6,114	103

## Warrantage systems and input shop activities

A total of 232 warrantage systems (inventory credit schemes) were developed and 189 input shops created or revitalized in the course of the project. Implementation of warrantage schemes was done in partnership with local microfinance institutions operating in each country: Credit populaire in Burkina Faso; Kondo Jiguima and Soro Yirawasi in Mali; ASUSU S.A. and Taanadi S.A. in Niger.

In addition to these microfinance institutions, the project has put revolving fund schemes in place in each country to facilitate farmer access to credit from the traditional banking system. A USD 200,000 risk-sharing fund was set up in each country for that purpose. In Burkina

Faso, an unsuccessful effort was made to contract with Banque Regionale de Solidarite (BRS), so focus shifted to making arrangements with the Banque Nationale de Developpement Agricole (BNDA) in Mali, and BNDA provided USD 138,629 to implement a warrantage scheme there. In Niger, an MOU was signed with the agricultural bank BAGRI (Banque agricole du Niger) covering USD 100,000 in guaranty funds for allocating credit to farmers and agrodealers. These funds are still being used to provide credit to farmers in Mali and Niger.

A total of 3,792 famers benefited from the warrantage system in Burkina Faso over the life of the project (USD 271,100 in credit) (Table 5.4), with women representing a slightly higher proportion of the beneficiaries (52.8%).

**Table 5.4:** Disaggregation of the beneficiaries of warrantage schemes in the course of the project in Burkina Faso

Province/Region	Number of beneficiaries of warrantage			Number of stores
	Total	Men	Women	
Nahouri	592	365	227	13
Oubritenga	873	387	486	17
Kouritenga	635	312	323	11
Ziro	512	219	293	4
Boulgou	858	402	456	10
Sanguié	134	29	105	2
Boulkiemde	188	74	114	3
<b>Total</b>	<b>3,792</b>	<b>1,788</b>	<b>2,004</b>	<b>60</b>

**Table 5.5:** Beneficiaries of warrantage systems in Mali

Region	Beneficiaries	Tons of Grain stored for warrantage
Koulikoro	152	610
Mopti	327	1,645
Ségou	1,046	7,023
Sikasso	477	2,588
<b>Total</b>	<b>2,002</b>	<b>11,866</b>

In Mali, 15 cooperatives were provided USD 300,922 in credit from microfinance, as well as conventional financial institutions, between 2010 and 2012. This initiative involved 2002 farmers, who stored 11,866 tons of grain in the warrantage warehouses (Table 5.5). In Maradi (Niger) in 2012, a total of USD 150,803 in loans was provided through the warrantage scheme.

Input shops were created or revitalized in all countries and supplied with relatively high quantities of inputs, including fertilizers, seed of improved varieties, and phytosanitary products. In Mali a total of 2,231 MT of fertilizer were placed in the shops, with the highest proportion going to Segou and Sikasso.

## Effects of Microdosing on the Soil

The yield increases following application of fertilizer microdosing imply increased nutrient uptake by the plants. Since Sahelian soils are acidic [pH 4 to 5 (H<sub>2</sub>O)] and low in organic carbon content (0.2%), it is possible that nutrient imbalances could develop following continuous use of the technology. Therefore, additional studies are needed to determine that the technology is truly sustainable, i.e., that potential soil nutrient imbalances do not constrain production.

Research revealed that grain yields in the control plots were lower than in the amended plots in all three years of experimentation. However yield differences relative to the control plots became more pronounced in the latter years of the project (41% and 57% yield increase on average in Year 2 and Year 3 respectively, compared to 27% in Year 1). The yield gaps between the control plots and amended plots increased year over year, which is an indication that a certain level of production could be maintained over time with the technology, even though yields on the amended plots decreased.

Grain yield dropped after three seasons of cropping. The greatest decrease was observed in the control plots (82%), which received no fertilizer. This compares to a 66% decrease in yields on the plots receiving 6 g NPK/hill. At

the end of the second cropping season, a yield decrease of only 29% was recorded when 6 g NPK/hill was applied; control plots experienced a 50% yield decline, and the productivity of those receiving 2 g DAP + 1 g urea declined by 44%.

It was also observed that the amount of N and K that was removed under all treatments exceeded the quantity applied, regardless of the fertilizers used. The highest amplitude of the negative balance was recorded in the control plots, followed by plots that received 6 g NPK/hill. The first trend could be due to no additional nutrients being made available from external sources, whereas nutrient removal because of high biomass production could explain the second trend. A negative balance for P was observed only in the control plots, which could be due to low pH favoring P trapping in the soil complex. Soil pH decreased under all treatments, indicating possible acidification of the soil at experimental sites (Table 5.6). The rate of pH decrease was more pronounced in the control plots, and in plots where 2 g DAP + 1 g urea was applied.

A negative balance for most soil parameters was observed, but whether this is the main cause of declining yields needs to be determined; apart from soil characteristics, rainfall and biotic parameters contribute to crop yields. Further analysis is therefore required.

## Mechanizing Microdosing

Microdosing is affordable to the poor because of its low cost and high returns. However, the labor required to use the practice is high. Three people are typically needed for efficient application of the technology when farmers are busy planting large areas, and it is the normal practice in extensive smallholder agriculture to involve two people in planting. To reduce the burden on farmers and increase labor efficiency, research has been initiated aimed at mechanizing microdosing. Mechanical prototypes were designed by IER in Mali, and more recently by INERA in Burkina Faso. Both prototypes place the seed and fertilizer at the same time, but this comes with a risk of salt damage to germinating seeds and emerging plants.

**Table 5.6:** Partial nutrient balances (data averaged over two years) and soil characteristics after three cropping seasons

Soil fertility options	Partial nutrient balance			Soil characteristics	
	Nitrogen	Phosphorus	Potassium	pH (H <sub>2</sub> O)	CEC Ag cmol/kg
Control	-9.83	-0.62	-10.84	-0.323	-0.14
DAP + Urea	-1.47	10.68	-12.73	-0.329	-0.33
NPK (3 g)	-5.90	4.81	-8.46	-0.217	-0.35
NPK (6 g)	-7.64	10.00	-13.07	-0.221	-0.17
Sed (±)	2.599	0.170	2.621	0.1988	0.267
Fprob	0.033	<0.001	0.307	0.001	0.389

Source: D. Fatondji – personal data



The IER prototype requires that the seed be pre-sorted by size, but this is often not feasible for farmers. Additional design work is needed to develop equipment that places the seed and fertilizer separately.

## Socio-economics and Impact of Adopting the Microdose Technology

A study conducted in Burkina Faso and Niger on the impact of adoption of the microdosing technology and the warrantage credit scheme revealed that in Burkina, the FFS approach was more efficient for reaching farmers, while in Niger the most efficient approach was to visit demonstration sites (Table 5.7).

Project interventions in West Africa have positively affected the access of farmers and farmer organizations to credit. This impact is most notable in Burkina Faso pilot villages, where more than 45% of the credit obtained comes from warrantage sources, as compared to only 20% coming from such sources in diffusion villages. In Niger the most important sources of credit to farmers are informal, such as friends and family, which account for 70.81%. Farmers in the project sites obtain less than 3% of the credit they use from existing savings and credit schemes (Table 5.8).

In both countries, project interventions in pilot villages have improved incomes compared to the control villages (by 2% in Burkina Faso and 34% in Niger). The growing value of livestock herds has contributed to these improvements in income – about 51% of the increase in Burkina Faso and 42% in Niger (Table 5.9).

Creating input shops has also helped to improve knowledge about and the purchase of farm inputs in the pilot villages (relative to control villages). The distance farmers must travel to get to an input shop is considerably lower for those living in pilot villages (7 km in Burkina Faso and 6 km in Niger) compared to those living in control villages (11 km and 14 km in the two countries, respectively) (Table 5.10). The closer proximity of input shops has contributed to the sale of small packs of fertilizer in the pilot villages, with 45% and 87% of the farmers in Burkina and Niger acquiring fertilizer. Still, the acquisition of improved seed is higher in the control villages compared to the pilot villages (Table 5.10)

The scaling up approaches taken were not equally efficient in raising farmer awareness about microdosing in the two countries. Working in the farmers' fields was more efficient than other means in both countries, followed by farmer-to-farmer visits. Radio broadcasting proved to be one of the least efficient ways to raise awareness.

**Table 5.7:** Activities implementation approaches and beneficiaries reached in Burkina and Niger

Project activities	Means of the regions		
	Burkina Faso	Niger	Mali
	(n=523)	(n=287)	(n=420)
Use of the input shops	22.4	34.0	26
Participation in the warrantage scheme	9.9	18.4	24
Participation in FFS	30.4	71.6	14
Visits to demonstrations	22.0	78.0	36

**Source:** Adapted from microdosing impact assessment in Burkina Faso & au Niger – AGRA report

**Table 5.8:** Proportions of farmers that have obtained credit, and the sources of that credit (Burkina Faso and Niger)

Country and source of credit	Village type					
	Pilots		Diffusion		Control	
	% EA	% Credit	% EA	% Credit	% EA	% Credit
<b>Burkina Faso</b>	<b>(n = 523)</b>		<b>(n = 264)</b>		<b>(n = 270)</b>	
Friends/Family	2.75	5.45	13.79	21.05	11.76	20
Saving and credit schemes	12.84	21.82	10.34	15.79	17.65	30
Commercial banks	0.92	0	10.34	10.53	0	0
Project credit	22.02	40	17.24	21.05	5.88	10
Warrantage credit	45.95	0	20	0	28.95	0
Input shop credit	0.92	1.82	6.9	5.26	0	0
Other sources of credit	15.6	30.91	20.69	26.32	32.35	40
Proportion of farmers not using credit	20.08	n/a	9.47	n/a	12.22	n/a
Contracted loans (000' FCFA)	99 (27)	n/a	11 (61)	n/a	9 (39)	n/a
<b>Niger</b>	<b>(n = 286)</b>		<b>(n = 389)</b>		<b>(n = 50)</b>	
Friends/Family	23.69	63.87	25.83	77.1	20	64.71
Saving and credit schemes	2.79	7.92	1.79	5.47	0	0
Commercial banks	0.35	0.99	0.26	0.78	3.64	11.76
NGO credit	0.7	1.98	0.26	0.78	1.82	5.88
Development project	5.23	13.84	2.05	4.95	1.82	5.88
Other sources of credit	3.48	9.41	3.32	10.14	3.64	11.76
Proportion of farmers not using credit	35.19	n/a	32.74	n/a	30.91	n/a
Contracted loans (000' FCFA)	74 (125)	n/a	63 (78)	n/a	223 (412)	n/a

**Note:** Standard deviation in parenthesis; % EA = Percentage of farms; % Credit = Percentage total credit; and n/a = not applicable.

**Source:** Adapted from microdosing impact assessment in Burkina Faso and Niger – AGRA report

In the project villages in both countries, microdosing has increased significantly since the start of the project. Sixty percent of farmers in project villages in Burkina Faso and 35% in Niger now use the technology. About 30% of farmers in diffusion and control villages in

Burkina Faso use microdosing, while about 20% of farmers in such villages in Niger use the technology. Globally, the study shows that fertilizer microdosing has increased to 27% from a baseline of 13% at the start of the project in 2009.

**Table 5.9:** Farmer income levels and sources ('000 CFA)

Country and income sources	Type of village					
	Pilots		Diffusion		Control	
Burkina Faso	(n = 523)		(n = 264)		(n = 270)	
	Mean	SD	Mean	SD	Mean	SD
Total value of the production	462	640	340	404	423	515
Herd total value	581	883	582	943	625	1294
Income from non-agricultural	84	215	56	150	72	187
Total income of the farm	1133	1223	973	1083	1112	1485
Niger	(n = 286)		(n = 389)		(n = 50)	
	Mean	SD	Mean	SD	Mean	SD
Total value of the production	309	626	180	356	274	504
Herd total value	364	620	320	708	149	193
Income from non-agricultural	201	517	133	243	151	409
Total income of the farm	874	1148	633	873	574	673

**Source:** Adapted from microdosing impact assessment in Burkina Faso and Niger – AGRA report

**Table 5.10:** Knowledge about inputs and accessibility to input shops in different types of villages in Burkina Faso and Niger

Country and variables measured	Village type					
	Pilot		Diffusion		Control	
Burkina Faso	(n = 523)		(n = 264)		(n = 270)	
	Mean	SD	Mean	SD	Mean	SD
Knowledge of input shops (%)	66.92	47.09	45.08	49.85	49.26	50.09
Buying in input shops (%)	34.03	47.43	20.83	40.69	34.07	47.48
Accessible input shops in 2011	0.97	0.9	0.63	0.84	0.75	0.99
Distance to the closest input shop (km)	6.96	10.84	11.31	10.68	11.05	10.91
Niger	(n = 286)		(n = 389)		(n = 50)	
	Mean	SD	Mean	SD	Mean	SD
Knowledge of input shops (%)	45.45	49.88	26.22	44.04	28	45.36
Buying in input shops (%)	30.42	46.09	18.77	39.09	24	43.14
Accessible input shops in 2011	0.56	0.71	0.3	0.53	0.42	0.76
Distance to the closest input shop (km)	5.92	10.98	9.48	13.9	14.2	14.81

**Source:** Adapted from microdosing impact assessment in Burkina Faso & au Niger – AGRA report

**Table 5.11:** Items offered by the input shops and their movement

Articles	Village type		
	Pilot	Diffusion	Control
<b>Burkina Faso</b>	<b>(n = 178)</b>	<b>(n = 55)</b>	<b>(n = 92)</b>
Small pack fertilizer (%)	45.51	27.27	23.91
Improved seeds (%)	18.54	18.18	20.65
Phytosanitary products (%)	20.79	16.36	10.87
<b>Niger</b>	<b>(n = 87)</b>	<b>(n = 73)</b>	<b>(n = 12)</b>
Small pack fertilizer (%)	82.76	79.45	83.33
Improved seeds (%)	5.75	9.59	16.67
Phytosanitary products (%)	24.14	27.4	16.67

**Source:** Adapted from microdosing impact assessment in Burkina Faso & au Niger – AGRA report

## Lessons Learned

- 1) In order to achieve the project objectives, simultaneous actions on microdosing dissemination, creation of an enabling environment, effective communications, and several types of expertise were needed.
- 2) Successful implementation of the microdosing technology requires that it be associated with warrantage systems to increase farmer access to fertilizer and the financial gain they realize from selling their produce when demand is high relative to supply.
- 3) Microdosing performed better when soil organic matter content was improved.
- 4) Farmers and farmer organizations need to invest in the production of organic inputs, such as farm or home waste composting.
- 5) Policy decisions that favor organic fertilizer production at the country level are required to enhance the benefits that farmers derive from microdosing technology.
- 6) Among the approaches used to transfer and scale up the technology, farmer field schools appear strong as they allow all partners, farmers, and extension agents to meet and exchange knowledge. In addition, farm-to-farm learning demonstrated the efficacy of bringing farmers together around specific project activities.
- 7) The warrantage system has helped to empower participating women by enabling the organization of small-scale trading and other post-harvest and agroprocessing activities.

- 8) In Niger, the FFS settings included seed multiplication as revenue-generating activity. After each season, the seed produced was stored in a warrantage warehouse, with financial support from ASUSU (a microfinance institution). Since seed demand is high in Niger and prices remain stable, risk was minimal and banks were more confident in loaning money using this seed as collateral, especially since it was stored under warrantage and could not be adversely affected by environmental conditions. Future warrantage operations should also target products that enjoy price stability, such as moringa seed.

## Perspectives

The project has shown that creating the proper enabling environment is key to farmer adoption of microdosing technology, including the sustainable availability of credit (a factor that was not successfully implementing in all cases). Results from the three-year initiative in Burkina Faso, Mali and Niger justify further efforts aimed at determining the most effective approaches to taking microdosing to scale in the region.

Among the approaches tested, large-scale demonstrations appeared to be the most successful way to raise farmer awareness about the technology. In addition, learning-by-doing is the most powerful way to encourage adoption. The next step should be to increase of the number of project sites so as to improve proximity to farmers.

The adaptive research conducted so far has indicated a risk of nutrient removal exceeding the amount added. Microdosing technology is meant to increase farmers' fertilizer use and move them towards production intensification. However, it is difficult for small-scale farmers to make the investments needed to reach and sustain the desired higher levels of intensification.



Microdosing appears to be the most affordable option to improve and sustain crop productivity and meet the food needs of farm households. Studies are needed to determine appropriate conditions under which microdosing can be used to achieve production increases under existing soil and environmental conditions. This research should consider not only soils aspects, but also climate variability.

In addition, the microdosing mechanization equipment developed by research teams in Burkina Faso and Mali holds promise for scaling up the practice of microdosing, but additional research is required to improve the machinery developed so far.

## Conclusions

The project has boosted awareness within project villages and beyond about the benefits of fertilizer microdosing, warrantage systems, and increasing the number and quality of input shops.

The creation, and in some cases rehabilitation, of warehouse facilities has enabled expansion of warrantage systems, which in turn has enhanced fertilizer use at project sites, especially when coupled with the development of input shops and the capacity building of agrodealers.

Establishing fertilizer supply points (input shops) closer to where participating farmers live greatly enhanced their access to fertilizer and other inputs, and this clearly led to increases in fertilized area in (or near) the project sites and beyond, and consequently to increased crop productivity.

Results from this initiative have also demonstrated the importance of easier farmer access to more affordable credit in order to boost the use of farm inputs. The success of the revolving fund approach indicates that it may be a promising option under the right circumstances, though such an approach needs to be implemented in the context of local financial realities.

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**Appendix 5.1:** Some characteristics of soils of the pilot villages of the project

<b>Burkina Faso</b>	<b>Boulgou (East Central zone)</b>	<b>Kouritenga (East Central zone)</b>	<b>Oubritenga (Central zone)</b>	<b>Ziro (South maize zone)</b>	<b>Nahouri (South maize zone)</b>
pH (H <sub>2</sub> O)	5.6	5.3	5.88	6.07	6.2
Organic matter (%)	0.6	0.88	1.18	1.21	1.3
Nitrogen (mg/kg)	0.31	0.27	0.39	0.43	0.41
Available P (mg/kg)	3.45	3.78	3.99	4.01	3.41
K (mg/kg)	56.5	54.5	58.02	61.22	216.15
<b>Niger</b>	<b>Zinder</b>	<b>Maradi</b>	<b>Dosso</b>	<b>Tahoua</b>	
pH (H <sub>2</sub> O)	5.855	5.825	4.98	5.615	
Organic matter (%)	0.185	0.18	0.32	0.25	
Nitrogen (mg/kg)	119.5	82	143	140.5	
Available P (mg/kg)	3.495	–	–	–	
K (cmol+/kg)	707	724.5	66	943.5	
<b>Mali</b>	<b>Northern zone</b>	<b>Central zone</b>	<b>Southern zone</b>		
pH (H <sub>2</sub> O)	5.82	5.76	5.81		
Organic matter (%)	1.75	0.16	0.41		
Available P (mg/kg)	2.58	4.28	7.60		





# Scaling Out Cassava-based Production Systems in West and East Africa

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## Key Messages:

- 1 Cassava has long served as a subsistence and food security crop, but where urban demand is high, it is becoming an increasingly important cash crop.
- 2 With appropriate inputs and good agronomy, cassava yields are now reaching 35 MT/ha, up from an average of just 12 MT/ha.
- 3 The Going Beyond Demos field approach is leading farmers to adopt ISFM practices to improve the productivity of their cassava crops.

## Introduction

Cassava is the second most important crop after maize in sub-Saharan Africa (SSA). According to FAO (2013), 172 million MT of cassava was produced worldwide in 2000, and SSA accounted for 54%. Cassava is mainly a subsistence crop grown for food by smallholder farmers and it is regarded as the cheapest staple food (Roothaert & Magado, 2011). Democratic Republic of Congo (DRC) and Nigeria are the largest consumers of cassava, but per capita consumption in Africa is about 80 kg of cassava per year, though intake varies from one country to another. For example, the per capita intake of cassava in Ghana stands at 151.4 kg/yr and in Tanzania it is about 157 kg/yr (Chauvin, Mulangu & Porto, 2012). However, with increasing urbanization and improved production and processing technologies, cassava is emerging as a cash crop, now used industrially for the production of “gari” (cassava flake), starch, beer, high-quality cassava flour (HQCF), and bio-ethanol among other products.

Cassava grows on a wide range of soils in the tropics and is known for its drought tolerance and potential to produce reasonable yields on infertile soils where other crops fail. For this reason, cassava is considered important for rural households cultivating marginal lands (Manu-Aduening et al., 2006). Despite its versatility and socio-economic importance, the root yield of cassava in Africa, until recently, has been low, ranging between 5 and 12 MT/ha (Fermont et al., 2009). This can be largely attributed to the cultivation of low-yielding and disease-prone traditional varieties. In addition, low yields are due to the poor fertility of most SSA soils.

Cassava research in Africa is now producing disease-tolerant and high-yielding varieties, some capable of yielding 35-40 MT/ha. However, achieving such yields requires the application of fertilizer in addition to good agronomy. The high prices of mineral fertilizers make them unattractive to smallholder farmers (Mkamilo & Jeremiah, 2005; IITA, 2013).

The adaptability of cassava in areas where other crops fail led many to believe that fertilizers are not important in cassava production, but this is a misconception, one that results in little or no fertilizer being applied and consequently low yields (Fening et al., 2009). Using fertilizer may be the easiest way to improve cassava productivity, but farmers are discouraged by high fertilizer prices, as well as some lack knowledge on its use. In Tanzania for example, some cassava production areas also have high livestock density, which makes farmyard manure readily available for improving soil fertility, yet farmers do not use it. To boost the low yields of cassava on smallholder farms and scale out integrated soil fertility management (ISFM) practices in SSA, AGRA's Soil Health Program (SHP) supported projects using ISFM practices in Ghana and Tanzania. The aim was to improve and sustain the yields of cassava roots, and to enhance household income in order to reduce rural poverty and ensure food security.

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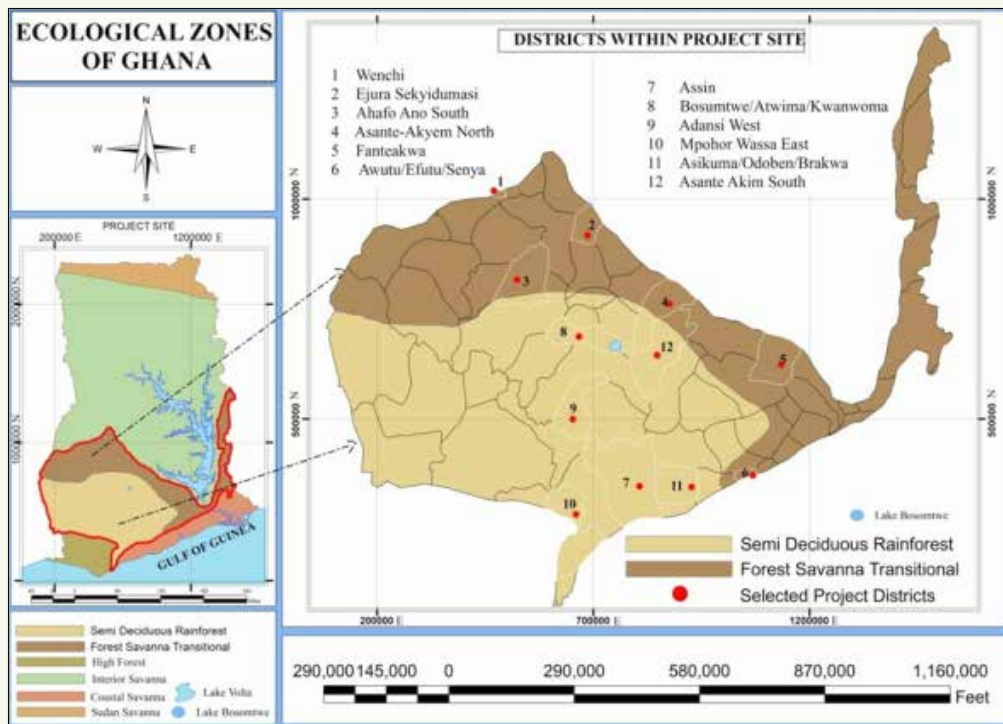
# Project Sites and Going Beyond Demos (GBD) for Scaling Out

## Creating awareness about ISFM practices

The SHP-supported projects established cassava demonstration sites to showcase the use of soil nutrient inputs, improved cassava cuttings and good agronomic practices. In Ghana, 12 demonstration sites were established, 6 in the semi-deciduous rainforest zone and 6 in the savanna transition zone (Figure 6.1). These zones constitute the major cassava-producing areas in Ghana. Likewise in Tanzania, 12 demonstration sites were established during the 2010-2011 cropping season in three districts of Kagera region: Bukoba (6 demos), Muleba (3 demos), and Biharamulo (3 demos). These districts respectively fall within the high rainfall (>1600 mm/yr), medium rainfall (1000-1500 mm/yr) and low rainfall (700-900 mm/yr) zones of Kagera region (Table 6.2).

**Table 6.1:** The location of demonstration sites in the agroecological zones of Kagera region in Tanzania

Agro-ecological Zone	Ward	Village	GPS reading
<b>High rainfall zone</b>	Ruhunga	Ntungamo	1.47104° S; 31.41755° E
	Kibirizi	Bwizo	1.61225° S; 31.41481° E
	Kyamu-laile	Kyamulaile	1.42373° S; 31.41467° E
<b>Medium rainfall zone</b>	Kabirizi	Mikale	1.65508° S; 31.54736° E
	Kimwani	Nyakabango	2.30525° S; 31.64967° E
	Kiwmani	Kyota	2.11625° S; 31.66040° E
	Muhutwe	Bukoki	1.72325° S; 31.46147° E
<b>Low rainfall zone</b>	Nyamuhanga	Kasuno	2.91299° S; 32.22046° E



**Figure 6.1:** Location of demonstration sites in Ghana

The soils at the demonstration sites had varied qualities, as indicated in Table 6.2. Soils in Ghana were slightly acidic to neutral, while those in Tanzania varied from strongly acidic to slightly acidic. All soils were low in total nitrogen and exchangeable bases (K, Ca, Mg). Ghana's soils were low in CEC, but those in Tanzania were high in CEC. For both countries, soil texture ranged from clay to sandy clay loam, the perfect texture for cassava production.

**Table 6.2:** Some physical and chemical properties of soils at the study sites in Ghana and Tanzania

Soil parameter	Ghana	Tanzania
Soil pH (1:1 H <sub>2</sub> O)	5.97-7.91	4.26-6.30
Org. C	0.51-2.87	1.06-3.36
% N	0.04-0.26	0.04-0.26
Ca cmolc/kg	1.87-6.68	0.41-10.51
Mg cmolc/kg	0.8-3.47	0.08-1.85
K cmolc/kg	0.11-0.50	0.01-0.92
Na cmolc/kg	0.02-0.19	0.04-0.27
Avail P (Bray 1)	0.08-7.73	11-15
CEC cmolc/kg	2.95-7.85	11.9-27.4
Texture	Sandy loam to sandy clay loam	Sandy loam to sandy clay

## Demonstration treatments

In Ghana, field demonstrations using the cassava variety *Bankyehemaa* were conducted on 6 m x 20 m plots. Plant spacing was 1 m x 1 m. Triple super phosphate and muriate of potash were applied to the cassava at a rate of 60 kg P<sub>2</sub>O<sub>5</sub> and 30 kg of K<sub>2</sub>O. Fertilizers were “band applied” to the side of crop rows. At harvest, cassava tuber yield was estimated from each replicated plot.

In Tanzania, the treatments used were: farmyard manure (FYM) at 6 MT/ha, P<sub>50</sub>K<sub>50</sub>, and the control (no applied nutrients). Average nutrient content of FYM in Kagera region is estimated at 15, 6 and 20 kg NPK, respectively (Baijukya & Folmer, 1999). The P source was triple super phosphate and the K source was muriate of potash. The cassava variety *Kiroba*, which is tolerant to both cassava mosaic (CM) and cassava brown streak (CBS) diseases, was established using a plant spacing of 1 m x 1 m.

## Capacity building for extension staff and farmers

The projects provided training to extension staff and lead farmers, who in turn trained other farmers. The projects conducted field days around the demonstration sites and farmers were able to compare their usual practices with ISFM technologies, good agronomic practices, and improved cassava varieties.

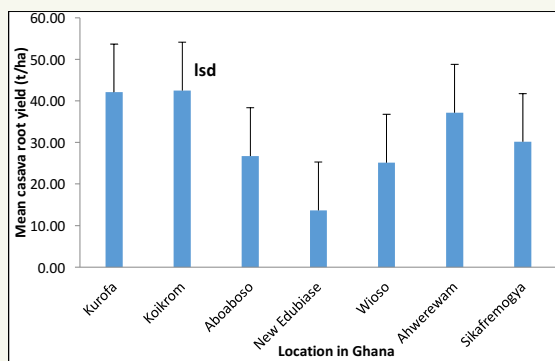
## Cassava yields

Cassava root yields varied across districts and ranged from 14 to 43 MT/ha in Ghana and from 28 to 37 MT/ha in Tanzania (Figures 6.2 and 6.3). In Tanzania, mean cassava yield was 32 MT/ha with fertilizer + manure, 27 MT/ha with fertilizer only, 26 MT/ha with manure only, and 14 MT/ha in the control (Figure 6.4). The marginal rate of return was 1.59 with fertilizer + manure, 1.53 with fertilizer only, and 0.95 with manure only (Table 6.3).

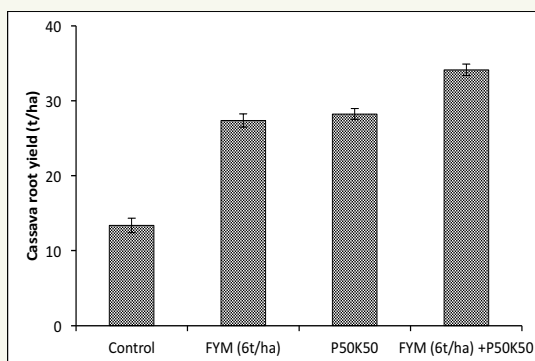
The soils at the study sites in both Ghana and Tanzania generally had low fertility, reflecting the soil conditions for cultivating cassava in sub-Saharan Africa. Agriculture in Africa is characterized by smallholder farming systems that are highly heterogeneous, diversified and dynamic (Vanlauwe et al., 2006). Spatial soil variability exists across regions, and within-farm soil variability is high. Consequently, management strategies that may work in one region may not necessarily work in other regions. Access to resources may vary from one region to another and it is important to understand how the agro-ecological conditions affect production objectives.

The use of improved cassava varieties in both countries showed the potential for increasing farmers' yields from 12 MT/ha to 40 MT/ha. FYM presents a good way to address fertility constraints in cassava cultivation in Tanzania because livestock is an integral component of the farming system (Fermont et al., 2009), though the marginal rate of return to mineral fertilizers is nearly the same. Legumes and inorganic fertilizer provided the entry points in Ghana. The application of FYM manure alone was a better technology with respect to the marginal rate of return in Tanzania compared to the application of inorganic fertilizers alone and the use of inorganic fertilizers + FYM. The application of FYM has both short- and long-term benefits for sustained crop production, and the production and management of FYM should be developed as a major practice for sustaining cassava productivity in East Africa.

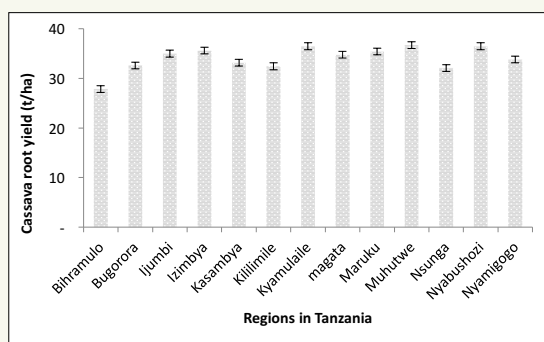
Although inorganic fertilizer alone produced a higher marginal rate of return compared to the combined use of fertilizer and FYM, continually applying mineral fertilizers over the long term is not sustainable, considering its high cost relative to the price of cassava. The combined application of inorganic fertilizer and FYM produced a low marginal rate of return (0.95) in the short term, but the residual effect of inorganic P fertilization and improved soil physical properties from applying FYM offers opportunities for sustainable cassava cultivation. In Ghana, fertilizer subsidies are a major entry point for improving and sustaining cassava cultivation. Improved varieties, as well as more effective seed systems, are major entry points for increasing cassava production in Ghana.



**Figure 6.2.** Cassava root yields with the application of fertilizer (N60-P40-K40) at different locations in Ghana



**Figure 6.4:** Mean cassava root yields (pooled for the sites) in Tanzania as influenced by nutrient application practices



**Figure 6.3:** Cassava root yields using fertilizer and manure [FYM (6MT/ha) + P50-K50] at different locations in Tanzania

## Creating awareness

In Ghana, a total of 13,700 farmers made aware of the potential benefits of cassava/cowpea strip intercropping across the 12 districts where demos were carried out. The highest number of farmers reached was in Wenchi District in the Brong Ahafo region, while the fewest number of farmers reached was in the Asante Akyem District of the Ashanti region.

**Table 6.3:** Marginal rates of return on cassava cultivation in Tanzania

Farming practice	Yield (MT/ha)	Amount in USD/ha							Marginal rate of return*
		Labor costs	Input costs	Total costs	Gross revenue	Net income	Incremental costs	Incremental revenue	
Farmers' practice	14	499	150	649	1,038	389			
Farmyard manure	26	466	536	1,002	1,952	950	353	560	1.59
Fertilizer	27	544	502	1,046	2,044	998	397	609	1.53
Fertilizer + manure	32	544	836	1,380	2,465	1,085	731	696	0.95

A total of 136 lead farmers and 82 extension agents were trained. The highest number of farmers and extension agents trained was achieved in the Ahafo Ano South District of the Ashanti region (28 and 5, respectively) while the fewest number of farmers trained occurred in the Assin District of the Central region (5 farmers). Also, the lowest number of extension agents trained was in both the Asante Akyem South District of the Ashanti region and Asikuma Odoben Brakwa District of the Central region (3 extension agents each). In general, 39 demonstrations were established in all the districts, with the highest being installed in the Wenchi District in the Brong Ahafo region. Most of the districts had two demonstrations.

In Tanzania, 81 male and 45 female extension staff were trained in ISFM, crop management, and the implementation of demonstrations. In Tanzania, 5 male and 7 female farmers were trained as farmer pioneers (lead farmers) and became responsible for informing other farmers about good agronomic practices for growing cassava. In addition, 19,939 male and 23,287 female farmers received training through field days and on-the-spot training in Tanzania while another 20,323 male and 34,203 female farmers received production information through agricultural shows.

The agricultural extension staff from the project districts were trained on the use of improved agricultural technologies (ISFM and improved crop varieties), how to manage the crops in the demonstration/trial fields, and proper data collection. This type of training imparted knowledge to extension staff on ISFM technologies, crop management and field data collection, which led to precise data collected during the project period. A total of 126 extension professionals were trained on ISFM technologies, crop management, and data collection in the four project districts (Table 6.4).

**Table 6.4:** Number of extension staff trained on trial management and data collection in Tanzania

Year	Men	Women	Total
2010/11	22	19	41
2011/12	8	4	12
2012/13	51	22	73
<b>Total</b>	<b>81</b>	<b>45</b>	<b>126</b>

A total of 97,752 Tanzanian farmers were trained, primarily through field days, on the use of ISFM technologies, good agronomic practices, and improved varieties. This type of training created farmer awareness about the importance of ISFM, good agronomic practices, and improved seed, which led to increased demand by farmers for fertilizers and more productive varieties. The increased demand for and use of fertilizers, FYM, and improved varieties, along with good agronomic practices, led to increased crop yields in the project area. Among these farmers, 12 were trained as farmer pioneers (5 men, 7 women). These farmers were responsible for training others in their respective areas. Table 6.5 summarizes the number of farmers trained in the use of improved agricultural technologies in the four project districts during the project period.

Year	Field days/on-spot training		Agricultural show		Total
	Men	Women	Men	Women	
2010/11	1,451	1,279	0	0	<b>2,730</b>
2011/12	5,467	10,046	12,456	17,544	<b>45,513</b>
2012/13	13,021	11,962	7,867	16,659	<b>49,509</b>
<b>Total</b>	<b>19,939</b>	<b>23,287</b>	<b>20,323</b>	<b>34,203</b>	<b>97,752</b>

**Table 6.5:** Number of farmers trained on the use of improved agricultural technologies in Tanzania

## Lessons Learned

- 1) Participatory demonstration of ISFM technologies – involving agrodealers, processors and marketers, farmer organizations, extension agents, and print and electronic media – helped to create a common understanding of how they work and the benefits that accrue to all stakeholders. For example, agrodealers were able to learn about the types and quantities of fertilizer that farmer organizations needed, and when they needed them, and processors/marketers learned when to expect the arrival of harvested fresh roots and better anticipate the quantities they would be processing and taking to market.
- 2) Stronger partnerships along the value chain aimed at improving the livelihoods of smallholder cassava producers was another key outcome of the program, enabling farmers to move from subsistence agriculture to producing surpluses for processing and marketing. In Ghana, the AGRA GBD innovation built on the achievements of earlier efforts funded by other donors to improve cassava productivity, such as the Root and Tuber Improvement Program (RTIP), the West African Agricultural Productivity Program (WAAPP), and the Cassava Value Addition Program (CAVA). The cassava/cowpea strip intercropping practice, developed under WAAPP, and the availability and accessibility of improved planting materials from cassava multiplication sites that were established earlier by the IFAD-funded Root and Tuber Improvement and Marketing Program (RTIMP) helped to increase farmers' interest in AGRA's GBD initiative in the country.
- 3) During the GBD program implementation period, farmers were able to access subsidized fertilizers, which gave many of them a step up towards commercial cassava production.
- 4) In Tanzania, the GBD field approach motivated farmers to learn about and accept ISFM technologies related to cassava (and other crops). The knowledge they acquired about the use of fertilizers, improved varieties, and good agronomic practices quickly accelerated the demand both for higher yielding plant materials and for appropriate fertilizers. Sensitization and training of participating farmers and extension staff rapidly changed the mindset of farmers, many of whom were reluctant to invest time, energy or money to increase cassava productivity.



## Conclusions

Cassava root yields can be increased from 12 MT/ha to as much as 40 MT/ha on Africa's marginal soils using improved varieties, farmyard manure, inorganic fertilizer, and legume-based cropping systems. Reducing cassava yield gaps calls for the development and evaluation of integrated management approaches to address multiple and often-interacting production constraints. Investments in research on the agronomy of cassava cultivation and ISFM are needed, and the application of research results must be delivered to smallholder cassava producers in order to improve their livelihoods.

Both Ghana and Tanzania are important cassava-producing countries, and the options for improving soil fertility for optimal cassava production in each country are different. While the increased yields achieved under the GBD program did not necessarily translate into higher returns on investments, the evidence indicates that the benefits of ISFM interventions across Ghana and Tanzania is likely to be higher when the technology is scaled up.

### Farmer Testimonial: “Cassava production made me a businessman”

Mr. Charles Bediako is a farmer at Nchiraa in the Wenchi District of the Brong Ahafo Region of Ghana. In 2010, Charles received seed of the improved cassava variety *Bankyehemaa*, the improved cowpea variety *Nhyira*, agro-inputs, and agronomic training in cassava and cowpea cultivation. In 2010 he planted 0.4 hectares of his land to cassava and cowpea. Charles obtained a cowpea yield of 2 MT/ha in 2010 and a cassava yield of 40 MT/ha in 2011. In 2011, he started selling cuttings of improved cassava varieties to farmers in his district, as well as to farmers in the West African Agricultural Productivity Program.

With the proceeds from selling cassava cuttings, he expanded his cultivation to cover 10 hectares in late 2011, and today he has 25 hectares of land under the crop. Charles received the Best District Cassava Cultivation Farmer Award during the 2011 Farmers Day. He has also been able to attract an Investor in cassava processing, and a new factory has been established at Wenchi to process fresh cassava roots. With the processing factory now in place, smallholder farmers in Wenchi District have greater access to markets for their higher yields of cassava fresh roots, which is significantly improving household incomes.



(A)

(B)

(C)

- A) Cassava field with ISFM intervention
- B) Cassava fresh roots from the demonstration field at Ahafo Ano South District in the Ashanti region of Ghana, ready to be sent to market
- C) Cassava-cowpea strip intercrop

## Farmer Testimonial: “Cassava production has improved my life forever”

The story of Iddi Nkubuuye’s success dates back to October 2010 at the start of AGRA’s GBD program in Bukoba District, and in Kyamulaile village in particular. This was when Iddi adopted the new technologies that the program brought to the farmers in his village.

Iddi was among the early adopters. In 2010, he began by establishing a cassava Mother Demo, which enabled him to learn about good cassava management practices, including the use of improved varieties, fertilizers, and other good agronomic practices. Iddi worked closely with researchers from Maruku Agricultural Research Institute to monitor the demo’s performance.

A year later, the crop ripened and was harvested. His demo field produced 18 bags of dried cassava, from which he earned TZS 724,500 (USD 468), and TZS 450,000 (USD 290) from the sale of cassava cuttings (USD 1.00 = TZS 1550). The total amounted to TZS 1,174,500 (USD 758). Iddi says “This was a huge amount of money a farmer like me, so I decided to save it for constructing a good house”.

With the availability of such funds, Iddi was able to make burnt bricks, buy corrugated iron sheets, and

put up his new house. He was finally able to assure housing for his family (see photo below). Iddi continued to invest in cassava and learn about the new technologies, and he was rewarded accordingly with additional income and food security for his household.

Iddi’s commitment, determination, and diligence in farming enabled him to participate in a complementary enterprise – keeping improved poultry. He now gets an average of 5 eggs/day from his hens, valued at about TZS 1,500 (USD 0.97), which is enough to assure food and income security for his family.

Iddi calls for other farmers to grab the opportunities offered by the new cassava production technologies showcased by the AGRA GBD program so that they, too, can improve their farm productivity, household incomes, and eventually, their standard of living. Iddi will always remember his big break. He says, “This AGRA program is my redeemer, my savior”. In fact, the program opened the door to increased productivity for Iddi and many other farmers like him; it was up to them to pass over the threshold.



*Iddi’s new house, a product of his success with cassava production*

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# 7 Cross-country Approaches to Scaling Out Rice Production in West and East Africa

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## Key Messages:

- 1 Rice has become a strategic crop and staple food in many African countries.
- 2 Use of improved seed, fertilizers and good water management more than doubled the yield of rice in smallholder farming systems.
- 3 Smallholder rice growers who had access to affordable credit and markets were better able to adopt ISFM technologies.
- 4 Farmer organizations need to be strengthened to enable members to have access to credit and to remunerative markets.

## Introduction

Rice has become a strategic crop and a staple food in many countries across Africa and constitutes the third largest source of dietary energy on the continent (Wopereis, 2013). Once an occasional luxury food, rice is now widely consumed in sub-Saharan Africa (SSA) and has become the fastest growing food commodity in the region. It is grown both as a cash crop and staple food in smallholder systems and offers immense opportunity for food security and poverty alleviation.

The increasing demand for rice is driven by urbanization, changing lifestyles, rising income levels, shifts in consumer preferences and rapid population growth. Over the past three decades, the growing importance of the crop has

become evident in the strategic food security planning policies of many African nations. In a number of these countries, rice demand far exceeds production and large quantities of rice are imported to meet demand at a huge cost in hard currency (Nasrin et al., 2015). In 2014, Africa produced 18 million MT of milled rice, but it also imported 14 million MT of the popular grain at a cost of about USD 6 billion. In West Africa, production reached about 8.7 million MT and another 8.4 million MT were imported at a cost of USD 3.6 billion (FAO, 2014).

Rice is produced in Africa under three systems: rain-fed upland, rain-fed lowland, and irrigated lowland. In West Africa, 44% of production is grown under rain-fed upland conditions, 31% in rain-fed lowland ecosystems, 12% in irrigated lowland areas, and 13% in mangrove swamps and floodplains or deep water systems (Bill & Melinda Gates, 2012). The irrigated lowland areas yield 3.5 MT/ha on average, while lowland rain-fed and upland rainfed zones produce 2.0 MT/ha and 1.0 MT/ha, respectively (Bill & Melinda Gates, 2012). Climate smart New Rice for Africa (NERICA) varieties and other drought- and flood-tolerant and early maturing cultivars are being developed for the upland rain-fed and lowland production systems. These are being promoted alongside other popular varieties as part of AGRA's investment in the crop. In addition, key climate change mitigation approaches (transplanting and improved water management) are being promoted.

Increasing rice production in Africa is important for meeting the rising food needs of the urban poor and rural smallholder farmers. As a cash crop, production increases will contribute significantly to poverty alleviation among smallholder farmers, women and youth. Significant opportunities exist for expanding rice production on the continent as large areas of land suitable for the crop are available and the development of small reservoirs for irrigation are receiving increased support from policy makers. Several small, medium and large processing facilities are available to support domestic production of the crop, and the policy environment is becoming more favorable for production and processing of rice as a strategic crop.

- 1 Association of Church-based Development NGOs in Northern Ghana (ACDEP), P.O. Box 1411, Tamale, Ghana
- 2 Alliance for a Green Revolution in Africa (AGRA), PMB KIA 114, Accra, Ghana
- 3 Quality Rice Development Project (QRDP), CSIR-SARI, P.O. Box TL 52, Tamale, Ghana
- 4 Burkina Rice Commercialization Project (BRICOP), Sicarex, O1 BP 2625, Ouagadougou 01, Burkina Faso
- 5 Institut d'Economie Rurale (IER), BP 258, Rue Mohamed V, Bamako, Mali
- 6 Institut National de Recherche Agronomiques du Niger INRAN, BP 429, Niamey, Niger
- 7 Sokoine University of Agriculture (SUA), P.O. Box 3000, Morogoro, Tanzania

Still, there are major challenges that must be addressed before African rice production can be substantially increased. These include i) low average yields, ii) very low soil fertility, iii) high post-harvest losses, iv) the low quality and competitiveness of local rice in the rice market, v) weak farmer-based organizations with limited capacity to access services needed to improve rice production, and vi) lack of financing for production and marketing. The low yields result from limited use of inputs and high yielding varieties by smallholder farmers, who often use saved seed for planting. Of all the constraints to improving rice productivity, however, low soil fertility is the most important (see Chapter 1). As a result, integrated soil fertility management (ISFM) was conceived as a key entry point for increasing production of the crop. ISFM offers the introduction and use of improved varieties, and organic and inorganic fertilizers, combined with local adaptation of crop rotation and intercropping systems.

The current yields of 1-2 MT/ha can be more than doubled in smallholder systems when improved seed and appropriate fertilizers and other good agronomic practices are applied. It is against this background that AGRA is supporting rice production in Burkina Faso,

Ghana, Mali, Niger, Nigeria and Tanzania using value-chain approach. This chapter details the approaches, achievements and lessons learned from AGRA soil health investments in rice.

## Project Locations and Socio-economic Environments

The countries in which AGRA has invested in rice production include Burkina Faso, Ghana, Mali, Niger, and Nigeria in West Africa and Tanzania in East Africa (Table 7.1 and Figure 7.1). In Ghana, there is also a West Africa Regional Rice Project (WARRP), which provides coordination, backstopping and networking support for the West African country projects. The network map of WARRP is shown in Figure 7.2. About 116,000 smallholder farmers were targeted to benefit from improved rice seeds, access to fertilizer, training and extension services.

The selected sites ranged from favorable lowlands and irrigated rice production systems in the dry Sudano-Sahelian, to moist savannahs with annual rainfall ranging between 600-1400 mm. The selected smallholder farmers are poor with landholdings between 0.25-2 hectares.

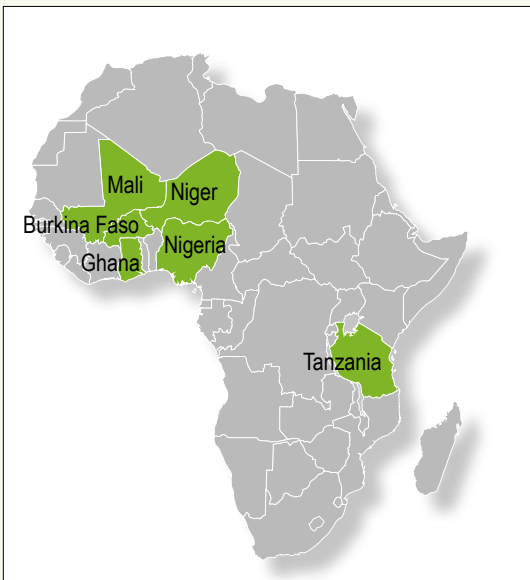


Figure 7.1. AGRA rice producing countries

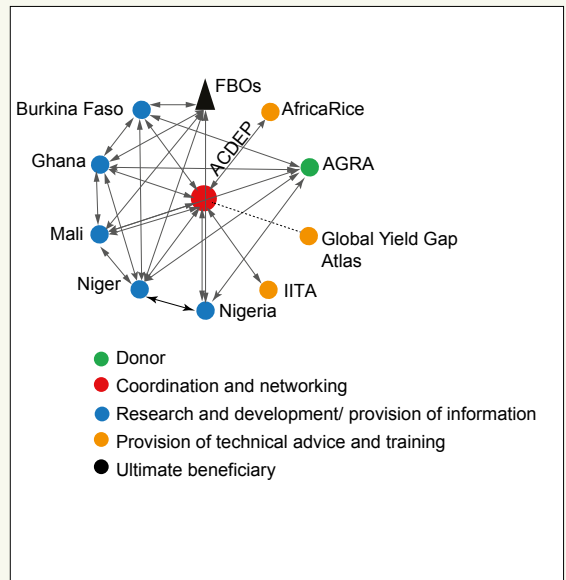


Figure 7.2. West Africa Regional Rice Project network map

**Table 7.1.** Project countries and locations

Country	Project Sites/ Locations	Agro-ecology	Number of Farmers Targeted	Soil Type	Rainfall (mm)
Burkina Faso	Houet Region	Sudano-Sahelien	20,000	Lixisols, Gleysols	900-1200
	Kéné Dougou Region				
Ghana	Upper East Region (25 communities)	Sudan/Guinea Savannah	20,000	Luvisols/ Gleysols	900-1000
	Northern Region (18 communities)	Guinea Savanna			1000-1200
Mali	Sikasso Region (7 districts)	Sudan/Guinea Savannah	10,000	Plinthosols/ gleysols	900-1200
Niger	Tillabéry Region (5 districts)	Sahelian	26,000	Gleysols	500-600
Nigeria	Niger state (6 Local government areas)	Guinea Savannah	20,000	Lixisols and Vertisols	1000-1200
	Kebbi State (6 Local government areas)	Guinea Savannah			1000-1200
Tanzania	Kyela and Mbarali Districts	Moist Savannah	20,000	Fluvisols, Gleysols, Vertisols	600-1400

The soils are generally low in nutrients, especially N and P; K is adequate, except in Mali (Table 7.2).

**Table 7.2.** Mean soil characteristics across project sites in each country

Parameter	Burkina Faso	Ghana	Mali	Niger	Nigeria	Tanzania
pH (Water)	6.3 ± 0.17	5.28 ± 0.66	4.7	6.5	4.23 ± 0.90	6.5 ± 0.85
Org. C (%)	1.33 ± 0.34	0.75 ± 0.31	0.58	0.91	2.23 ± 0.61	2.2 ± 0.81
Total N (%)	0.09 ± 0.02	0.06 ± 0.03	0.07	0.023	0.06 ± 0.03	0.18 ± 0.09
P (mg/kg)	4.6 ± 1.6	5.44 ± 3.31	9.3	3.8	18.7 ± 9.26	11.9 ± 6.6
K (mg/kg)	-	119.8 ± 28.7	47.5	312	243.2 ± 108.6	479.7 ± 174.9

## Approaches Used

Demonstrations were used from 2012 to 2015 to create awareness and showcase bet-bet ISFM technologies on rice at multiple locations in all six countries. Graduate students also collected data through field experimentation to support the on-farm demonstrations.

A value chain approach was used to scale out ISFM, with the following activities being given prominence.

## Awareness creation and training on ISFM

A total of 1,156 demonstrations were established to showcase improved varieties, nursery and transplanting practices, fertilizer use, and good agricultural practices (GAP) in general. Farmer Field schools (FFS) and Farmer Field Fora were used to train farmers (Table 7.3). Field days were held to expose non-participating farmers and policy makers to the evaluation demonstrations planted by participating farmers. In Ghana, tricycle farm video vans were used to show videos about ISFM. Radio broadcasts on ISFM were also used in all countries to help create farmer awareness.



## Farmer organization development

Primary farmer organizations (FOs) were registered and trained in governance, contracting, credit management, and warehouse receipt systems. Two apex FOs were established in Ghana from among existing FOs to support and extend the influence and bargaining power of the primary FOs.

## Partnerships

Private sector input dealers joined in partnerships to enhance the supply of seeds and fertilizer to farmers.

## Linkages to financial services

Attempts to link farmers to financial institutions are ongoing in all six countries. In Ghana, CSIR-Savanna Agricultural Research Institute partnered with the CARD-Financial NGO (a non-bank microfinance institution) to provide credit and market services to farmers (see case study below). Through this credit arrangement, farmers were able to access inputs and market their produce. In Tanzania, farmers were given starter packs of improved seeds and fertilizers through a revolving fund credit scheme.

## Harvesting and processing

Farmers are being supported with the provision of threshers and reapers. Drying platforms, tarpaulins and moisture meters were also provided to FOs to facilitate grain drying. Farmers were trained in parboiling and post-harvest management of rice to ensure good quality of local rice in order to increase its competitiveness on the market.

## Access to markets

In all six countries, meetings were held between farmers and buyers/aggregators to facilitate marketing of produce. Aggregating centers were created in Burkina Faso, Ghana, Tanzania and Mali to facilitate rice marketing.

## Technologies tested in demonstrations

Technologies developed by the International Rice Research Institute (IRRI), AfricaRice, and from such previous projects as the Valley Bottom Rice Project (VBP), the Emergency Rice Project, and the Rice Sector Support Project (RSSP) were selected with farmers for demonstration purposes, using farmer practices as controls.

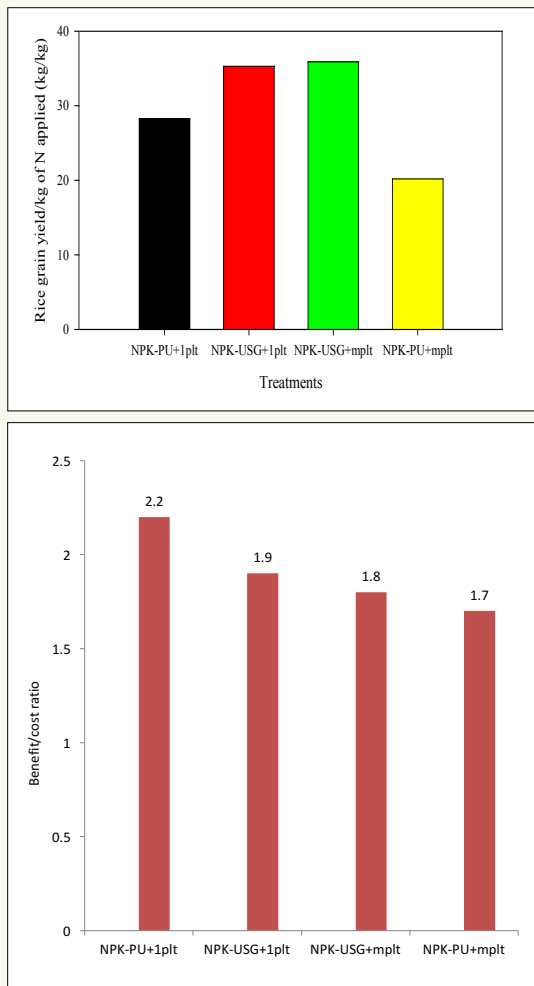
## Demonstrations and treatment descriptions

- 1) Effect of transplanting, fertilizer type and application method on rice yield in Burkina Faso, Ghana and Niger:
  - a) Treatment 1: (Farmer practice): Transplant three to five seedlings per hill and broadcast NPK 15-15-15 shortly after planting, followed by broadcasting of urea at flowering (NPK-Prilled Urea + multiple plants);
  - b) Treatment 2: (Slight modification of farmer practice) Transplant one seedling per hill while maintaining the farmers' fertilizer application methods (NPK- Prilled Urea + 1 plant);
  - c) Treatment 3: Transplant one seedling per hill, followed by broadcasting NPK fertilizer after transplanting and USG deep placement of Urea Supergranules (USG) (a best-bet practice) (NPK-USG + 1 plant); and
  - d) Treatment 4: Transplant many seedlings (farmers' transplanting method) and apply NPK and USG deep placement (NPK-USG + multiple plants). In Ghana and Burkina Faso only treatments 2 and 3 were demonstrated.
- 2) Effect of compost and inorganic fertilizer on rice yield in Northern Ghana and Mali:
  - a) Treatment 1: No fertilizer
  - b) Treatment 2: Apply compost at 1.5 MT/ha
  - c) Treatment 3: Apply mineral fertilizer at recommended rate of NPK 60-40-40 kg/ha
  - d) Treatment 4: Apply compost at 1.3 MT/ha and add mineral fertilizer at recommended rate
  - e) Treatment 5: Apply compost at 3 MT/ha and add mineral fertilizer at recommended rate
- 3) Effect of sowing methods on rice yield in Ghana. In this demonstration, direct seeding either in a row or haphazardly was compared to transplanting and broadcasting. The treatments were: 1) broadcasting (farmer practice), 2) dibbling haphazardly, 3) dibbling in rows, and 4) transplanting in rows.
- 4) Effect of processed rock phosphate (Minjingu-Mazao with nitrogen 10%, P<sub>2</sub>O<sub>5</sub> 19%, boron 0.3%, sulfur 5%, zinc 0.5%, MgO 1.5% and CaO 25%) at different P rates and Di-ammonium phosphate (DAP) on rice yields in Tanzania:
  - a) Treatment 1 (farmer practice): No phosphorus is applied at planting, but 80 kg/ha N is applied at flowering (P0);
  - b) Treatments 2: Apply 20 kg of P/ha at planting from Minjingu-Mazao and follow by 80 kg/ha N at flowering (P20 MRP);
  - c) Treatment 3: Apply 30 kg of P/ha at planting from Minjingu-Mazao and follow by 80 kg/ha N at flowering (P30 MRP); and
  - d) Treatment 4: Apply 30 kg P/ha from DAP at planting follow by 80 kg/ha N at flowering (P30 DAP).

# Achievements

## Demonstration outputs

*Effect of transplanting, fertilizer type and application method on rice yields* – Because the N rates used by each country are different for each treatment, agronomic efficiency (AE) expressed as rice grain yield produced per unit of N applied was used as the basis of comparison. There was significant gain in the AE of N when rice is transplanted at 1 seedling per hill and USG is used as topdressing. When several seedlings are transplanted per hill, as farmers often do, using USG instead of prilled urea can increase the AE of nitrogen use on rice (Figure 7.3a).

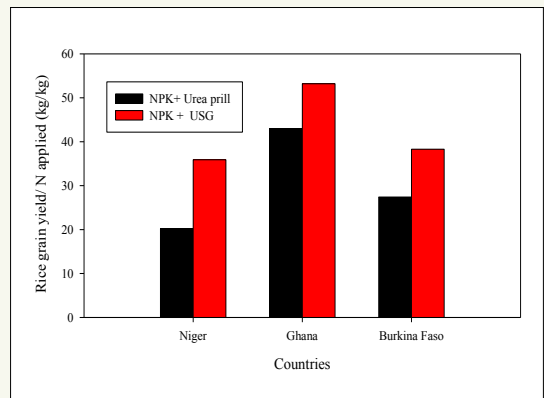


**Figure 7.3.** Effects of fertilizer management on the agronomic efficiency of nitrogen and benefit/cost ratios in 5 districts in Niger; NPK-PU+1plt = 1 seedling/hill + farmer practice, NPK-USG+1plt = 1 seedling/hill + USG, mplt = several seedlings per hill.

In Niger, transplanting rice at 1 seedling per hill with the farmer fertilizer application method (broadcasting urea as topdressing) increased rice yield from 5.4 MT/ha to 7.2 MT/ha and increased AE by about 30% over the farmers' practice. The use of USG, which reduces N loss from fertilizer, is a climate smart practice and merits scaling up and wider adoption. However, increased adoption will require policy support to make the USG available to farmers at a subsidized price.

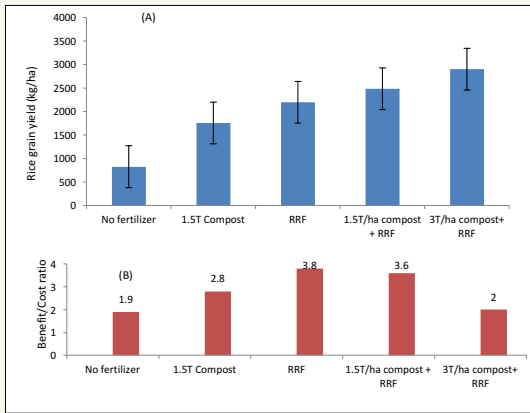
The benefit cost ratio (BCR) shows that transplanting one seedling per hill, combined with the farmer's fertilizer application method (topdressing with urea by broadcasting), performed better than transplanting one seedling per hill combined with USG (Figure 7.3 b). The difference is due to the extra labor required for USG application.

Across Niger, Ghana, and Burkina Faso, however, a gain of 30% in AE of N was achieved with USG (39 kg/kg) compared with prilled urea application (27.6 kg/kg) (Figure 7.4).



**Figure 7.4.** Effect of prilled urea and USG on the AE of N in Burkina Faso, Ghana and Niger

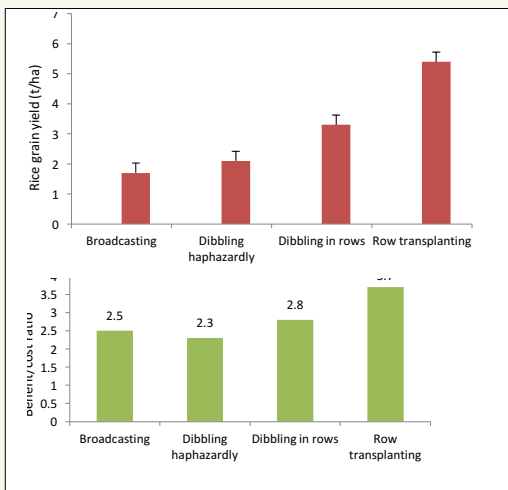
*Effect of compost and inorganic fertilizer on the yield of rice* – Integrated use of compost at 3 MT/ha and mineral fertilizer in Northern Ghana, increased yield of upland NERICA rice by 350% over the farmers' practice (Figure 7.5). Average yield increases as a result of compost application ranged from 288 to 705 kg when 1.5 and 3 MT/ha of compost, respectively, were applied. Integrated use of compost and mineral fertilizer is a climate smart technology that reduces fertilizer losses, increases soil water availability, and sustains crop yield. To increase the use of compost in rice production and take the technology to scale, Ghanaian farmers were trained to compost rice straw and crop residues.



**Figure 7.5.** Effect of organic fertilizer (fertisoil) and inorganic fertilizer and benefit cost ratios (BCR) on rice in Northern Ghana; RRF = recommended fertilizer rate. Bars = se

The BCR values indicate that the recommended rate of mineral fertilizer application (RRF), and compost at 1.5 MT/ha + RRF offer the best returns on investment (Figure 7.5 b).

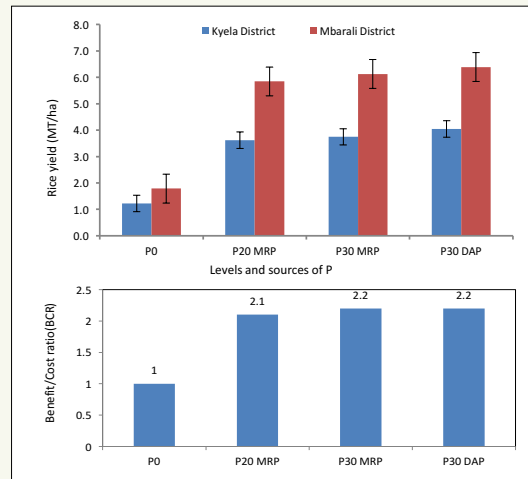
**Effect of planting methods on rice yield** – Row transplanting was found to be the best method for planting rice. The yield advantage of this method was 300%, 150% and 40% over the farmers’ practice, dibbling haphazardly, and dibbling in rows, respectively (Figure 7.6). The benefit cost ratio of row transplanting was 148% relative to the farmers’ practice (broadcasting). Availability of labor for transplanting is a key factor affecting adoption of this technology.



**Figure 7.6.** Effect of planting methods on paddy yield and benefit cost ratios (BCR) in Ghana

**Effect of processed rock phosphate at different P rates and di-ammonium phosphate (DAP) on rice yields** – The use of Minjingu Mazao and DAP significantly increased the yield of rice compared to the farmers’ practice in Kyela and Mbarali Districts in Tanzania (Figure 7.5). Application of 20 kg P/ha from Minjingu Mazao increased the yield of rice by over 200% above the farmers’ practice in Kyela and Mbarali Districts of Tanzania. This was comparable to the yield gained from using 30 kg/ha P from DAP. Benefit cost ratio values show that all three treatments are more profitable than the farmers’ practice (Figure 7.7).

In general, transplanting with either type of fertilizer is recommended. However, since Minjingu Mazao is locally available and slightly cheaper, policy support should be given to increase its usage.



**Figure 7.7.** Yield of rice and benefit cost ratios (BCR) as affected by Minjingu Mazao and DAP in Tanzania; P0 = farmers’ practice, P20 MRP = 20 kg P/ha from Minjingu, P30 MRP = 30 kg P/ha from Minjingu, and P30 DAP = 30 kg P/ha from DAP in Tanzania. Bars = se

## Dissemination and capacity building

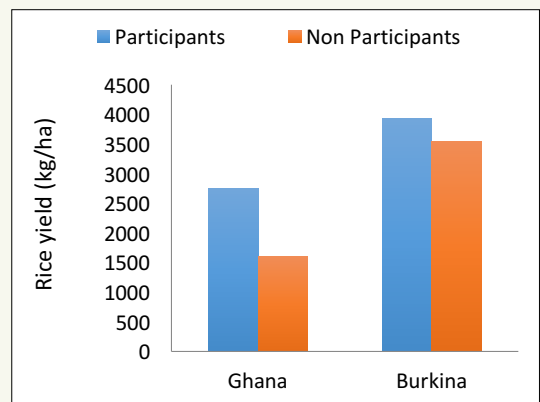
**Farmer training** – A total of 41,000 rice farmers out of the 116,000 targeted have so far received ISFM knowledge through field days, field schools, video programs, radio and leaflets, and 89% of those reached practiced ISFM (Table 7.3). The number of farmers that have received ISFM knowledge is small (35%) at this stage, however, the West Africa projects are ongoing and the number of farmers involved is expected to increase. In Ghana the use of tricycle video vans and formation of radio listening clubs led to much greater number of farmers reached than the other countries. The video van contains an LCD projector, a generator, a video deck or

laptop, and a public address system, which are used to show videos about ISFM and rice production. A total of 19,647 farmers were trained on ISFM and GAP, with up to 56% of the participants in Mali being women (Table 7.3). In addition to ISFM, training was conducted in other areas. For example, in Ghana 1,665 members of farmer organizations were trained in governance, business development strategy, and financial management; 1,970 women were trained in marketing, and 210 in par-boiling, branding and packaging of rice. In Tanzania, Niger and Burkina Faso, farmers learned about warehouse receipt systems and post-harvest management. This training work was very important to the scaling up of ISFM and GAP in rice.

*Training of extension staff*— A total of 391 extension staff across the countries received training in GAP, management of demonstrations, and data collection. This training improved the quality of data collected from the demonstrations, as well as the quality of extension services provided to farmers.

*Impact of farmer training and participation in ISFM demonstrations on rice productivity in farmers' fields* – To measure the impact of farmer training and subsequent participation in the implementation of ISFM demonstrations on farmers rice yields and productivity, yield data were taken from participating and non-participating farmers' fields in Burkina Faso and Ghana. In Ghana, farmers who received training went on to participate in the implementation of demonstrations. Trained farmers in Burkina Faso did not participate in the implementation of demonstrations. Equal numbers of participating and non-participating farmers were randomly selected for this assessment. Five 4-metre

square sample areas were demarcated randomly in each farmer's field for yield assessment. The area was then harvested and yields from the 20 m<sup>2</sup> harvest area were converted to yield per hectare. A farmer's participation in ISFM training and the subsequent implementation of a demonstration had a significant influence on his or her rice yields (Figure 7.8). The average yield increase on farmers' fields as a result of being trained in ISFM and subsequently participating in demonstrations (as in Ghana) was about 70% higher than for those who did not participate in implementing demos. The impact of farmer training alone resulted in an average yield increase of only 11% in Burkina Faso. This shows that participation in demonstrations increases farmers' knowledge far beyond what training alone can do.



**Figure 7.8** Rice yield from farmers' fields was positively affected by participation in demonstrations in Ghana and Burkina Faso

**Table 7.3.** Capacity building, demonstrations and uptake of ISFM in West and Eastern Africa

Country	Farmers Aware	Farmers Using ISFM Technologies	Farmers Trained Directly	Extension Agents Trained	Number of Demos Established
Burkina Faso	10,000	8,086	8,086 (2811 women)	24	34
Ghana	21,000	16,000	8850 (2655 women)	75	290
Mali	10,000	-	672 (376 women)	70	716 (64% women, 36% men)
Niger	ND	2,000	123	27	5
Nigeria	ND	10,491	612 (44 women)	-	11
Tanzania	-	-	1,304	195	100
<b>Total</b>	<b>41,000</b>	<b>36,577</b>	<b>19,647</b>	<b>391</b>	<b>1,156</b>



## Farm Input Financing: A Case Study of the CARD-FNGO/ CSIR-SARI Cashless Lending Facility

In Ghana, the CARD-FNGO partnered with CSIR-SARI to help take AGRA-sponsored soil health project technologies beyond the demonstration stage. This 3-year program has been implemented in nine districts of Ghana's Northern Region. ISFM practices include appropriate fertilizer and organic input management, together with the use of improved crop varieties that are adapted to local conditions.

### Project funding

Through AGRA, CSIR-SARI granted a revolving fund of USD 100,000 to the CARD-FNGO for on-lending to smallholder farmers using its innovative cashless financial services model, an in-kind input credit scheme in which farm inputs and services were supplied to farmers. The Crops Cashless Financial Service (CCFS) model is summarized in Figure 7.9.

### The main features of the CARD-FNGO Model

- 1) Sensitization of farmers on the Crops Cashless system and the importance of forming Credit Worthy Groups (CWGs);
- 2) Acceptance of in-kind fixed terms of repayment;
- 3) Door-step delivery of farm inputs and services;
- 4) Training on agribusiness practices; and
- 5) Management of the challenges associated with price fluctuations, warehousing and marketing of inputs and outputs.

### Sensitization of farmers on the Crops Cashless Financing Model (CCFS)

The CCFS model was presented to farmers and community leaders. Complete information was provided to farmers on the arrangements CARD made with input and service suppliers that work with farmer group executives so that these services and inputs are provided at the right time. Beneficiary farmers were provided with the procedures to be followed while waiting to receive

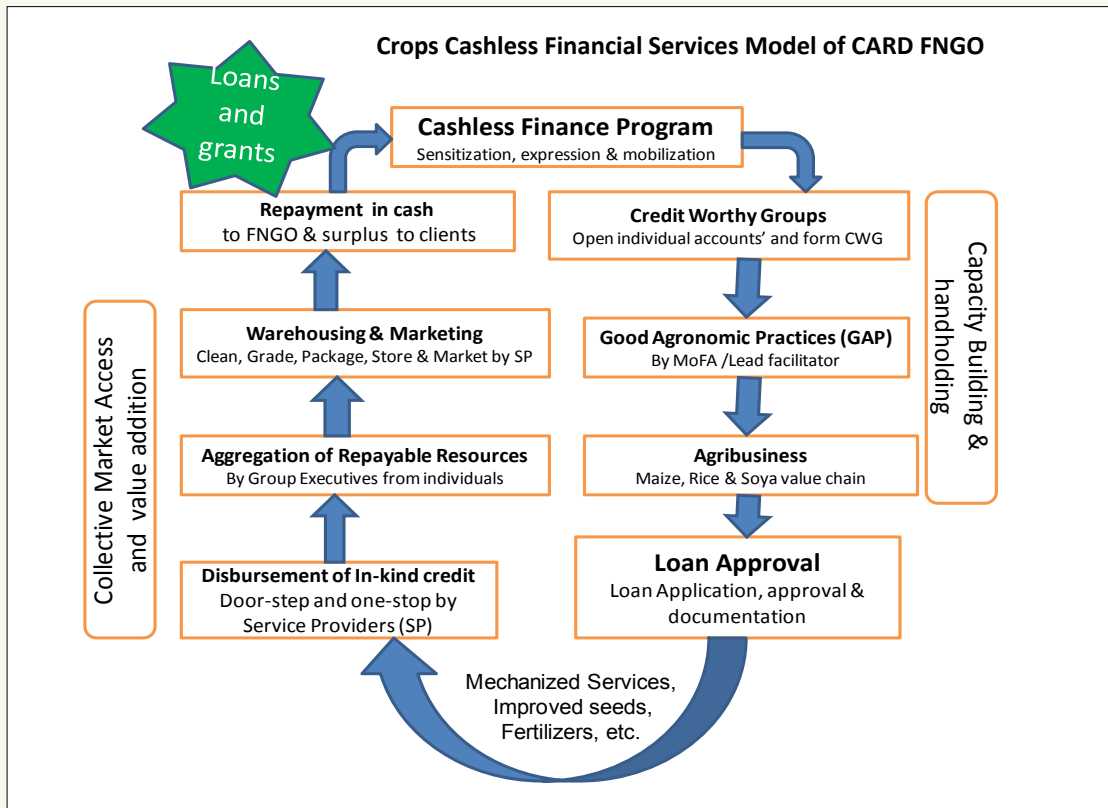


Figure 7.9. Cashless Financial Services Model of CARD-FNGO

their inputs, and how aggregation was to be done so as to ease loan repayments. In all, 9,750 farmers and community leaders were sensitized on the CSIR-SARI/CARD Scheme.

### Organization of individual farmers into Credit Worthy Groups (CWGs)

Farmers were organized into CWGs and they elected their leaders – a Chairperson, a Secretary and a Treasurer – to steer the affairs of the group. The CWGs were made up of members from existing farmer groups who accepted the credit terms. CARD provided support and mentoring to help form the groups. In the three-year period, 38 CWGs were formed in the first year, 49 in the second year, and 51 in the last year of the program.

### Disbursement of inputs and services to group members

Farmers received in-kind credit in the form of farm inputs and services instead of cash, which they may be tempted to spend on other family needs instead of acquiring needed inputs and services. Each of the farmers received inputs costing an average of USD 100. Input service providers, with the consent of the CWG executives, disbursed the cashless credit directly to the farmers' doorsteps. The inputs and services were arranged before the start of the farming season with service providers.

### Training on Good Agricultural Practices (GAPs) and agribusiness

As the focus of the project was soil fertility management, farmers were taken through the fundamentals of soil fertility maintenance and improvement. SARI trained extension agents, who in turn trained CARD staff and farmers.

### Duration of credit and its repayment

Inputs and services were delivered to client farmers during the months of May-July. The clients began compiling their in-kind repayments, or cash, or both, between November and February, working with the Credit Officer. Full repayments were made during the months of April-July when prices are normally higher, such that farmers could cover the principal, interest and services fees.

### Aggregation, warehousing, marketing and repayment

The role of the CWG executives was to ensure timely recovery/aggregation of farm produce from beneficiary farmers for onward transport to warehouse.

The group executives determined the selling price jointly with CARD-FNGO, aiming to capture peak produce prices based on market information. After the produce was sold, the farmers repaid their debts to the project and kept the excess. The repaid funds were used to continue the revolving fund for the cashless credit scheme in subsequent years.



### Farmer Testimonial

Atabisa Akolga has finally overcome the challenge of low rice yields. She joined the AGRA SHP Quality Rice Development Project (QEDP), implemented by CSIR-Savanna Agricultural Research Institute, in partnership with Amsig Resources and Trias in Ghana during the 2014 cropping season. Atabisa Akolga is 60 years old and a widow. She is a resident of Veza Zangongo catchment community in the Veza irrigation scheme in the Upper East Region. She is a rice farmer and heads a household of nineteen people. By participating in the QRDP, her crop productivity has risen sharply. Atabisa said, *“I harvested 5 MT/ha instead of the usual 0.6 MT/ha. This intervention has increased my farm yield even at a time when we still do not get the best services from irrigation, and we have to plant on the same piece of land that we consider no more fertile”*.

## Interest rate and services fees

A management fee of 2.5% was incurred on the total approved loanable funds, while an interest rate of 1.5% per month was charged on the amount disbursed to any client farmer. In addition, the client paid all service fees for aggregation, transportation, warehousing and marketing.

## Monitoring the use of inputs

Credit officers and group executives visited beneficiary farmers in the field 1) to help ensure the efficient use of the inputs received, and 2) to avoid the painful situation in which farmers, in the midst of pressing social needs, might sell the fertilizers and agrochemicals for immediate cash, resulting in poor farm yields, and in the process compromising their ability to repay the credit received.

## Impacts and outcomes CCFS approach

- 1) From a total of 4,818 farmers (50% being women) who had direct access to in-kind credit in the form of farm inputs and services, and reliable off-taker markets, 1,445 were rice farmers.
- 2) ISFM and credit interventions increased rice yields from 1.5 MT/ha to 3 MT/ha, with a total of 10,120 household members benefitting from the increased yields.
- 3) A total of 13,000 MT of paddy rice was produced by farmers, which at a price of USD 372/MT amounted to USD 4.84 million in income.
- 4) Qualitatively, farmers shared various opinions on how adopting the new technologies have translated into harvesting higher yields, sufficient food to feed their families, and increased income.

## Lessons Learned

- 1) Technologies developed by earlier donor-funded projects provided a range of options for scaling up ISFM.
- 2) Availability of improved rice seeds and fertilizers enhanced farmer uptake of ISFM.
- 3) Training and demonstrations enhanced the productivity of rice in farmers' fields.
- 4) The labor required to apply Urea Super Granules fertilizer (USG) limited its profitability and adoption.

## Conclusions

Agronomic efficiencies of nitrogen use by rice can be increased by the application of USG instead of prilled urea and transplanting at one seedling or more per hill. Compost application, in combination with mineral fertilizer, enhances the productivity of upland rice. The application of P at 20

kg/ha from processed rock phosphate containing nitrogen, sulfur, zinc and boron increases average rice yields to a level on a par with di-ammonium phosphate at 30 kg P/ha. Farmers benefit more by transplanting than dibbling haphazardly or in rows. Input financing through the micro-finance NGO greatly enhanced farmer access to inputs and remunerative markets. Partnerships with the private sector – particularly agrodealers, financial NGOs and marketers – are important for increasing rice production. The WARRP coordination project contributed to building the capacity of country project teams and also enhanced cross-country learning. AGRA's contributions to rice cultivation are moving in the right direction and offer diverse models for increasing production.

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# 8 Promoting the Benefits of Liming Acidic Soils

**Authors:** *Vicky Ruganzu<sup>1</sup>, Martins Odendo<sup>2</sup>, David Kimani<sup>3</sup> and Bashir Jama<sup>4</sup>*

## Key Messages:

- 1 Crop productivity in sub-Saharan Africa is often constrained by soil acidity and related elemental toxicities or nutrient deficiencies
- 2 Applying agricultural lime is one of the most effective ways to reduce soil acidity and increase crop productivity
- 3 The use of lime is constrained by limited awareness about the benefits of liming, the difficulties in its application, poor access by farmers, and its high cost.
- 4 Creating farmer awareness about the benefits of lime and facilitating their access to the input will increase its use and raise crop yields and income

## Introduction

Soil acidity, with its associated elemental toxicities and nutrient deficiencies, adversely affects crop growth and limits agricultural productivity (Nduwumuremyi, 2013), especially in high rainfall areas in tropical sub-Saharan Africa (Kisinyo, 2011). Soil acidity condition occurs due to natural processes such as heavy rainfall, the decomposition of organic matter, and biological nitrogen fixation. Moreover, the condition is exacerbated by various farming practices, such as the use of plant types that contribute to acidity and the continuous application of acid-forming fertilizers like di-ammonium phosphate (DAP) and urea (Nekesa, 2007; Obiri-Nyarko, 2012; Mbakaya et al., 2010). Acidic soils with a pH lower than 5.5 – which is considered the maximum level of soil acidity if land is to be used for growing most crops – occupy about 29% of the total land area in sub-Saharan Africa. Not surprisingly, different countries are afflicted to different extents. For example, about 13% and 45% of the land in Kenya and Rwanda is, respectively classified as acidic (Beernaert, 1999; Kanyanjua et al., 2002). Soil acidity reduces crop yields by about 10% in tropical areas (Sierra et al., 2003)

and in Kenya acidic soils reduce yields anywhere from 16-28% (Ligeyo, 2007).

Applying agricultural lime (hereinafter referred to as lime) to acid soils raises soil pH, benefiting soil properties and plant growth (Caires, 2006). It improves the efficiency with which some soil nutrients are used by increasing their availability to plants, it enhances root growth (Fageria & Baligar, 2008), and it can have long-term benefits. Using lime on acidic soils, along with other good agricultural practices, can significantly increase crop productivity (Mbakaya et al., 2010).

Despite its documented benefits, the use of lime by Africa's smallholder farmers is low. This is due to inadequate farmer awareness, limited availability, high cost (primarily because of high transport costs), and the poor access of smallholders to financial services. Against this backdrop, AGRA's Soil Health Program invested in raising smallholder awareness and increasing their access to lime in Kenya and Rwanda, where acid soils occupy large areas.

This chapter details the approaches used to create awareness about the benefits and use of agricultural lime and to facilitate smallholder access to lime, fertilizers and other inputs in line with AGRA paradigm shift of Going beyond demos (GBD). Achievements and lessons learned from these efforts are also summarized.

## Project Sites

In Kenya, the project was implemented in Siaya and Kakamega Counties<sup>5</sup>. The elevation of Siaya County ranges from 1,140 to 1,400 meters above sea level (masl). The County experiences a bimodal rainfall pattern, with long rains occurring from mid-March to July/August and short rains from September to November. Average rainfall averages from 800-2,000 mm/year. The soils are predominantly "Orthic Acrisols" that are well drained, deep and friable (crumbly), but in some places shallow. The elevation of Kakamega County ranges from 1,300-1,900 masl, and the County has a bimodal annual rainfall that totals 1,200-1800 mm/year (Table 9.1). The dominant soils are highly weathered clay loams classified as Acrisols. The project sites are known to be generally

1 Rwanda Agriculture Board (RAB), P.O. Box 5016, Kigali, Rwanda

2 Kenya Agricultural & Livestock Research Organization (KALRO), P.O. Box 169, Kakamega

3 Alliance for Green Revolution in Africa (AGRA), P.O. Box 66773-00800, Nairobi, Kenya

4 Islamic Development Bank, 8111 King Khalid St., Saudi Arabia

5 The Government of Kenya is devolved and consists of one national and 47 county levels governments that are distinct and interdependent and conduct their mutual relations on the basis of consultation and cooperation.



**Table 8.1:** The trial and demonstration site characteristics in Kenya and Rwanda

Country	Site	Soil Type	pH (H <sub>2</sub> O)	P (ppm)	Agro-ecological Zone	Mean Rainfall (mm)	Temp. (°C)
Kenya	Siaya	Orthic-Acrisols	4.9-5.7	3.0	Upper/midland	2,000	15 to 30
	Kakamega	Humic-Acrisols	5.2-5.4	5.2	Lower midland	2,000	8 to 25
Rwanda	Nyaruguru	Acrisols	4.2- 5.2	6-1	Central Plateau	1,600	13 to23
	Nyamagabe	Ferrisols	4.4 -5.2	7-16	Congo-Nil watershed divide	1,688	14 to23
	Gisagara	Ferralsols	5.1-6.0	8-20	Central Plateau	1,350	17 to23

**Source:** Mbakaya et al. 2010; Jaetzold et al. 2005; Ruganzu, 2013

acidic, but for purposes of the project, the soils of each farm that hosted demonstrations were sampled and analyzed.

In south Rwanda, project implementation was in Nyaruguru, Nyamagabe and Gisagara Districts. These three districts are located along the Southwest Central Plateau and the Congo-Nile watershed divide. The soil types range from Acrisols to Ferralsols with low pH. Among the three sites, Nyaruguru and Nyamagabe are the most acidic (pH of 4.4-5.2) as compared to Gisagara (with a pH of 5.1-6.0). This region also experiences long and short rainfall periods, with total rainfall averaging 1,600-1,700 mm/year in Nyaruguru and Nyamagabe, and 1,350 mm/year in Gisagara.

## Creating Awareness

A participatory process was used to select demonstration (demos) treatments, as well as the farmers that hosted awareness-creating field demonstrations. Focus group discussions (FGDs) and key informant interviews helped in designing the demos. Researchers and extension agents worked together to propose “best-bet” technologies for the demos involving burnt lime that contained 92.5% calcium carbonate (CaCO<sub>3</sub>), provided by Homa Lime Company Ltd in Western Kenya. Local farmers validated the proposed treatments as being appropriate for their circumstances.

A mother and baby design was used in setting up the demonstrations. In Kenya, from the 2009 short rains season to the 2012 long rains season, a total of 40 mother and 600 baby demonstrations were established to raise the awareness of farmers and other stakeholders about the effects of lime on acidic soils and related improvements in maize yields. The mother demonstrations comprised a set of four treatments: 1) lime only; 2) lime + di-ammonium phosphate (DAP); 3) DAP alone; and 4) the control (no lime and no fertilizer). A popular maize hybrid (H513) was planted as the test crop and the same

recommended management practices were applied across all treatments. These treatments were selected based on perceived effectiveness in improving crop productivity and economic benefits. Each treatment was applied on 10 x 10 m plot.

The farmers that hosted the mother demonstrations were selected in collaboration with extension workers and community representatives during FGDs, supported by key informant interviews. Researchers, in collaboration with extension workers and host farmers, established the validated treatments on the mother demonstrations. Four treatments were used: 1) lime only; 2) lime + di-ammonium phosphate (DAP); 3) DAP alone; and 4) the control (no lime and no fertilizer). A popular maize hybrid (H513) was planted as the test crop and the same recommended management practices were applied across all treatments. The “baby” demonstrations comprised a subset of three or less of the treatments used in the mother demos, and were planted and managed by participating farmers. Qualitative feedback was obtained from meetings between farmers, extension workers and researchers, and during the six field days that were held around the demonstration plots. Moreover, four farmer-exchange visits involving local authorities, extension workers, agrodealers, and farmers were conducted to help create more awareness.

Similarly, in Rwanda mother and baby demonstrations were set up on farmers’ fields using commonly grown Irish potato, wheat, beans and soybeans as test crops. The mother demos contained four treatments: 1) the farmer practice (no lime + compost from household organic waste), 2) application of 3.5 MT/ha of lime (travertine) + fertilizer, 3) 3.5 MT/ha of lime + 5 MT/ha of farmyard manure, and 4) 3.5 MT/ha of lime + 5 MT/ha farmyard manure + fertilizer. The fertilizer rates were 51 kg/ha N, 20 kg/ha P, and 38 kg/ha K for potato and wheat, and 18 kg/ha N and 20 kg/ha P for beans and soybeans. These application rates were based on research recommendations in the region.

## Building Capacity

Primarily, agrodealers, extension workers and farmer groups were used as avenues for dissemination of technologies and this required capacity building to enable them effectively deliver knowledge and information to the farmers.

In Kenya, the project strengthened 32 farmer groups by organizing them into commercial units. Each group had an average membership of 30, with a 1:2 ratio of men to women. The project trained and strengthened the capacities of these farmers in group dynamics, leadership, business skills, good agronomic practices, and value addition. The group members and other individual farmers, agrodealers, extension workers, and local authorities were trained on various aspects of liming, including the rate, method and timing of lime application, fertilizer use, and good crop management practices.

The capacity of government and non-government extension officers to disseminate lime and other ISFM practices to farmers at the grassroots was enhanced through relatively advanced training that focused on elements and principles of ISFM, good agronomic practices, options for marketing inputs and outputs, and group governance.

In Rwanda, awareness was created through agrodealers, lead farmers and extension workers. The project trained them on the use of lime, organic and inorganic fertilizers for increasing crop productivity. Demos were used to show case performance of different lime treatments.

## Facilitating Market Access

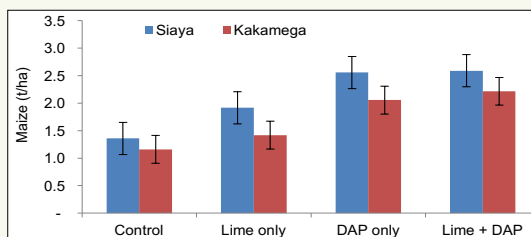
In Kenya, the project used an innovative model featuring a value chain approach for each of the target crops, working with farmer associations to reach more producers, and engaging effectively with the private sector to improve access to input and output markets. The key private sector players brought on board included: lime production companies in the region; agrodealers that stock fertilizers, improved seeds, and in some cases lime; Equity Bank and microfinance institutions (which provided credit to some of the participating farmer associations); and aggregators of produce (which helped improve access to output markets). For example, sugar companies came on board to help farmers involved in their out-grower schemes to access lime, having observed the benefits of using lime on their crops. This comprehensive approach produced remarkable results and generated tremendous enthusiasm among all the actors involved.

In Rwanda, linkages of agribusiness stockists, farmers and retailers were strengthened through collaboration with financial institutions to facilitate farmer cooperatives in obtaining loans. Market-related training was provided

to different stakeholders, including lime producers, local administrators, NGOs and financial institutions. Fertilizer was supplied through 50% subsidy schemes by the government and other stakeholders, while improved seeds were acquired using a revolving fund. The farmers involved in liming were linked to agrodealers who were also linked to manufacturers. Local authorities facilitated the organization of farmer groups into cooperatives in order to improve their access to inputs and to financial services.

## Achievements

In Kenya, the Going beyond Demos (GBD) approach was used to train 20,000 farmers in the use and benefits of lime through field days, field demonstrations and exchange visits. About 12,800 (64%) were using lime three years after testing it. In the two target counties, average on-farm maize yields improved from 1.3 MT/ha to 2.5 MT/ha among farmers that adopted lime, fertilizers and improved seeds (Figure 8.1). A cost-benefit analysis showed that using a combination of lime with DAP was the most profitable treatment – on average, for every Kenya shilling invested in the treatment, farmers realized additional return of 3 Kenya shillings. This clearly demonstrated that use of lime and DAP was a viable practice. The positive effects from liming increased demand for lime by agrodealers in Kakamega and Siaya counties, which increased from zero in 2008 to 4,000 and 6,000 MT, respectively within three years of the project.



**Figure 8.1:** Mean maize yields under different treatments in western Kenya (2010-2012)

Observing the yield benefits due to using lime on maize, participating farmers extended lime application to other crops, including sugarcane, sweet potato, beans, and horticultural crops. This resulted in increased yields, greater household food security, and increased incomes. The use of lime on sugarcane rose dramatically, from zero hectares in 2009 to over 40,000 hectares by the end of 2011.

Soil tests in project areas where lime was applied revealed a reduction in acidity levels over the three years of project implementation (Table 8.2). The initial soil analysis in September 2009 before the application of lime showed soils were highly acidic, with initial pH (1:2.5, soil: water) averaging 5.2 and 4.9 in Kakamega and Siaya Counties,



## Farmer Testimony: Francis Sakula, from Kakamega North district, Kenya

“In our village, we thought the land was bewitched. Then government scientists came and told us that our land was not bewitched, but that the soil was acidic and that was why our maize did not grow well. First, they took samples of our soils to analyze. When they came back they brought something that looked like ash, which they told us was agricultural lime for reducing acidity. Most of us did not believe, but I reluctantly gave part of my land for testing. The first season was not good and this proved to most that the ash was not going to improve our maize yields. However, by the end of the third season, we saw big increases in yields, and we now call the agricultural lime a “savior”. We, the members of the Mwangaza Farmers Group, Isanjiro village, Central location, East Kabras, have been planting maize in our acid infested fields for the past many years. Little did we know that our ancestors did not bewitch our soils. By applying lime, we have improved our maize yields from an average of four 90 kg bags/acre to 13 bags/acre!”

respectively. It was noted that 94% of the 160 farms sampled (80 in Kakamega and 80 in Siaya), recorded very strongly acidic pH (4.9-5.2) with only 6% recording moderate acidic pH (5.2- 5.5). Thereafter, soil pH was analyzed at four-month intervals until the end of the long rains in 2011. Changes in soil pH varied by treatments. In the control plots, there was minimal soil pH improvement of 4.5% and 0.22% in Kakamega and Siaya Counties, respectively. However, higher pH improvements of 19% and 32% were recorded in Kakamega and Siaya Counties, respectively, in plots where 2 MT/ha of lime were applied (Table 9.2).

With regard to phosphorus (P), in the Kakamega plots that were spread with 2 MT/ha of lime and had crop residues left in place, the available soil P went up from 5.23 to 7.88 ppm, an increase of 2.63 ppm; in Siaya, similarly treated plots had an average increase in available soil P of 2.19 ppm, increasing from 3.01 to 5.20 ppm.

In Rwanda, 18,000 farmers were exposed to the benefits of lime usage, with about 14,100 (78%) voluntarily using it three years after its introduction. Results indicated that high yields for all crops tested are significantly related to the application of lime in combination with farmyard manure and inorganic fertilizer (Figure 8.2). The high performance of this treatment appears to be a synergistic effect from combining the three types of inputs. The increase of pH from liming (0.5 to 1.1 units) and the subsequent reduction of aluminum (1.8 to 3.2 cmol.kg, as shown in Table 8.3) could favor good crop nutrition and hence higher yields.

The partial budget analysis from the four treatments (on Irish potato) is summarized in Table 9.3. The highest cost-benefit ratio was obtained using a combination of lime, farmyard manure and inorganic fertilizer, with the lowest ratio associated with the farmer practice.

**Table 8.2:** Effect of lime application on soil pH and phosphorus in western Kenya

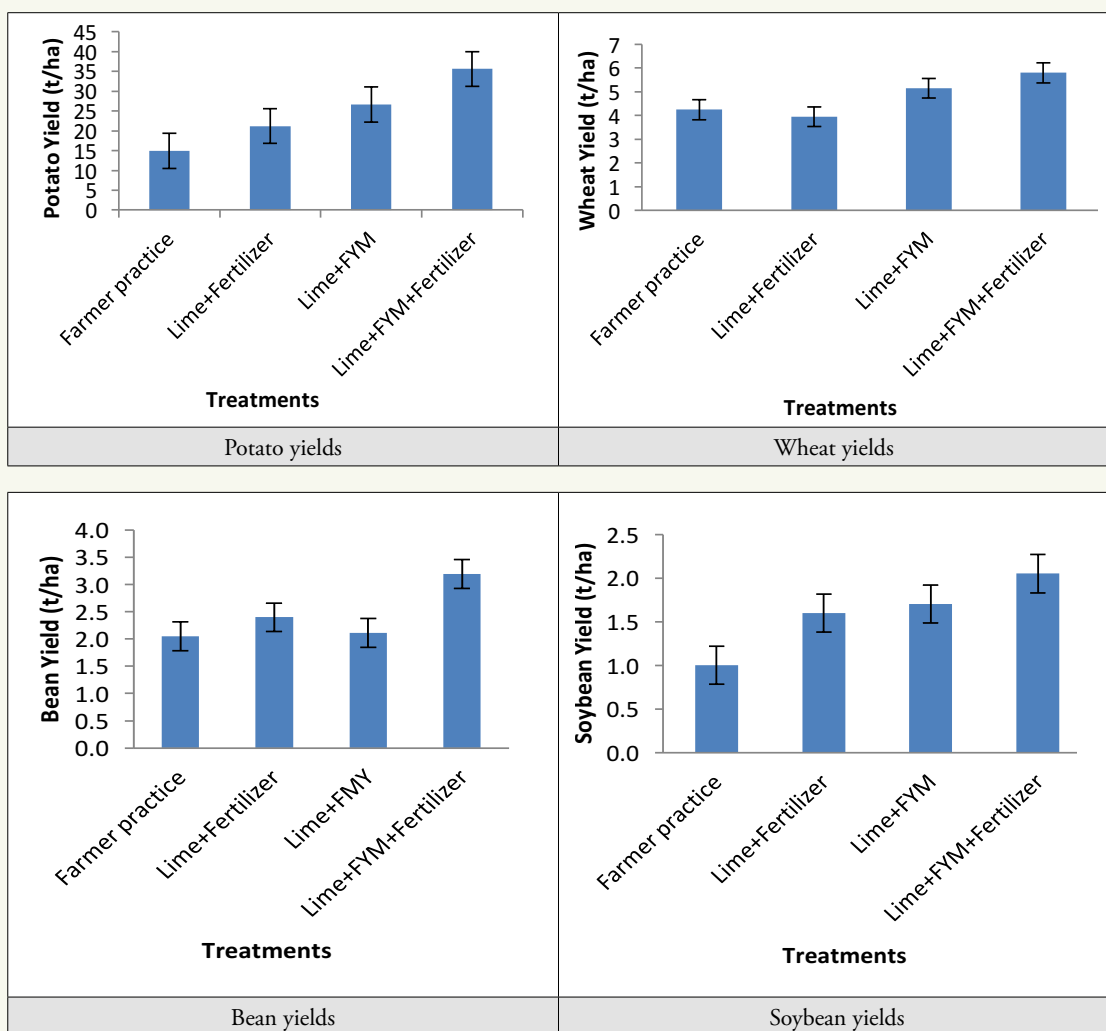
Sites	Treatments	pH (H2O)	P (ppm)
Siaya	Initial	5.23	3.01
	Control (no lime and no fertilizer).	5.23	2.98
	Lime (2 t/ha)	6.45	5.20
Kakamega	Initial	4.91	5.23
	Control (no lime and no fertilizer).	5.13	4.93
	Lime (2 t/ha)	5.59	7.88

**Table 8.3:** Financial return of Irish potato, Rwanda

Crop	Treatments	Production cost (USD ha <sup>-1</sup> )	Gross revenue (USD ha <sup>-1</sup> )	Net benefit (USD ha <sup>-1</sup> )	Benefit Cost Ratio
Irish Potato	Farmer practice	1,974	3,642	1,668	1.8
	Lime + fertilizer	2,149	5,171	3,022	2.4
	Lime + FYM	2,584	6,496	3,912	2.5
	Lime + fertilizer + FYM	2,875	8,683	5,808	3.0

Results from a feasibility study on using lime in Rwanda (Beernaert, 1999) demonstrated that its use is both profitable and viable, financially and economically. The study showed that, on a per hectare basis the net present value was positive, indicating that the use of lime is profitable.

The study also showed the positive overall economic value of the practice, i.e., while the use of lime is not necessarily beneficial for every individual, from the perspective of overall public benefit it is an economically viable practice.



**Figure 8.2:** Yield responses under different treatments in Rwanda

## Farmer Testimony: Xaverine Murebwayire, from Munini Sector, Nyaruguru District, Rwanda

I live in Gisizi village with my family of five, and for a long time I earned money by working in the fields of our neighbors. We had a small plot of land, but we also hired land to grow some of our own food. We were very poor; we did not even have a house. Then the lime project was started and I was lucky enough to get some of the inputs. I learned from the people running the project how to use the inputs to increase the yield of my Irish potato crop, and the difference is amazing! I used to get about 10 MT/ha in a good season, but now I get about 30 MT/ha from the same area. We have been able to build our own house and buy two pigs. We have all the food we need and even earn enough money to hire additional land and pay four field workers. We can now pay my son's school fees, and even have medical insurance. The government gave me a cow as an award for my success, we are planning to get electricity into the house soon, and I hope we will be able to hire more land in the future to produce more potatoes for sale.

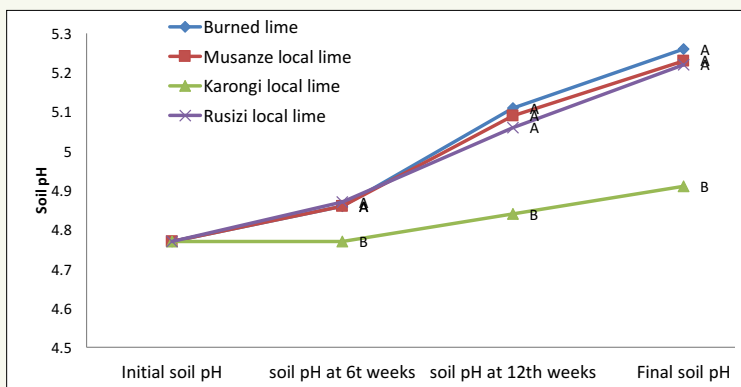
### Impact on Soil Properties

The application of lime at a rate of 3.5 MT/ha contributed to the increase of pH, the availability of phosphorous, and a reduction in aluminum toxicity (Table 8.4).

In general, the use of lime effectively reduces soil acidity, as the results from different plots indicate. However, the effectiveness of liming depends on the type of lime used. In Rwanda, lime from different sites produced different results (Figure 8.3).

**Table 8.4:** Change in soil chemical properties across demonstration sites in Rwanda (0-20 cm) after 3 cropping seasons

Sites	Treatments	pH (H <sub>2</sub> O)	P (ppm)	Al <sup>3+</sup> (cmol.kg <sup>-1</sup> )
Nyaruguru	Initial	5.0	13.3	3.6
	Lime + fertilizer	6.1	31.1	0.5
	Lime + FYM	6.1	36.7	0.6
	Lime + fertilizer + FYM	6.2	36.7	0.35
Nyamagabe	Initial	5.1	16.5	2.2
	Lime + fertilizer	5.4	33.4	0.5
	Lime + FYM	5.7	36	0.5
	Lime + fertilizer + FYM	5.5	42	0.4



**Figure 8.3:** Effects of different liming materials on soil pH in Rwanda (Source: Project trials)

The above results show that burned lime, Rusizi local lime, and Musanze local lime are equally effective in improving soil pH, while Karongi local lime is less effective. The three types of lime contain high levels of calcium carbonate (CaCO<sub>3</sub>); Karongi lime contains much more magnesium carbonate (MgCO<sub>3</sub>). Lime was applied through broadcasting method.

## Lessons Learned

- 1) Improving crop productivity on acidic soils requires a combination of inputs, including lime, inorganic and organic materials, coupled with improved crop varieties and appropriate agronomic practices.
- 2) Dissemination approaches such as participatory on-farm demonstrations, farmer field days, farmer exchange visits, and linking farmers with agrodealers have enabled a large number of farmers to learn about an adopt soil liming.
- 3) Creation of lasting and mutually beneficial business partnerships among different players along crop value chains requires strengthening the capacities of value chain actors to ensure profitable linkages between them.
- 4) The going beyond demos approach generated a discernible enthusiasm among participating farmers, with many of them continuing to use lime and other inputs to produce better yields. Strategies that ensure the supply of required inputs, especially lime, through local agrodealers will encourage farmers to expand the area they have under liming. For instance, the project evaluation report<sup>6</sup> indicates that the demand for lime by agrodealers in Kakamega and Siaya counties jumped from zero in 2008 to 4,000 and 6,000 MT, respectively by 2011 as a result of the project.
- 5) The going beyond demos approach is transformative, leading to improved linkages with private sector actors to help ensure scaling up.
- 6) In addition, the project showed that facilitating farmer access to financial services is critical to success.
- 7) Important limitations and gaps require further research:
  - a) Lime can be applied using different methods; hence, research is still underway to determine the most effective and efficient application methods.
  - b) The application of lime has a residual effect on soil. Research is therefore needed to determine the most efficient frequency and rates of lime application, taking into account specific site characteristics.
  - c) Lime from different locations have different chemical compositions (some rich in Ca and other in Mg), hence more research is needed to determine the most effective or balanced utilization of different limes.
  - d) The problem of soil acidity and its effects on crop production is not widely known among many stakeholders in the agriculture sector, including farmers. There is a need to strengthen demonstrations and knowledge dissemination to increase awareness of the problem and how it can be overcome.
  - e) Requirement of soil test results as a requisite for application of appropriate rate of lime may limit the adoption of lime in locations where soil testing services are either not available, expensive or both.

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<sup>6</sup> Unpublished AGRA report on: Up-Scaling the Use of Agricultural Lime to Enhance Soil Health and for Increased Crop Production in Acidic Soils of Western Kenya (2012)



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GRANULAR LIM  
BLOCK 1  
FERTILIZER  
60 KG HA<sup>-1</sup> P  
60 KG HA<sup>-1</sup> N  
PLOT 4





# 9 Growing Africa's Fertilizer Supply

**Authors:** *Asseta Diallo<sup>1</sup>, Cecilia Khupe<sup>2</sup>, Andrew Mbetse Msolla<sup>3</sup> and Felicia Ansah-Amprofi<sup>4</sup>*

## Key Messages:

- 1 Growing the networks of agrodealers, especially hub-agrodealers, is essential for improving the availability of fertilizers in rural areas while simultaneously reducing farmgate prices for inputs.
- 2 The Agribusiness Contract Partnership Model, which is used by the African Fertilizer and Agribusiness Partnership (AFAP), has a key role to play in improving the supply of fertilizer and other inputs.
- 3 Facilitating access to affordable credit is crucial for the fertilizer supply business. In some cases, agrodealers have developed strong relationships with commercial banks, which have facilitated access to credit for their members; in other cases, agrodealers are subjected to high interest rates, to the point of being unable to stay in business.
- 4 The constraints of fertilizer affordability, availability and accessibility must be addressed if farmers are to use the amounts needed to significantly boost crop yields.

## Introduction

In sub-Saharan Africa, agriculture remains the major economic sector. It accounts for about 80% of all African livelihoods and 70% of the income of the poorest (AFAP, 2015). However, agriculture has been stagnant or declining, and 27% of Africa's population is chronically undernourished (Wanzala & Groot, 2013). This makes it difficult to achieve the recently agreed Sustainable Development Goals (SDGs). African soils present inherent difficulties for agriculture, and land-use practices during the past several decades have exacerbated those difficulties through nutrient mining by crops, leaching, and inadequate erosion control.

It is estimated that around 485 million Africans are affected by land degradation, making that one of the continent's urgent development issues (Bationo & Egulu, 2013). In addition, fertilizer use is low, which is one of the factors explaining lagging agricultural productivity growth in Africa countries. Soil health is critical to sustainable agricultural productivity and there is widespread agreement that improvements in soil fertility will require substantial increases in the use of inorganic fertilizers (AGRA, 2012). Mineral fertilizers are seen as the "fuel" that powers the green revolution (IFDC, 2006, citing Nobel Peace Prize Laureate Dr. Norman Borlaug) and a magic material that can transform the lives of smallholder farmers by helping them produce larger harvests and adapt to the impacts of climate change (Heffer, 2015).

It is also understood that organic fertilizer plays an important role in raising soil fertility. It adds organic matter to the soil and enhances the benefits that come from applying inorganic fertilizer. Still, to be effective organic fertilizer has to be applied at a rate of 1-2 MT/ha, and the sheer availability and cost of that much organic fertilizer adversely affects the economics of its widespread use. There is not enough grazing land available to produce manure in sufficient quantities and, in addition, one cow can produce only about 15 kg of Nitrogen in manure each year, while a maize crop with a target yield of about 3 MT/ha needs about 100 kg of N/ha (Palm, 1995). It is therefore a misconception to think that Africa can produce the food it needs by relying on organic fertilizer only while the rest of the world is fed using chemical fertilizers.

Climate change and a rapidly burgeoning population will place further demands on Africa's overworked soils. Africa's development agenda includes achieving an annual agricultural growth rate of at least 6% (a target established by the Comprehensive Africa Agriculture Development Programme – CAADP). Heads of African States recognized during the Abuja Fertilizer Summit in 2006 that fertilizer is crucial for achieving an African Green Revolution in the face of rapidly rising population and declining soil fertility (African Union, 2016; NEPAD, 2016).

Fertilizer demand in sub-Saharan Africa (SSA), while still very low, is projected to grow annually by 4.7% until 2018. Over the same period, global fertilizer demand is forecast to grow at 1.8%, with the total world fertilizer use expected to exceed 200.5 million MT in 2018, a 25% rise over 2008 levels (FAO, 2015). While the demand for fertilizer in SSA is expected to grow significantly in percentage terms, the actual volumes of fertilizer used across the region will remain low relative to those of other regions around the world.

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2 African Fertilizer and Agribusiness Partnership (AFAP), P.O. Box 53, Rivonia 2128, Johannesburg, South Africa

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4 Department of Agriculture, Birim Central Municipal Assembly, Akim, Oda, Ghana



Some countries have increased their fertilizer use. For example, the number of countries consuming more than 20 kg/ha has increased. From 2006 to 2011, nutrient use increased from 32.5 kg/ha to 36.1 kg/ha, indicating an average increase of 11.4% (Wanzala, 2012; Bationo & Egulu, 2013). However, if Egypt is excluded, the fertilizer applied in 2011 drops to 23 kg/ha for the remaining 13 countries considered<sup>5</sup>. Even though fertilizer demand is rising, most of the countries studied are still far below the minimum target of 50 kg/ha agreed during the Abuja Summit (Bationo & Egulu, 2013).

Smallholders dominate Africa's agriculture landscape, but the yields of their crops (an average of < 1 MT/ha) are unfortunately too low to feed continent, which is currently spending over USD 35 billion annually to import food.

This is what AGRA's Soil Health Program and its partners have been working to resolve since 2009 in 13 SSA countries<sup>6</sup>. Fertilizer supply is a cornerstone of the integrated soil fertility management (ISFM) strategy, which is at the heart of the Program's going beyond demos (GBD) approach. The aim of this chapter is thus to showcase initiatives on the supply side that have helped achieve impacts by going beyond demos.

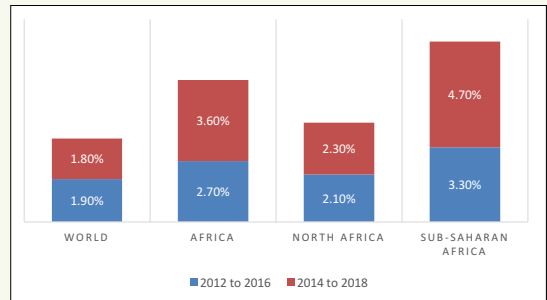
## Fertilizer Trends in Africa

### Rising demand

Fertilizer demand by farmers in sub-Saharan Africa has been increasing since 1995, and markedly so since 2003, reaching almost 1.6 million MT in 2010 (Wanzala &

5 Algeria, Morocco, Ethiopia, Kenya, Tanzania, Zambia, Madagascar, South Africa, Burkina Faso, Ghana, Mali, Nigeria, Malawi  
6 Burkina Faso, Ghana, Mali, Niger, Nigeria, Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda, Zambia and Mozambique

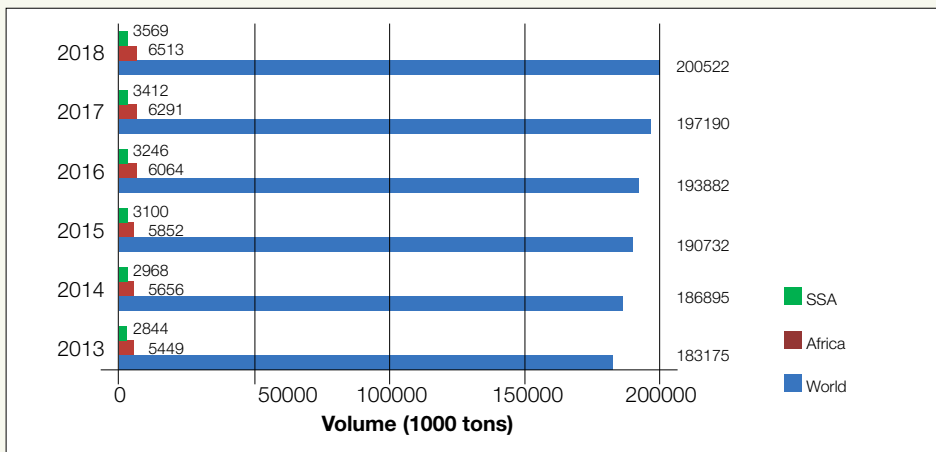
Groot, 2013). The increase in total demand for NPK in all of Africa was 2.7% from 2012 to 2016; from 2014 to 2018, the rate of increase is expected to be 3.6% (Figure 9.1). In SSA, these rates of increase are higher, at 3.3% and 4.7%, respectively, for the 2012-2016 and 2014-2018 periods. South Africa, Nigeria, Kenya, Ethiopia and Malawi are the major users of fertilizers in SSA (FAO, 2015). However, in some countries, increased demand may be due to government subsidy programs and greater use by commercial farmers.



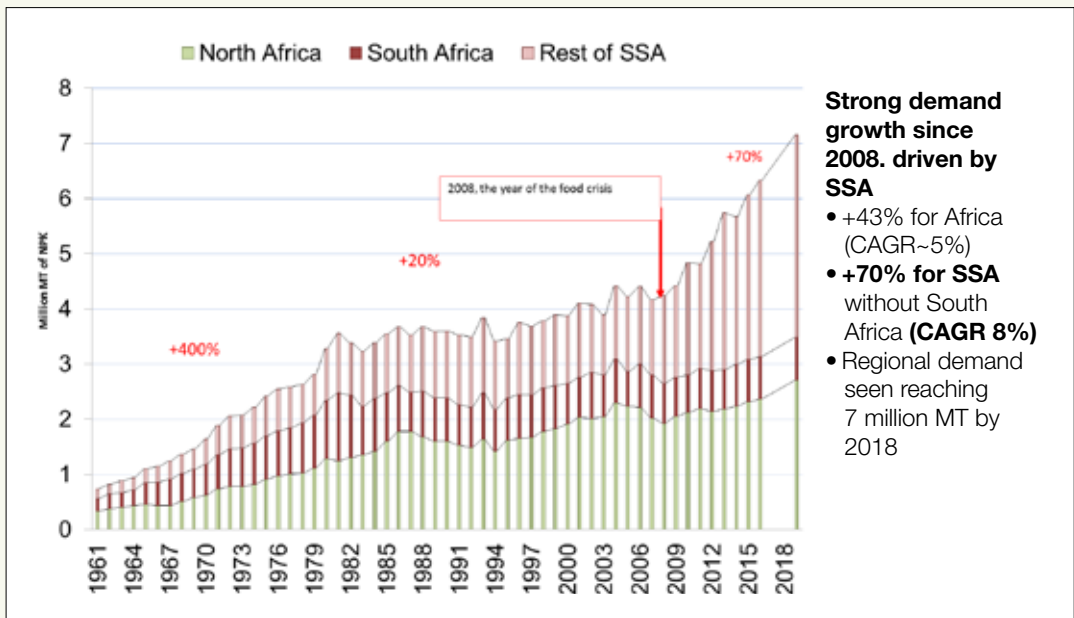
**Figure 9.1:** Changes in the rate of fertilizer consumption (%), globally and in Africa, from 2012-2016 and forecast 2014-2018 (Source: FAO, 2015)

### Total fertilizer use remains low

As can be seen from Figure 9.2, despite growing demand, the total volume of fertilizer used by SSA farmers is still low relative to the rest of the world. The forecast for 2018 is around 6.5 million MT for the whole of Africa, which is only 3% of global fertilizer consumption, even though Africa is larger than America, Asia and Europe combined (IFDC). Within Africa, the SSA region is expected to account for only 54% of the continent's projected total consumption (6.5 million MT) by 2018.



**Figure 9.2:** Fertilizer (NPK) demand forecasts in volume (1000 tons) in the world, Africa, and SSA (Source: FAO, 2015)

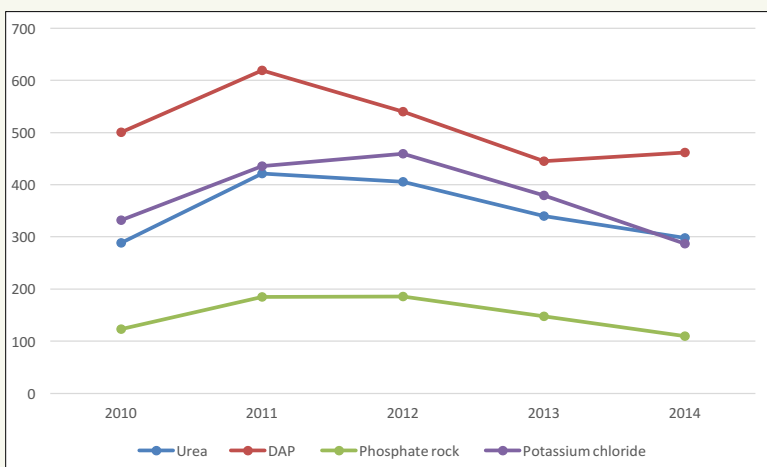


**Figure 9.3:** Growth in demand for fertilizer in Africa 1961-2018 (Source: IFA 2016)

Looking at projected medium-term regional fertilizer demand, the trend suggests that the potential for Africa to use fertilizers to raise agricultural production remains enormous. Since 2008 for example, there has been strong growth in fertilizer demand in SSA (Figure 9.3). While this trend is expected to continue, the level of fertilizer use in the region is still very low compared to the rest of the world. This is due to a number of factors, but especially to the constraints faced by smallholder farmers, such as not knowing about the correct use and benefits of fertilizers, the high prices of such inputs, and limited access to affordable credit.

### Affordability and availability

While there is no doubt about the importance of using fertilizers, farmers face many barriers to accessing these and other critical inputs. International fertilizer prices increased sharply in 2008, making them unaffordable to the majority of smallholder farmers. This contributed to large food shortages in the developing world. Although fertilizers prices dropped in 2009, on average they increased until 2011-2012 before dropping back in 2013 due to changes in supply and demand (Figure 9.4). Prices continued to decline in 2014 and 2015 (Source: FAOSTAT, 2015)



**Figure 9.4:** Fertilizer prices (USD/MT) from 2010 to 2014 (Source: FAOSTAT, 2015)

Average farmgate prices are USD 500-800/MT. Most of the fertilizers in African countries are imported and many factors influence their cost:

- Importers order in small batches, which results in paying higher prices on the world market;
- Poor port infrastructure results in high port charges;
- Internal distribution is expensive, with poor road and rail networks resulting in high transport costs;
- High interest rates charged to those purchasing fertilizer on credit adds to the cost; and
- Few agrodealers operate close to the farmgate and farmers often have to travel long distances to purchase inputs, again adding to their cost.

Based on the data in Figure 9.5, finance, transportation and distribution costs constitute 75-78% of the total cost of fertilizer in the domestic supply chain in Ghana, Nigeria, Mali and Senegal. Another study done in 2007 (Wanzala & Groot, 2013) also shows that transport costs account for a high percentage of the retail prices in Mali (32%) and Tanzania (22%), relative to, for example, Thailand (Figure 9.6).

In Tanzania, an assessment done in 2015 by the African Fertilizer and Agribusiness Partnership (AFAP) shows the same trend. For the three main fertilizers used in that country, transport, distribution, and margins account for 24-41% of the retail price of DAP, calcium ammonium nitrate (CAN) and urea (Figure 9.7).

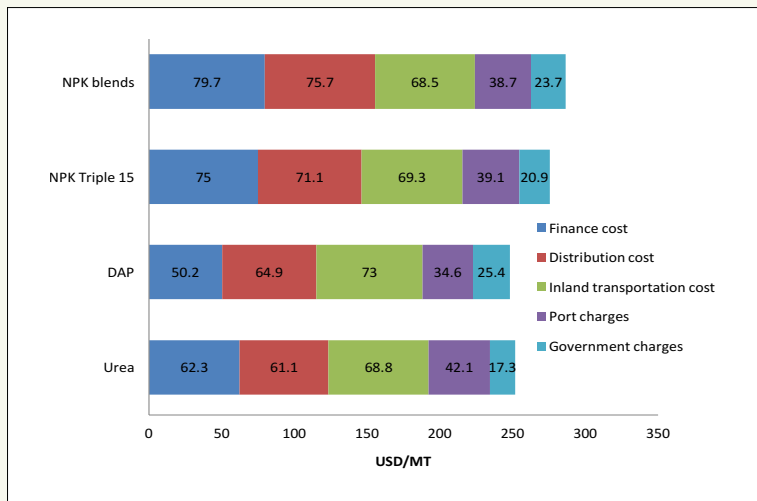


Figure 9.5: Domestic supply chain cost components (USD/MT); the average for Ghana, Nigeria, Mali, and Senegal in 2009 (Source: IFPRI, 2012)

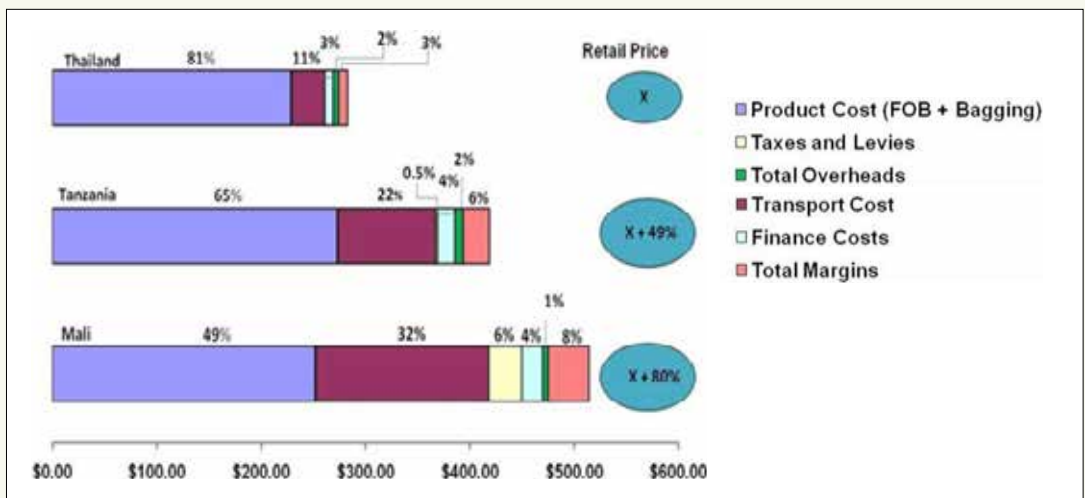
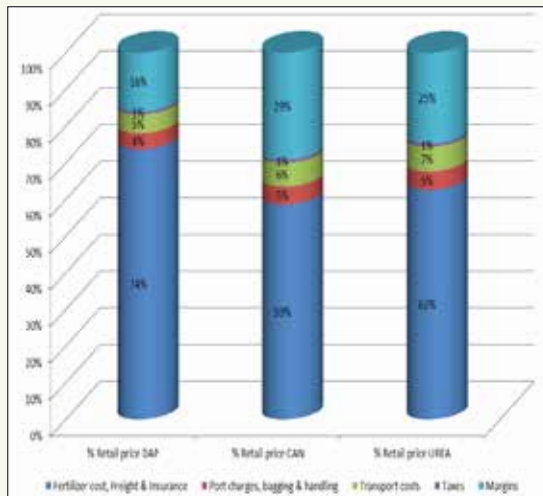


Figure 9.6: Fertilizer cost components (USD) for Mali and Tanzania, compared to Thailand (Source: IFA, 2015)

In some countries, the depreciation of domestic currencies is also an issue affecting the affordability and availability as fertilizer prices, since they are quoted in US dollars. For example, between 2014 and 2016 the Tanzanian shilling (TZS) has devaluated against the dollar by 34%, while Zambian kwacha (ZMW) has dropped by about 83% and the Malawian kwacha by 149%. These kinds of monetary fluctuations dramatically increase the cost (in local currency) of all imports, including fertilizer.



**Figure 9.7:** Cost breakdown of retail prices in Tanzania for DAP, CAN, and urea fertilizers (Source: AFAP, 2015)

Fertilizer use by smallholder farmers in SSA remains low for reasons other than (or in addition to) appropriate products not being readily available or affordable:

- *Limited farmer knowledge of the correct use and benefits of fertilizers:* farmer awareness of the importance of fertilizer is still low because, for example, there are relatively few extension agents to serve a large number of farmers, and they lack access to well developed information packages and demonstration opportunities.
- *Limited access to credit:* smallholder farmers usually require credit in order to purchase fertilizers and other inputs, but interest rates tend to be too high and repayment schedules too rigid for smallholders to take advantage of it.
- *Lack of or limited access to output markets:* for farmers to earn decent returns on their investments, it is critical that they have access to remunerative markets for their surpluses.

## Initiatives to Improve Fertilizer Availability, Affordability and Use

At the 2006 high-level Abuja Fertilizer Summit, African governments committed themselves to increasing the use of fertilizer from the prevailing average of 8 kg/ha to at least 50 kg/ha in order to increase agricultural productivity and reduce poverty.

Due to the 2008 food crisis and because of the Abuja commitments, many African governments have implemented fertilizer (and other) subsidy programs to facilitate farmer access to and use of modern inputs to increase production and food security. However, a 2013 study done by AGRA and IFDC showed that many of these subsidy programs were modeled on the conventional approaches employed in the 1960s through the early 1980s.

In the 1980s and 90s, a consensus was reached among African governments, development organizations, and donors that conventional subsidy programs had been ineffective and costly, and as a result, many countries eliminated them.

While the idea of subsidies is coming back, governments are working to create market-friendly SMART subsidies that target farmers who need such assistance the most, and that are more efficient and sustainable (IFDC & AGRA, 2013). Even so, these programs tend to negatively influence efforts and achievements by private sector organizations, which many development professionals believe should be strengthened. Many countries also face a lack of resources for their subsidy initiatives, which is changing the amounts and approaches being used. Still, it is likely that most of the countries implementing subsidies will continue them in an effort to increase the use of fertilizer and other inputs by smallholder farmers. In addition, at the 2014 AU Summit held in Malabo, Equatorial Guinea, African governments reaffirmed their commitments to the CAADP framework and targets, as well as to the Abuja Summit objectives. Subsidies in one form or another will be essential to achieving the outcomes envisioned during those two Summits.

AGRA's SHP and its partners also took a number of steps aimed at improving the availability, affordability and use of fertilizer by smallholder farmers in SSA.



## Development of agrodealers

The Program was an early investor, for example, in the development of agrodealers. Its objective was to widen and strengthen agrodealer networks that supply quality inputs to farmers. Agrodealers have been trained and their networks have been strengthened in 12 SHP focal countries (Ethiopia is the exception because fertilizer supply is driven by the government).

*Building the capacity of agrodealers to supply quality fertilizers* – For many smallholder farmers, agrodealers are the sole source of farm inputs and guidance on how to use them best. SHP recognized the need for these agrodealers to provide quality inputs, and to have knowledge and skills relating to their use. SHP-supported projects provided training to agrodealers with respect to technical knowledge, marketing and management of input shops, storage requirements, and how to access timely agro-input market information. In many cases, a Training of Trainers or “cascade” approach was used, training those who could then train others.

*Facilitating access to finance for agrodealers to improve their business and provide quality inputs* – In many cases, the cost of money was a significant barrier to entry into the fertilizer market. To address this, AGRA has been working on a number of fronts to help facilitate agrodealer access to finance. Credit guarantees have been provided to commercial banks in some countries (Burkina Faso, Ghana, Mali, Mozambique, Tanzania and Uganda) in order to facilitate access to affordable credit and to leverage loan capital for importers, wholesalers and retail agrodealers.

In Burkina Faso for example, 149 loans have been granted to agrodealers for a total amount of USD 836,370, and in Rwanda, loans in the amount of USD 264,705 have been

made. In Niger, 14% of agrodealers were able to access to credit, and in Mali 90 agrodealers have accessed USD 225,600 in loans.

*Creating demand for fertilizer* – On the demand side, AGRA’s SHP supported the scaling up of ISFM technologies in 13 focal countries, and through these projects about 1.6 million farmers learned about the potential payoffs of using fertilizer. These farmers have used about 318,000 MT of fertilizers since SHP began its work in 2008. In addition, hub-agrodealers (larger agro-input dealers that supply other agrodealers), and smaller, more rural agrodealers implemented demonstration plots to create awareness and demand for fertilizers.

In Burkina Faso, Rwanda and Uganda for example, 144, 446, and 240 demonstrations, respectively, have been implemented by agrodealers. In Mali, 220 demos for women were implemented, and in Rwanda, 260 demos related to agricultural liming have been implemented, with the support of IFDC.

## Creation of the African Fertilizer and Agribusiness Partnership (AFAP)

In early 2012, AGRA’s Soil Health Program, in concert with the International Fertilizer Development Center (IFDC) established the African Fertilizer and Agribusiness Partnership (AFAP), a first of its kind organization dedicated to establishing competitive and sustainable fertilizer markets in Africa, markets that provide African smallholders with the incentives and capabilities needed to purchase and use fertilizer to improve crop production and food security. This step was taken in response to intensified public commitments by African governments to increase the availability and use of fertilizer across the continent, especially in SSA. Since AFAP was established, various

## The Limpopo Valley Agricultural Society (SAVAL) in Mozambique

In 2013, SAVAL was procuring only 20 MT of fertilizer. That year, AFAP provided a supplier guarantee of USD 85,000 to kick-start the flow of fertilizer.

In 2014, SAVAL acquired 1,500 MT from a supplier, which it sold to about 10,000 smallholder farmers growing rice, maize and vegetables.

By the end of 2015, SAVAL was supplying fertilizer to over 20,000 farmers who grow rice on 25,000 hectares of irrigated land, and who produced a crop valued at over USD 2 million.

The supplier payment guarantee facility not only allowed increased fertilizer supply capacity and lower prices, but also resulted in the establishment of commercial relations that include the production and supply of fertilizer packages in small bags for smallholder farmers (5 kg, 10 kg, 25 kg and 50 kg) and the provision of technical assistance through soil sampling, appropriate fertilizer recommendations, and the production of balanced blends.

SAVAL increased its storage capacity to also provide output storage for farmers.

organizations have been working together to support its efforts – including AGRA, AfDB, NEPAD, IFDC, IFA and AGMARK. AFAP presently has three target countries (Ghana, Mozambique, and Tanzania) and two pilot countries (Ethiopia, Nigeria). AFAP is working to increase private sector participation and investment in the African fertilizer industry, and is supporting key initiatives in its target and pilot countries related to enhancing soil fertility, including the use of conventional and biological fertilizers.

*Supporting value chain initiatives* – AFAP provides critical support to fertilizer suppliers and hub-agrodealers through Agribusiness Partnership Contracts (APCs). An APC provides an effective way to collaborate with private organizations that want to participate in the trading of fertilizer. APCs are agreements under which eligible international, regional and local agribusinesses apply for AFAP assistance as they make inroads into African fertilizer markets. AFAP assistance may include any combination of payment and/or credit guarantees; matching grants; technical, logistical and marketing support; and training and organization of local entrepreneurs and farmers.

In return for AFAP’s assistance, agribusinesses agree to engage in significant market development activities with local farmers and/or agribusinesses (e.g., increasing demand, providing extension support, and strengthening farmer organizations).

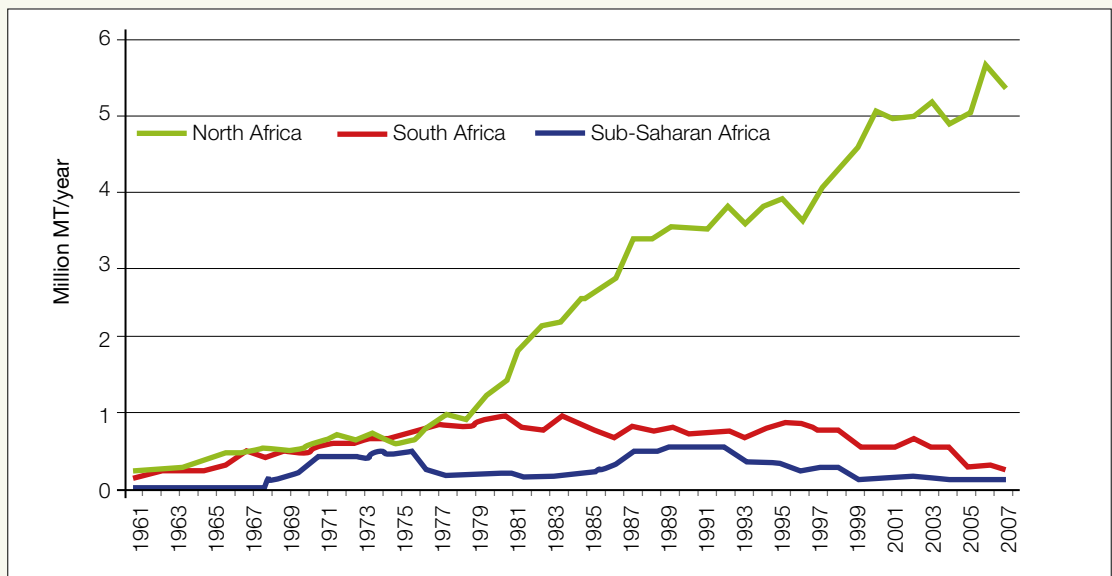
*Linking suppliers to hub-agrodealers through fertilizer credit guarantees* – AFAP uses a hub and spoke model in reaching out to farmers and to help them obtain fertilizers. Access to finance by hub-agrodealers is the most common

obstacle mentioned by participants across the fertilizer distribution chain. Financiers find agriculture to be risky.

Hub-agrodealers have proven able to alleviate many of the supply and distribution challenges faced both by suppliers and more remote agrodealers. Through credit guarantees, AFAP provides assurance to fertilizer suppliers, and in so doing it helps to relax trading terms. For instance, while earlier trade terms may have been cash on delivery, AFAP can help suppliers provide fertilizer on softer conditions, such as the hub-agrodealer paying 50% of the consignment cost upfront and the remaining 50% within 60 days. An additional benefit is that the hub-agrodealers receive fertilizers according to their preferred delivery schedule and are able to avail fertilizers to farmers when it is needed and in the right quantities.

*Supporting hub-agrodealers through matching grants* – Fertilizer storage is an important function when it comes to ensuring its timely availability to farmers. Agrodealers often have limited storage facilities and are not able to buy fertilizers in bulk, even if they have the financial capacity to do so. To address this shortcoming, AFAP has supported construction of needed storage facilities.

*Boosting local fertilizer production* – Africa, and especially North Africa, has taken major strides toward fertilizer production using locally available resources (Figure 9.8), a trend encouraged both by AGRA and AFAP. These include rock phosphates, natural gas, and potash deposits. Due to the availability of abundant natural gas, which is used in the production of ammonia and urea, many African countries are working with private agribusinesses to produce urea.



**Figure 9.8:** Trends in fertilizer production in Africa (Source: IFDC)

Nigeria, for example, has taken the lead in urea production, working with Nortore Chemical Industries Ltd. The latest initiative is expected to start in 2016 and involves construction of a urea plant in southern Tanzania. The total production capacity of the plant is expected to be 1.2 million MT, which will be channeled mainly to the regional market in East and Central Africa. Mozambique is also developing a similar initiative to use their abundant natural gas in urea production.

Phosphate production is being undertaken in North Africa, with Office Chérifien des Phosphates (OCP) in Morocco taking the lead. There are other initiatives underway involving Minjingu Mine and Fertilizers Ltd in Tanzania and Toguna Agro Industries SA in Mali.

Africa is expected to become a potash (K) producer, despite the present low use of K across the continent (< 1 million MT). Extensive potash deposits are found in the Danakil Depression in Ethiopia and Eritrea (with large deposits at depth of between 50 and 300 meters). The potash reserve at Colluli in Eritrea stands at 347 million tons and is said to be the shallowest evaporite deposit in the world (16-140 meters) allowing for open cut mining. Other major potential potash deposits are in the Democratic Republic of Congo, Niger, Morocco, Libya, Egypt and Tunisia.

*Blending initiatives* – Blending offers a low-cost way to make NPK from imported raw materials and provides flexibility in the grades that can be produced to better suit different agronomic and soil requirements.

Fertilizer blending is now seen as the most appropriate way of addressing specific soil nutrient deficiencies. Substantial yield increases for almost all crops can be achieved in Africa by blending secondary macronutrients and micronutrients into standard NPK fertilizers. Blending plants that can produce fertilizers appropriate for specific soils and crops should therefore be encouraged as part of any effort to increase productivity and production. AGRA and AFAP are encouraging fertilizer suppliers to invest in fertilizer blending so that farmers have access to appropriate fertilizers for their crops and soil types.

## Intervention Outcomes

### Improved fertilizer supply and use

There has been a noticeable increase both in the number of fertilizer suppliers and the amount of fertilizer being consumed. For instance, about 25,000 agrodealers (Figure 9.9) have received support of various kinds, and half of them are now geo-referenced and mapped.

In addition, since 2008/2009 the number of African fertilizer companies has increased: from 12 to 45 in Ghana for example, and from 15 to 51 in Tanzania. Actions implemented in various countries and with various partners led to a growth in the business of agrodealers in terms of the sale of fertilizer and improved seed. They were able to supply an estimated 2.5 million farmers.

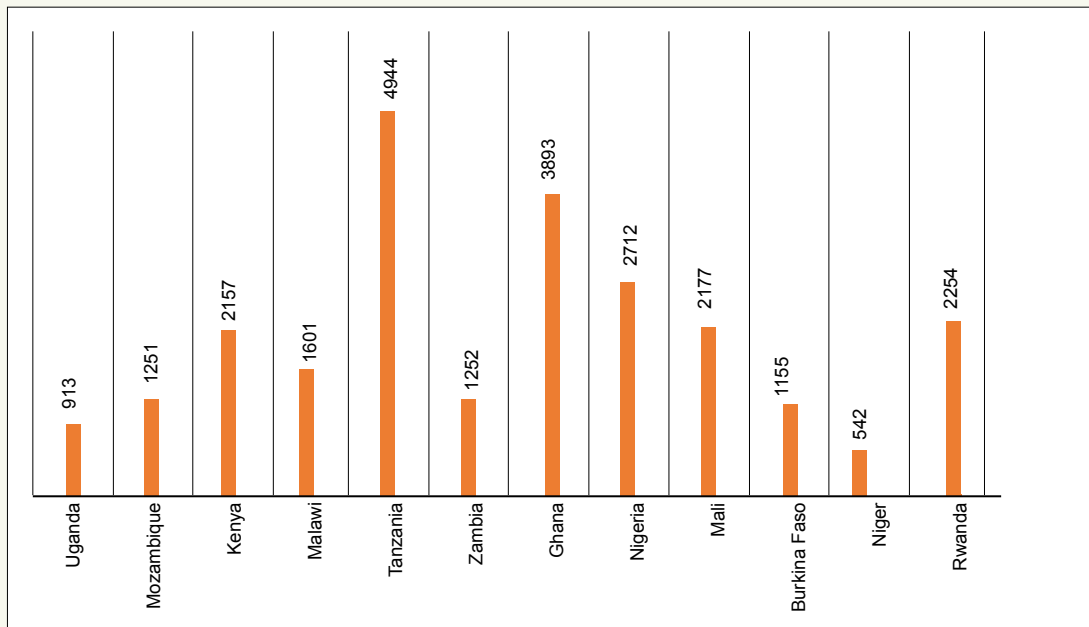


Figure 9.9: Distribution of agrodealers trained in 12 African countries

## Professionalization of Agrodealers in Burkina Faso (PRODIB), an AGRA-funded Project implemented by IFDC (2011-2014)

The project trained 20 trainers of agrodealers and developed a training manual. This manual was used for grassroots training for 1,090 agrodealers and technical sales agents. In addition, the project has contributed to the training of 149 seed producers and 20 seed inspectors of the Ministry of Agriculture. In three years, trained agrodealers sold 5,672 MT of improved seeds and 164,431 MT of fertilizers. Agrodealers have expanded their businesses by opening 227 new stores in rural areas. Trust among the association's members has improved, and there has been an increase in membership from less than 300 at the start to 757 by the end of the project. These efforts have led to the reduction of the average distance farmers must travel to reach an agrodealer from 27 km to 20.4 km. These combined efforts have improved access to agro-inputs for 413,048 smallholder farmers. The project also supported agrodealers in accessing credit by facilitating linkages with a commercial bank (Bank Of Africa) and by depositing a small credit guarantee of around USD 300,000. In two years, 118 agrodealers accessed loans totaling about USD 870,000 (FCFA 434 million), with a preferential interest rate of 9.5% instead of the 11-12% usually applied.

An impact assessment has shown that farmers' annual income in the project area has increased from USD 216 to USD 394 (FCFA 108,454 to FCFA 197,000). The income earned by agrodealers also has rose by about 33% (IFDC, PRODIB Final Report, 2014).

AFAP's fertilizer credit guarantee scheme (involving USD 6.4 million) has allowed beneficiaries to move more than 600,000 MT to about 3,700 agrodealers, and through them reach 7 million smallholder farmers. This facilitated the timely availability of the desired quantities of fertilizers to farmers. Complaints by farmers about untimely availability and inadequate quantities of fertilizer have become much less common in the areas where AFAP is operating.

Furthermore, AFAP support for the construction of fertilizer storage facilities increased the ready supply of fertilizer supply. AFAP's contributions averaged about 30% of the construction costs, and total fertilizer storage space has increased from 116,069 MT in 2013 to 214,043 MT in 2015 (Tanzania: 41,169 MT; Ghana: 31,900 MT; and Mozambique: 26,225 MT).

### Reduced distance between agrodealers and smallholder farmers

By having more agrodealers stocking fertilizers and having knowledge about how it should be used helps make it cheaper and easier for farmers to access quality fertilizer. In areas where agrodealer development projects have been implemented, the average distance between agrodealers and client farmers has been reduced – from 27 km to 20 km in Burkina Faso, 15 km to 9 km in Rwanda, and 41 km to 15 km in Niger over a 3-year period.

### Fertilizer quality improvement

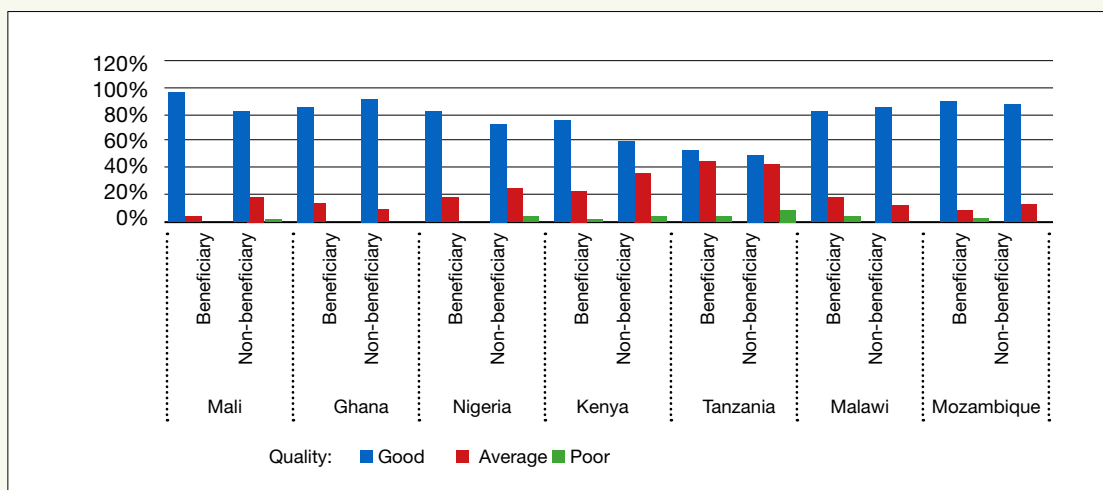
While working on the supply side by strengthening agrodealers and hub-agrodealers, AGRA and its partners also supported governments in developing policies and regulations to ensure fertilizer quality control. This enabled countries to adopt and enforce sensible regulations on fertilizer quality and to regularly check fertilizers entering countries, which has improved the quality of fertilizers reaching smallholder farmers. A Household Evaluation Survey (2014) done by AGRA reported that the quality of fertilizer available at the nearest agrodealers had improved (Figure 9.10).

## Impact of Agrodealers on Farmgate Prices

Reductions in fertilizer prices have been realized due to:

- Hubs purchasing fertilizers in bulk from suppliers, leading to the reduction of fertilizer prices to rural agrodealers, and by extension to farmers. For instance, a reduction of between USD 1-3 per 50 kg bag of fertilizer has been realized in Tanzania.
- By getting fertilizers from suppliers well ahead of the rainy season, while rural and feeder roads are still passable, reduces transport costs and contributes to lower fertilizer prices at the farmgate.





**Figure 9.10:** Quality of fertilizer available at nearest agro-dealer (farmer responses)  
Source: AGRA, 2014

With storage facilities in place, hub agrodealers were able to reduce farmgate fertilizer prices by USD 0.50-1.00 per 50 kg fertilizer bag. The reduction in price was attributed to:

- Hub-agrodealers renting fertilizer storage facilities were able to save on overhead costs (averaging between USD 1.5-3.0 million/year), and a portion of those savings was passed on to farmers. Furthermore, by having larger fertilizer storage facilities, hub agrodealers were able purchase bulk quantities and supply them early to farmers, again reducing distribution costs.
- By having big storage facilities, hub-agrodealers were able to get fertilizers from suppliers soon after being offloaded at the ports. A case in point here is Yara supplying fertilizer directly from the ports of Tamale and Dar-es-salaam to two hub agrodealers – Mrs. Elizabeth Dwamena, the CEO of Northgate (Ghana), and Mrs. Rose Assenga (in Tanzania). This reduced the cost of a 50 kg bag by USD 2.00-3.00.

## Lessons Learned

A number of lessons have been learned from the implementation of projects to increase fertilizer supply and use by smallholder farmers:

- 1) Supplying appropriate fertilizer blends for different crops and soils is important. The use of balanced fertilizers that contain macronutrients (NPK), secondary macronutrients, and micronutrients is therefore important if yield gaps are going to be closed in profitable ways. As of now, not many companies are providing blended fertilizers, but several are changing.

Like the rest of the world, African farmers must use blended fertilizers if they are to improve their agricultural productivity. And that fertilizer must be packaged in a range of sizes, from 5 kg up to 50 kg.

- 2) Growing the networks of agrodealers and hub-agrodealers is essential to improve the availability and accessibility to fertilizers in rural areas. AGRA and its partners established AFAP to help facilitate this networking process. It has done this through a combination of matching grants and credit guarantees that enable fertilizer companies to more readily supply hub-agrodealers. The matching grants have helped hub-agrodealers to grow their storage capacity for fertilizers and purchase large quantities. This has helped improve access to fertilizers over longer periods of time and resulted in lowering distribution and transaction costs for suppliers. Higher volume orders enable volume discounts, which are passed on to rural agrodealers. In addition, lower costs are incurred by importers and suppliers when servicing fewer hub-agrodealers.
- 3) The AFAP model has demonstrated its key role in fertilizer supply (this is also true for other inputs, such as seeds and agricultural chemicals). The beauty of this model is that:
  - a) No financial institution stands in the way of processing the credit guarantees, which reduces overhead costs and interest rates. The credit facility money sits in AFAP account.
  - b) The grants provided by AFAP for the construction of storage facilities has encouraged hub agrodealers to do just that, build warehouses. The AFAP support acted as a catalytic fund.

- 4) Facilitating access to finance is crucial for the fertilizer supply business. The limited overhead costs associated with the credit facility enables hub agrodealers supported by AFAP – and indeed the more remote, rural agrodealers – to be in fertilizer business. In addition, agrodealers have developed strong relationships with commercial banks, which has facilitated access to credit for their members (Burkina Faso, Mali and Rwanda provide good examples of this). However, in some instances where agrodealers were subjected to high interest rates by financial institutions, many ceased to operate. In Tanzania, for example, while 3,850 agrodealers were trained from 2008-12, only 1,203 remain operational. Most of them had to close their doors after the Financial Services Deepening Trust (FSDT) credit facility, which was provided through the National Microfinance Bank, ended in 2012.
- 5) Timely availability of fertilizers is very important. Through the APC mechanism, fertilizers are delivered to hub-agrodealers according to preferred delivery schedules, which take into account the local seasonality. Fertilizers are normally available in desired quantities two months before the onset of the rainy season.

## Conclusions

There is evidence of increased usage of fertilizers by farmers in areas where AGRA and its partners have adopted the going beyond demo value chain approach, which addresses challenges related both to input and output markets and improves the extension of good agronomic practices.

The fertilizer industry is responding well and increasingly engaging in several countries to develop distribution channels. AGRA and its partners are poised to support this growth. In addition, the African Fertilizer Financing Mechanism (AFFM), which has been established and located with the African Development Bank (AfDB), became a reality in July 2015. Going forward, more work has to be done with the public sector to improve port facilities and inland roads to reduce distribution costs. In addition, countries will need support in redesigning their input subsidy programs in ways that make them more targeted, efficient and sustainable. This would help the fertilizer industry, hub-agrodealers and rural agrodealers to grow. Through public-private collaboration, the supply and use of fertilizer in Africa can grow considerably, and in doing so enhance the food security of all Africans.

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# 10 Improving Fertilizer Policies and Regulations

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## Key Messages:

- 1 The adulteration of commercial fertilizer by some players in the fertilizer supply chain is a major constraint to African agriculture.
- 2 Appropriate fertilizer policies and regulatory frameworks are either absent in many countries or simply not well enforced, leading to fertilizer adulteration and the subsequent marketing of low quality fertilizer products.
- 3 Sound policies, regulatory frameworks and effective controls are needed in order to increase the use of quality fertilizers for improved soil fertility, and contribute to a sustainable transformation of African agriculture.
- 4 AGRA's Soil Health Program invested in building the technical and institutional capacity of fertilizer regulatory institutions in 13 countries to enable the effective implementation of fertilizer regulations, quality control, and the proper use of fertilizers.

## Introduction

Going beyond demonstrations (GBD) as an institutional innovation by AGRA focuses on supporting farmers' access to and use of new technologies, including such vital inputs as appropriate fertilizer blends. The GBD approach also focuses on helping smallholder farmers adapt and use improved soil and seed technologies after they have been shown to be effective, and helps ensure smallholder farmers' access to affordable credit and remunerative output markets. In the case of fertilizer, the challenges that need to be overcome include affordability, timely delivery, and the availability of appropriate and high-quality fertilizer products. Addressing these challenges requires effective fertilizer policies and

regulatory systems that are properly and consistently enforced. The availability of appropriate and affordable high-quality fertilizer products, coupled with their proper use, will result in maximum benefit to farmers. This in turn will motivate farmers to go beyond learning from demos to using fertilizers that improve the productivity and profitability of their operations.

The 2006 Africa Fertilizer Summit, held in Abuja, Nigeria, declared that average annual fertilizer use in Africa should increase from the prevailing low level at that time of 8 kg/ha to 50 kg/ha by 2015 (African Union, 2006). Even this increase, however, would be insufficient to achieve the first Millennium Development Goal of halving hunger, as well as the second Sustainable Development Goal of ensuring food security.

In an effort to increase fertilizer availability and use, several sub-Saharan Africa countries (in addition to their subsidy programs) liberalized the importation and distribution of fertilizer, but without appropriate quality controls. This has led to fertilizer quality problems in the region. Some disreputable manufacturers, distributors and agrodealers engage in fraudulent practices, such as distribution of nutrient-deficient fertilizers, underweight packaging, misleading and deliberately inaccurate fertilizer labels, and adulteration of packaged fertilizer with such unnecessary additives as sand and gravel.

There are few systematic studies on the quality of fertilizers marketed in Africa. The most recent survey, conducted by IFDC's Marketing Inputs Regionally (MIR) Plus project, was done in 2010 in West Africa. It showed that the physical attributes of 5-10% of the fertilizers sampled were not acceptable; 42% of the fertilizers tested were nutrient-deficient; and 41% were underweight (Sanabria et al., 2013). The study attributes these problems to the absence of legal frameworks or their ineffective enforcement. These quality problems will increase if the market continues to grow without effective controls. Using poor quality fertilizers hinders farmers from maximizing returns from their investments and will discourage them from continuing to use such inputs. Regulatory systems therefore must be strengthened to ensure that farmers are receiving the quality fertilizers they need to increase the productivity and profitability of their farms.

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## The Importance of Developing Fertilizer Policies and Regulations

African farmers pay the highest retail fertilizer prices in the world. This contributes directly to the lowest fertilizer application rates and the lowest crop productivity in the world (NEPAD, 2016; World Bank, 2013). To overcome this problem, many African countries have implemented policy reforms, and many governments have imposed price controls and subsidies so as to increase fertilizer use (Bumb et al., 2006). The universal subsidies and state-controlled distribution systems of the 1970s and 1980s proved to be fiscally unsustainable and inefficient (International Monetary Fund, 2015; NEPAD, 2016; World Bank, 2015). This was followed by a period of market liberalization that further reduced the use of fertilizer, resulting in a renewed interest in fertilizer subsidies and, by extension, the need for new fertilizer policy reforms (NEPAD, 2016; World Bank, 2015). These reforms should cover all types of fertilizers: organic, inorganic, and biological, or any combination of the three.

As reported by the World Bank (2015), increasing fertilizer use and farm productivity requires:

- Taking steps to reduce inefficiencies and the transaction costs of fertilizer procurement and distribution;
- Providing complementary investments in human and institutional development;

- Researching appropriate fertilizer recommendations for improved crop varieties;
- Intensifying the availability of quality extension services; and
- Developing relevant infrastructure and putting in place effective regulatory systems.

All these actions can be facilitated through the formulation of good national and regional fertilizer policies, while governments, through their ministries of agriculture and national agricultural research systems, give attention to fertilizer-related technical issues (NEPAD, 2016; World Bank, 2015).

The aim of fertilizer policies and regulatory frameworks should be sustainable environmental management, as well as growth of the fertilizer sector based on science, technology development and dissemination, and assured fertilizer quality control. The availability of quality fertilizers is recognized as essential for increasing crop productivity in Africa, which clearly implies a need for effective regulation. Baseline studies conducted by AGRA between 2009 and 2010 showed that most of the countries in which it worked had no formal policies or regulations for fertilizers, though there were a few exceptions (Table 10.1). AGRA decided to support its focus countries in providing favorable environment for fertilizer research, business, and use; it invested in the development of fertilizer policies and regulations, and also supported the effective enforcement of regulations.

**Table 10.1:** Country baseline and current status of fertilizer policies, laws and regulations

Country	Policy in Place		Fertilizer Law Enacted		Regulations Developed	
	Baseline 2010	Current 2016	Baseline 2010	Current 2016	Baseline 2010	Current 2016
Burkina Faso	No	No	Yes	Yes	No	Yes
Ethiopia	Yes	Yes	Yes	Yes	Yes	Yes
Ghana	No	Yes	Yes	Yes	No	Yes
Kenya	No	No	Yes	Yes	No	Yes
Malawi	No	In Progress	No	Bill Drafted	No	No
Mali	Yes	Yes	Yes	Yes	No	Yes
Mozambique	No	Yes	No	In Progress	No	Yes
Niger*	No	No	No	No	No	Yes
Nigeria	Yes	Yes	No	In Progress	No	No
Rwanda	No	In Progress	No	Yes	No	Yes
Tanzania	No	Yes	Yes	Yes	No	Yes
Uganda	No	Yes	No	No	No	No
Zambia	No	In Progress	Yes	Yes	No	In Progress

**Sources:** AGRA Baseline Studies Conducted in various countries (2009-2010); AGRA Grantees Annual Reports (2014 – 2016)

\* Being part of ECOWAS, Niger benefits from regional regulations (which constitute the supra-law) and has drafted a national decree for implementing the regional law

A favorable fertilizer policy environment and regulatory framework is required to ensure that fertilizer is affordable and of high quality. Farmers must get value for their investments if they are to become fertilizer users. To this end, since 2009 AGRA has been supporting several countries in addressing four key interventions deemed essential for improving the quality of fertilizers available in the market: 1) policy formulation and strengthening of regulatory systems; 2) creating public awareness; 3) building institutional and staff capacity; and 4) harmonizing regional fertilizer policies and regulations. Public institutions in these countries led implementation efforts.

## Policy Formulation and Strengthening of Regulatory Systems

AGRA's Soil Health Program learned from the baseline study about the status of fertilizer policies and regulations in its 13 focal countries. These countries were lacking the policies and/or regulations needed to support the implementation of fertilizer regulatory systems and the adoption of inorganic fertilizer and Integrated Soil Fertility Management (ISFM) practices by smallholder farmers. AGRA therefore supported the formulation of policies in these countries and helped to improve regulatory systems so as to control quality and make fertilizers more affordable.

Some countries, including Ghana, Mali and Tanzania, decided to address the entire process of policy and regulation formulation. Hence, regulations are in place and implementation is underway in these countries. Other countries, including Uganda, Mozambique, Zambia, Burkina Faso and Rwanda are at an advanced stage, while Niger, Nigeria and Kenya are still at an early stage of fertilizer policy and regulatory development (Table 10.1).

Although the fertilizer market had been liberalized in Ghana, there was no functional regulatory system in place before AGRA's intervention. AGRA provided a grant to the country's Ministry of Food and Agriculture to implement a project through the Pesticide and

Fertilizer Regulatory Division (PFRD) of the Plant Protection and Regulatory Services Directorate (PPRSD), to develop, review and publish manuals for inspection and analysis, and also to develop fertilizer administrative forms for the registration of fertilizer dealers and products. By the end of 2014, 1,380 fertilizer retailers, 178 distributors, 45 Importers, 3 manufacturers and 146 products had been registered by the PFRD.

In Tanzania, the government enacted a national fertilizer policy in 2009 (The Fertilizer Act No. 9 of 2009). AGRA then funded a project in 2010, which supported the development of the framework for the Tanzania Fertilizer Regulatory Authority (TFRA), which was formally established in 2012. So far, 721 fertilizer companies and dealers have contacted TFRA for registration and 491 have been registered.

In Uganda, the National Fertilizer Policy (NFP) was developed under the leadership of the Economic Policy Research Centre (EPRC) at Makerere University. This initiative aims to develop fertilizer policy, strategies, regulations and quality control in Uganda. Among key stakeholders is the Uganda National Agro-input Dealers Association (UNADA), which works closely with Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) to ensure all fertilizer importers are registered and licensed.

In Nigeria, a national fertilizer bill was prepared and sent to parliament. The bill has passed the second reading. In addition, four draft regulations regarding inspection, analysis, specification, and labeling have been produced.

In Mali, the Fertilizer Quality Control Unit has been established within the National Directorate of Agriculture and the Research Institute (IER). The remaining regulations have been finalized: i) a Decree for labeling, inspection, sampling and analysis of fertilizers in Mali was adopted and signed in January 2012 and became the "Order No. 2012-0146/MA-SG of 25 January 2012; and ii) a Decree was also issued for the nomination of National Fertilizer Committee members.

The regulatory systems developed so far have facilitated the registration of fertilizer dealers and products, which is enabling improved quality control assurance (Table 10.2).

**Table 10.2:** Fertilizer dealers registration in selected countries as of 2014

Country	Retailers	Distributors	Importers	Manufacturers
Burkina Faso	1,155	100	7	2
Ghana	1,380	178	45	3
Mali	2,177	5	6	2
Mozambique	980	59	7	4
Tanzania	395	61	51	5

## Creating Public Awareness

For policies to be implemented and regulations enforced effectively, it is important that the public and major stakeholders are made fully aware of them. In the countries supported by AGRA's Soil Health Program, stakeholder meetings and workshops were organized to create awareness about fertilizer regulations and quality control. Factsheets were developed and distributed, and public awareness was intensified through the use of electronic media. These steps increased awareness among stakeholders about fertilizer policy and regulations. The awareness workshops (such as the one held in Kumasi, Ghana; see photo) involved stakeholders from different backgrounds who were given the opportunity to discuss the new policies and regulations that have been developed. Major stakeholders included farmers, agro-input dealers, agricultural extension specialists, fertilizer inspectors and other collaborators (police, immigration, customs, researchers and environmental protection agency staff).

In Ghana, the PFRD also sponsored airtime on local and national radio stations to discuss Part III of the Plants and Fertilizer Act, which outlines the responsibilities for key stakeholders, the mandate of PFRD, offenses and penalties, and other miscellaneous matters concerning fertilizer regulatory efforts. In Zambia, radio programs are organized to discuss fertilizer quality issues and the registration process.



*Fertilizer policy and regulatory awareness creation workshop for major stakeholders held in Kumasi, Ghana*

## Achievements

### Creating awareness

In countries where AGRA supported fertilizer quality control measures, importers, distributors, and retailers have been made aware of the key role they play in ensuring that farmers and the general public purchase fertilizers that are of high quality and that will perform as guaranteed on their labels.

Awareness efforts have given distributors and retailers a good understanding of the various offences and penalties associated with the different regulations and this has helped to foster stronger compliance within the industry. This is because the fertilizer inspectors now have a legal basis for prosecuting non-compliant dealers, something that was not possible before the regulations were developed.

Institutional collaboration following the awareness work has increased considerably with other regulatory and security agencies operating at the various entry and exit points in Ghana, Mali and Tanzania.

### Building institutional and staff capacity

AGRA saw a need to build the capacities of fertilizer regulatory institutions to ensure effective enforcement. This was done mainly by supporting the training of 3,200 fertilizer inspectors and fertilizer dealers in AGRA focal countries. In addition, 18 laboratory technicians were trained in fertilizer-related analysis. The training of inspectors and lab analysts resulted in a substantial improvement in their

technical skills. Other institutional capacity-building activities included improving the logistics of registration, post-registration surveillance, and testing of fertilizer quality, including the procurement of modern lab equipment for analyzing fertilizer samples. In Tanzania, needed equipment was procured for the new Tanzania Fertilizer Regulatory Authority, and additional lab equipment was supplied to the Agricultural Research Institute Mlingano in Tanga to enable analysis of fertilizers in addition to soil, water and plant samples. In Ghana new lab equipment for analyzing fertilizer was procured for the country's fertilizer laboratory. In Mali, the Research Institute (IER) laboratory has been upgraded with equipment needed for fertilizer analysis.



*Training of fertilizer inspectors at Koforidua, Ghana*

Building the capacity of regulatory institutions to implement new fertilizer policy and regulations is helping to guard against fraudulent practices by fertilizer producers, importers and dealers in AGRA's focal countries.

With their improved technical and logistical skills, fertilizer inspectors are able to successfully undertake the registration of fertilizer products, importers, and the licensing of distributors and dealers. This has facilitated post-registration monitoring as well as the development of current databases that enable regulators to track registered and unregistered dealers.

Stronger institutional and technical capacity has facilitated quality evaluations of fertilizer products both in the laboratory and in the field prior to their registration. The farmers who use fertilizers have become more knowledgeable about fertilizer quality and appreciative of the ability to purchase the input from registered dealers.

Moreover, improved technical capacity has enabled inspectors to initiate investigations into non-compliance issues by dealers and to follow up with evidence-based legal action.

## Harmonizing regional fertilizer policies and regulations

The use of fertilizer by African farmers is constrained by restrictive input markets, high transaction costs, and uncertainties about product quality. Fertilizer markets in Africa are highly fragmented (World Bank, 2012). Poor access to and use of fertilizers in Africa has been partly attributed to weak, unresponsive and fragmented policy frameworks and standards governing fertilizer supply chains. In order to facilitate fertilizer trade among and within ECOWAS member states and COMESA member states, these bodies have decided to dismantle trade barriers through the harmonization of fertilizer policies and regulations at the regional level.

The Regional Policy Formulation bodies in the agricultural sector (including ECOWAS, CILSS, COMESA, EAC, and SADC) recognize the need to harmonize regional policies to strengthen the efficiency of input and output markets. These bodies are committed to ensuring that appropriate policies and regulatory frameworks facilitate sustainable agricultural development.

The proposed regional fertilizer policies for West and East Africa are designed to enhance farmers' access to affordable, high-quality fertilizers that are better suited to local soil and climatic conditions. These policies will also promote inter- and intra-regional trade of agricultural inputs, as well as improve technology transfer. Recognizing the need for harmonization at the regional level, AGRA is supporting this important process.

In West Africa, the International Fertilizer Development Center (IFDC), through its Marketing Input Regionally (MIR Plus) project and the West African Fertilizer Program (WAFP), is the key entity leading the policy harmonization work in countries within the ECOWAS region. Locally manufactured fertilizer has been reported as adulterated, both in terms of chemical components as well as weight (Eilittä, 2006). Many ECOWAS countries are seeking to address this market failure through effective regulatory policies at the country and regional levels. Success in this effort will open new opportunities to increase the use of fertilizer by farmers. In this process, the Regulation C/REG. 13/12/12 relating to Fertilizer Quality Control in the ECOWAS region has been enacted in 2012.



In Eastern and Southern Africa and in Egypt, COMESA is partnering with AFAP to lead the harmonization work. As in West Africa, the goal is to promote the harmonization of fertilizer policies, laws and regulations at the regional level so as to facilitate fertilizer trade across borders. The harmonization process is complicated and is still underway. It involves six primary phases: 1) review of national fertilizer policies and regulations; 2) validation of national fertilizer policies and regulations of member states and development of a roadmap for the harmonization process; 3) harmonization of technical standards and regulations; 4) drafting of harmonized COMESA fertilizer policies and regulations; 5) approval of the harmonized COMESA policies and regulations through COMESA policy organs; and 6) domestication of the harmonized COMESA fertilizer policies and regulations (COMESA/ACTESA Proposal on Fertilizer Harmonization, 2014).

## Soil Health Policy Action Nodes

Soil Health Policy Action Nodes (SHPAN) comprise a policy support system established to generate evidence and increase its use for evidence-based policy making and advocacy in order to put better policies, laws, regulations in place, along with stronger institutional arrangements for soil health to support a uniquely African Green Revolution. AGRA supported the formation of SHPANs in its 13 focal countries. The goal of these nodes is to improve soil and crop productivity, and hence reduce poverty and food insecurity, through the development and implementation of good soil health policies.

SHPAN objectives include: 1) facilitating the development and implementation of policies and regulations to guide the implementation of fertilizer regulatory activities; 2) supporting the development of policy strategies to promote the use of integrated soil health technologies in Africa; 3) supporting African countries to improve the implementation of their fertilizer subsidy programs; and 4) regularly reviewing fertilizer prices to provide evidence in support of advocating for various governments to intervene to minimize price hikes. Some notable progress has been made through the SHPAN mechanism.

In Ghana, for example, a team of experts led by the International Fertilizer Development Center (IFDC) developed a National Fertilizer Policy Document in consultation with other stakeholders. Led by the Plant Protection and Regulatory Services Directorate (PPRSD), a team of experts produced the Plant Fertilizer Regulations, 2012 (L.I. 2194). Ghana's SHPAN, in partnership with IFDC, supported development of a web-based fertilizer- and seed-tracking system to monitor the subsidy programme being implemented by MOFA. Led by ISSER University, Ghana's SHPAN reviewed the

build-up of fertilizer prices in the country and proposed measures to reduce transaction costs. At the same time, the SHPAN advocated for continued tax exemption on fertilizer imports, and tax holidays on local fertilizer production so as to minimize price hikes.

Tanzania's SHPAN helped to develop a new policy on extension services, facilitated the development of an electronic monitoring and tracking mechanism for the National Agricultural Input Voucher Scheme, and developed alternative delivery mechanisms for fertilizer subsidies. It also developed a system for monitoring the returns to investments in agricultural extension services.

With support from Mozambique's SHPAN, a document has been developed to guide the country's fertilizer subsidy program at the national level. These guidelines have been presented to the Ministry of Agriculture for approval. The SHPAN has conducted policy analyses of the feasibility and profitability of local fertilizer production and blending (nitrogen and phosphates) to garner evidence to support policy advocacy. Proposed policy reforms have been developed to reduce the cost of fertilizer to farmers, including the removal of a 2.5 % duty on fertilizer imports; the latter has been tabled for discussion in Parliament. In addition, a new extension strategy for fertilizers has been developed, and local governments are being asked to increase budget allocations to extension services that target the Beira Corridor.

## Lessons Learned

- 1) In countries where new policies and regulations were developed and implemented, a level playground was created for fertilizer importers and dealers. This ensured that labels were truthful and pricing was based on the true quantity and quality of fertilizer products.
- 2) Institutions with improved technical and logistical capacity were able to successfully undertake the registration of fertilizer products, importers, and the licensing of distributors and dealers; they were also able to strengthen their fertilizer sector databases.
- 3) Countries that invested in their institutional and technical capacity are better able to implement quality control measures for fertilizer products. They are able to evaluate these products both in the laboratory and in the field before they are registered and sold, and thus make sure fertilizers of assured quality are on the market.
- 4) Effective enforcement of regulations is essential for achieving assured quality. Despite the existence of national fertilizer regulatory systems that cover the entire process, product adulteration and quality problems persist because of ineffective enforcement due to staff inadequacies and limited operational resources. Still, a better level of control exists generally in AGRA's focal countries that are making farmers more willing to use fertilizers.

## Conclusions

The AGRA Soil Health Program has invested heavily in building the fertilizer regulatory institutions' technical and institutional capacity for the effective implementation of fertilizer regulations, quality control, and the proper use of all types of fertilizers. The activities carried out with AGRA's support have resulted in focal countries developing improved policies, laws and regulations, and an on-going harmonization process at the sub-regional level. Some are still in the process of doing so. Staff and institutional capacities have been improved so as to help ensure enforcement. Major stakeholders, such as importers, dealers, and farmers, have been sensitized to the need for compliance with the regulations. Although enforcement cannot be said to be fully effective in these countries, improvement in the quality of fertilizers, and their increased and proper use have been recorded. The inclusion of fertilizer issues among the priorities of governments and major public and private stakeholders is an important goal, and rests on the belief that doing so can, over time, lead to increased crop productivity and greater food security in Africa.

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# 11 Training the Next Generation of Soil Scientists and Agronomists in Africa – Best Practices and Lessons Learned

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## Key Messages:

- 1 Given the central role agriculture plays in the economic and social wellbeing of most African countries, increasing public and private investments in agricultural education and research is absolutely critical. This is particularly important for soil science and agronomy, which are essential to reversing the low productivity of Africa's smallholder agriculture.
- 2 In order to develop a scalable training and education program, in 2010 AGRA's Soil Health Program (SHP) made significant investments in 11 public universities across 13 countries. Over the past 6 years, 186 graduate students were supported by SHP, of which 50% were women.
- 3 The Program's core thrust was graduating students: a) with skills that fit with what the market needs; b) that have the right mix of theory and practice in the subject matter; c) that return home to serve their national agricultural R&D institutions; and d) that graduate on time.
- 4 A major obstacle faced by the Program was weak capacity in some universities to implement new training projects, carry out cutting-edge research, and supervise students effectively. Partnerships with other institutions [such as the Consultative Group on International Agricultural Research (CGIAR) and top level universities outside Africa], and with regional agricultural education networks have helped to address some of these challenges.
- 5 Going forward, university leaders must play a pro-active role in strengthening their graduate programs, and be committed to developing and implementing changes in curricula. These are essential elements for success, and for replicability of the initiative in other African countries and universities.

## Introduction

Support for agricultural education and training, production, value addition, marketing, and policy development has not been commensurate with agriculture's importance for food security and livelihoods (Drame-Yaye, Chakeredza, & Temu, 2011). Investment in agricultural education and training is part of the equation, and an important aspect of transforming

Africa's agriculture. The importance of capacity building in agriculture is increasingly recognized by all actors keen to achieve sustainable development (NEPAD, 2016). Though concerted efforts have been made by a number of African countries, with substantial donor support, "capacity" remains a constraint to development and poverty reduction (USAID & FARA, 2015). Capacity is defined as the organizational and technical abilities, relationships, and values that enable countries, organizations, groups, and individuals at any level of society to carry out functions and achieve their development objectives over time (Sarfo & Nyamwanza, 2015). Capacity is treated here as a system composed of different levels – individual, organizational, societal, and sectoral. Across the African continent, research institutions, private companies, and development agencies find it difficult to attract the highly qualified and motivated staff they need (AGRA, 2014). The lack

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of a critical mass of qualified scientists poses significant constraints to conducting high-quality research in Africa (Stads & Gert, 2013). For example, the New Partnership for Africa's Development (NEPAD) estimates that only 2% of Africa's agricultural scientists are soil scientists, making it extremely difficult for African countries to confront agricultural problems relating to soil fertility and sustainable land use and management (NEPAD, 2016). The development of the Science Agenda for Agriculture in Africa (Science Agenda) under the auspices of FARA is an important step on the road to the transformation of Africa's agriculture (FARA, 2014). African science needs billions – not millions – of dollars in investment.<sup>6</sup> For example, in 2013 Kenya included a commitment to spend 2% of its GDP on research and development (R&D) in a new Science, Technology and Innovation Act. Overall, there is a need to invest in infrastructure and career development, both at universities and national research organizations.

The challenge facing governments of sub-Saharan African countries is how to build human capital through sustained investment in education and training to produce a highly qualified and trained workforce that can serve the continent. The problem emanates from a shortage of qualified staff, inadequate budgetary support to education, and poorly equipped laboratories and learning facilities (RUFORUM, 2007). There is a shortage of young professionals in the pipeline to replace aging and retiring professionals, resulting in capacity gaps in African agricultural science. As a consequence, the current cadre of professionals is not training enough capable students to serve as the continent's next generation of agricultural scientists. At the same time, historically wide gender disparities in the mix of students and professional staff remain.

The capacity problem is especially pronounced today as climate change rapidly alters crop-growing conditions in Africa. African farmers must be prepared to adapt to climate change, and to do so they will need strong extension support, backed by soil and crop scientists and other professionals who are familiar with the region's many different agricultural ecosystems and are able to sustain effective, efficient and adequate food production systems. The situation is aggravated by the declining interest of youth in taking up careers in agriculture, and especially agricultural research<sup>7</sup>. Agricultural careers no longer attract students because of the drudgery involved in low technology farming practices. Additionally, agricultural courses are too often delivered from outdated, narrowly defined and specialized perspectives, with curricula designed to train employees rather than employers or entrepreneurs.

Overcoming these challenges to African agriculture will require fundamental changes in the way universities and colleges train their students (Juma, 2012). According to Juma, part of the problem arises from the traditional separation between research and teaching – the former is carried out in national research institutes and the latter in universities. Moreover, as long as representatives with subject matter expertise from business and industry are not involved in curriculum reform processes, educational institutions will continue to churn out graduates that are not relevant to industries. Graduates are expected to possess professional capabilities to deal with the concerns of sustainable development along the entire agricultural value chain. A 21<sup>st</sup> century agronomist will need traditional knowledge of cropping systems and fertilizer regimes, but will also be expected to know about climate smart agriculture, entrepreneurship, research methods, GIS and remote sensing, and communications and writing. The 21<sup>st</sup> century agriculturist needs to be knowledgeable and skilled in developing innovative solutions to address the complex cropping systems and soil health related problems facing smallholder farmers. In this regard, over the past decade research has emphasized the need for today's young professionals to possess deep disciplinary knowledge, along with a keen ability to communicate across social, cultural and economic boundaries (Michigan State University, 2014).

Towards addressing the above capacity constraints, critical inputs are required in the following areas: infrastructure, such as classrooms, offices, laboratories, and library facilities; well-qualified and motivated faculty and support staff; high-quality and motivated students; and competent administration (Drame, Chakeredza & Temu, 2011). There is also a dire need for training in such topics as seed production and processing, soil fertility, fertilizer blending, post-harvest handling, food processing and value addition, and mechanization, especially to increase the effectiveness of the private sector.

This chapter underscores the importance of education and training for agricultural transformation in Africa and the need for higher agricultural education to prepare graduates in new and innovative ways. The chapter is divided into six sections including the introduction. Section two describes an innovative capacity development model for agricultural transformation. The third section describes the strategy and its guiding principles adopted to implement the capacity development model. The fourth section presents progress to date, highlighting key results and outcomes. The fifth section outlines lessons learned, and the last section focuses on conclusions and links to recommendations for action.

6 How Africa can close its continent-wide science funding gap, April 12, 2016. (<http://theconversation.com/how-africa-can-close-its-continent-wide-science-funding-gap-55957>/Accessed June 6, 2016)

7 <http://www.fara-africa.org/>

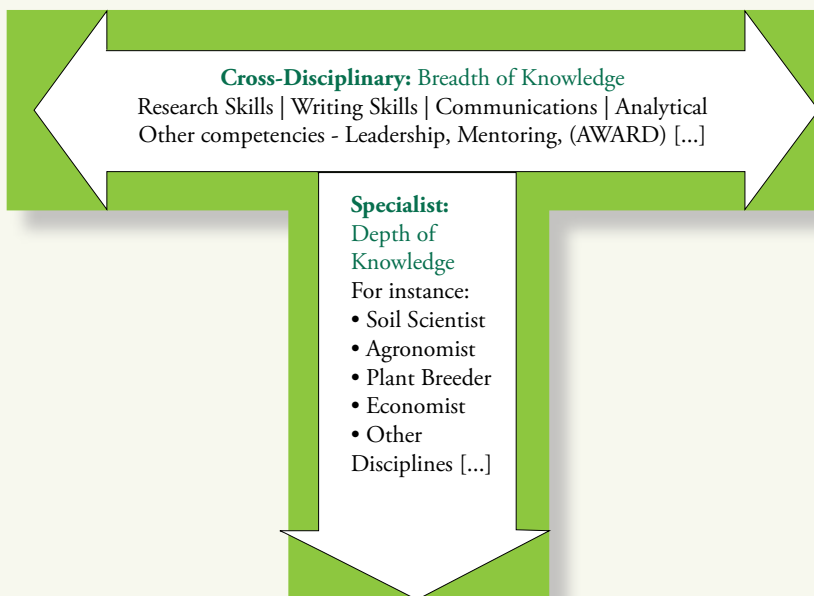
## Model for Transforming Agricultural Capacity Development in Africa

Developing skills and capacities is key to achieving an agricultural transformation in Africa. AGRA is working in partnership with major African universities, as well as with international counterparts that include Wageningen University Resource Centre (WUR), Cornell University, and Iowa State University. It has invested in putting together a training model to produce the next generation of African agricultural scientists and technicians who will be able to improve understanding of the agricultural landscape, i.e., soils challenges, crop improvement needs, and applied agricultural economics, all of which are key to tackling many social challenges across the continent (AGRA, 2014a; AGRA, 2014b).

The model adopted by AGRA's Soil Health Training Program is termed *T-skilled Agricultural Professional (TAP)*, a model adapted from WUR training programs and applied at all the universities supported by AGRA's Soil Health Training Program (Figure 11.1). The vertical bar of the "T" represents disciplinary specialization and the deep understanding of one system or a discipline, while the horizontal bar represents the ability to function across a variety of different disciplines. This model was introduced to overcome the shortcomings of linear approaches in teaching and research at institutions of higher education, which focus on producing students with deep disciplinary knowledge (referred to here as "T"-skills).

It is increasingly clear that agricultural industry and employers are placing ever-greater importance on skills that reach beyond a single discipline or focus. This model strives to produce the needed cadre of professionals who have new sets of skills and competencies that are needed to ensure the achievement of AGRA's model of "going beyond demos" (described in Chapter 2) that aims to catalyze wide uptake of improved technologies.

The aim of AGRA capacity building initiatives is to develop the skills and capabilities required to promote a value chain-driven transformation of smallholder agriculture in Africa. AGRA's initiatives strive to produce "T-shaped" professionals – graduates who are problem solvers in their own disciplines but also capable of interacting with and understanding specialists from a wide range of other disciplines and functional areas. In order to do this, AGRA-supported training offers students the opportunity to gain qualifications in such areas as agribusiness, GIS and remote sensing, scenario modeling, writing and communication skills, and research methods. Such interdisciplinary training equips graduates with the competencies needed to apply knowledge across diverse situations and engage well with peers from other disciplines. Generating graduates with such skills is at the heart of efforts in support of curriculum revision. The TAP-model was adopted in 2010 as the guiding framework for training programs supported by AGRA across sub-Saharan Africa.



**Figure 11.1.** The *T-skilled Agricultural Professional (TAP)* model

The section that follows outlines the strategy and interventions undertaken by AGRA partner universities (shown in Figure 11.2) to deliver on the TAP model. The T-skilled model is being advanced as a best practice for building the next generation of professionals more generally (Michigan State University, 2014). It is a scalable model that can be applied beyond training in soil health, i.e., it has the potential to be adapted to other academic programs and disciplines.

## AGRA's Approach

Africa's changing agricultural landscape, education sector and employment opportunities requires graduates who have deep knowledge in their field of specialization, as well as a wide range of skills in research, communication, and strategic and analytical systems. Given this backdrop, AGRA's Soil Health Program was designed to support graduate training in soil science and agronomy at the PhD and MSc levels in 11 African universities across 13 focal countries (Figure 11.2). This training sought to enhance the application of knowledge, science and technology in agriculture to improve the livelihoods and incomes of smallholder farmers. The Program also supported training of extension staff to improve information dissemination, and of soil laboratory technicians to improve the quality of plant and soil analysis.

The strategy used to achieve this takes a seven-prong approach:

- 1) **Strengthening institutional capacity to improve quality and relevance:** Africa's training infrastructure has historically been under-valued and under-resourced, which in turn has negatively impacted the capacity of the continent to supply graduates with needed skills, especially in agriculture and related disciplines. Strengthening human and institutional capacity is central to AGRA's seeds and soils training programs, which have provided unique opportunities to African agricultural scientists to develop the skills they need to advance agricultural
- a) *Laboratory equipment upgrades:* Recognizing the importance of well equipped, efficiently run soil and plant analysis laboratories to the development and promotion of integrated soil fertility management (ISFM) packages, AGRA's Soil Health Program provided grants to selected laboratories for the purchase of key lab equipment. This was coupled with grants to such service providers as the International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the Crop Nutrition Laboratory Services (CROPNUTS) to provide refresher training in laboratory analysis techniques and lab management. Prior to investing in procurement and the training of technicians, AGRA commissioned a review of the condition and capability of soils and plant analysis facilities at universities and research institutes in target countries. As part of the needs assessment, the faculty proposed a list of equipment that need to be procured. To date, the program has supported 11 universities in refurbishing their labs with new state-of-the-art equipment.
  - b) *Research relevance:* Solving Africa's soil productivity problems requires homegrown solutions, and perhaps one of AGRA's greatest contributions to agricultural transformation and innovation is through supporting the

## Kwame Nkrumah University of Science and Technology – Infrastructure Development:

AGRA support in plant breeding, seed and soil science post-graduate student training has stimulated investment by the University to erect an office block to accommodate all its graduate students, and extended the contracts of retired professors to mentor the younger faculty and staff. KNUST has become a centre of excellence that attracts top-notch visiting professors from within and outside Africa. The new facility is attracting students and projects from other countries in the West African region. A World Bank project has supported 39 students from The Gambia, Ghana, and Sierra Leone to enroll in various agriculture programs (Akromah R., personal communications). The University's research volume has increased and KNUST partnerships with other universities have grown. (AGRA and IIRR, 2014).

## Impacts of Education and Training Initiatives in Africa

Soils scientists are increasingly being asked to resolve real-world problems, putting science to work in developing policies and regulations. One such case is highlighted here: the development of drought and soil nutrition mitigation strategies for sorghum production in Burkina Faso.

Burkina Faso suffers an extreme, variable climate; both floods and drought can affect the same regions within the span of just a few months. The rainy season is only 3-5 months long and come just once each year. The main strategy used to reduce the impacts of variable rainfall is promoting water control techniques.

Dr. Sermi Idrisis, a Burkinabe national, tackled this problem during his AGRA-funded PhD program at Kwame Nkrumah University of Science and Technology (KNUST). He conducted research and wrote his thesis<sup>1</sup> on soil water conservation, in which he proposed a tillage option of tied rigging in the South Sudano zone of Burkina to help conserve water as a result of the effects of climate change in the area. Tied ridging, a simple water harvesting technique that, when combined with soil fertility management, can enhance production and resiliency in the event of drought which is common in Burkina Faso.



*Dr. Idrisis – Sorghum field trials in Burkina Faso*

Dr. Idrisis is currently working as a researcher at INERA (the national research organization of Burkina Faso) where he is undertaking trials to advance his thesis research using newly released sorghum varieties from Mali that are being evaluated for adoption in the various agro-ecologies of Burkina Faso. Dr. Idrisis will also use his training, especially the computer-aided modeling techniques he learned at KNUST and Wageningen University Research where he did his MSc in Natural Resource Management, to develop recommendation domains for the new sorghum varieties and their associated agronomy in different regions of Burkina Faso.

development of such solutions to food security challenges, coupled with delivering them to African farmers and partners (see Box above). Student thesis research supported by AGRA was designed to give students the opportunity to build on their course work and examine how ISFM and its components contribute to improved soil health in the context of specific agro-ecologies and the limited resources available to farmers. While students selected their thesis research topics, they also worked with university staff to ensure alignment and responsiveness to real-world needs. In some cases, student research was aligned with ongoing projects funded by the Soil Health Program. To strengthen research supervision, where possible students were assigned supervisors from different institutions in their home countries.

- c) *Theory and practice*: Agra-supported training takes a dual approach of combining scientific training (theory) with an understanding of the

practical context (hands on – putting theory into practice), providing African agricultural scientists with the grounded education needed to increase agricultural productivity across the continent. An expansion of initiatives like this, which recognize the link between basic scientific research and agriculture, is needed to drive forward a long-term approach to increasing agricultural productivity.

- 2) **Producing professionals that are “fit for purpose”**: Changes in Africa’s agricultural business arena – from a farm-to-market value chain approach – signal the need for changes in the agricultural profession, which in turn implies a need to prepare graduates in new and innovative ways. Dramatic changes are occurring in African agricultural research and development, and the urgency and importance of these changes is reinforced by the need to meet new challenges arising from climate change. Today’s agriculture-related careers require that students be trained in both hard and soft skills.





**Ms. KIBA/SOMA Dohan Mariam**  
 AGRA SHP Graduate  
 Country of origin: Burkina Faso  
 Institution: KNUST  
 PhD Soil Science (2010 – 2014)

## Learning in new languages

“The program greatly improved my proficiency in English by offering a dedicated English language course. The program empowered me to address soil fertility challenges in an integrated manner. The courses were carefully designed to equip me with advanced knowledge in soil science and deep insight into social, economic and extension issues. I am so glad I participated in the AGRA PhD Soil Science Program. My PhD research study earned me the Presidential Award for Emerging Agricultural Scientist in 2012. Prior to the completion of my PhD studies, I was appointed as a Research Scientist of the “Institut de l’Environnement et de Recherches Agricoles” (INERA) in Burkina Faso. I am currently the head of the Soil Chemistry Laboratory and a Team Leader for long-term soil fertility management trials.”

Graduates need more management and business skills and broader technical and science foundations, as well as in-depth disciplinary knowledge, to remain relevant in the job market. The generation of T- skilled agricultural professionals remains an imperative.

a) *Curriculum reforms:* To better align university soil science curricula with a changing agricultural landscape, a value chain approach to agricultural development is being stressed. AGRA’s Soil Health Program has supported universities in developing new curricula that are tailored to addressing ISFM issues, and revamping existing curricula based on the T-skilled model approach discussed in this chapter. The curricula being promoted include a wide range of course modules that take into account the complexities inherent in agricultural development. They include agribusiness, writing and communications skills, geographical information systems (GIS) and remote sensing, and the policy and regulatory environment within which agricultural development occurs. In April 2009, for example, the program supported curriculum development workshops at Kenyatta University (Kenya) and the Sokoine University of Agriculture (Tanzania). In August 2011, AGRA’s soil health training staff supported a curriculum review workshop for all AGRA-funded training programs in order to analyze current training curricula for relevance, appropriateness, content, and redundancy, as well as to share successes, challenges and lessons learned. The Regional Universities

Forum for Capacity Building in Agriculture (RUFORUM), the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAPE), Wageningen University and Research Centre (WUR) and other key stakeholders contributed to the workshop.

3) **Training within Africa:** Africa’s soil health problems require homegrown capacity building solutions. This takes into consideration the following attributes: research relevance, quality assurance, gender parity, strong partnerships, and institutional capacity building. It requires innovative approaches – in science, education and training – that address complex challenges facing farming communities. Students learned of and studied new problems faced by farm families and rural communities. Students supported by AGRA’s Soil Health Program were selected considering regional needs for highly trained people in ISFM. AGRA targeted both post-graduate (MSc and PhD) training and vocational training of laboratory technicians that serve the university laboratories and national agricultural research institutions. Students were drawn predominantly from national and international agricultural research systems, ministries of agriculture, non-governmental organizations, and universities.

a) *Regional coverage:* AGRA’s soil health training program adopted a regional approach to achieving its objectives. At the doctoral level, Kwame Nkrumah University of Sciences and Technology was targeted as the focal point for training new soil scientists for West Africa;

## The Value of Training Locally

“When we started this program we had the option of sending students to the US and Australia. However we chose to have them trained locally. This meant we could train more students and we could use the resources saved to build the capacities of selected universities. We knew the road would be tough, but in the long term it would pay off. There are a lot of people watching this experiment – they are concerned about quality and relevance, and not so much about quantity. As you go into this, know that there is a whole world watching you, and be cognizant that failure is not an option. Nonetheless, there is a lot that still needs to be done, and unless we are honest and ready for change, then I see a lot of the concerns being raised as real. Let us start in an earnest way and address the challenges that require going beyond individual departments, and then move on.”

**Dr. Bashir Jama, Director**  
AGRA's Soil Health Program  
(Quote from 2010)

Sokoine University of Agriculture (SUA) was selected as the training hub for the East and Southern Africa region. The program strives to strengthen regional networks by promoting cross-learning initiatives, attracting visiting professors from local and regional universities to support teaching and learning at the delivery universities through such initiatives as student mentorship and staff and student exchange programs.

## Regional Approach to Teaching and Research

A case study for Katibougou University shows that the University benefited from bringing lecturers and visiting professors from across the region, including from Burkina Faso, Niger and Mali. A total of twenty-five lecturers participated in teaching the 1st and 2nd cohorts of students. Among them were five visiting professors drawn from Université Polytechnique de Bobo in Burkina Faso, Abdou Moumouni de Niamey in Niger, Centre Régional Agrhymet, and ICRISAT-Niger. To enhance teaching, research and student supervision, four lecturers were drawn from national collaborating universities (USTTB), the national agricultural research organization (IER), and the Sotouba laboratory of IER, with the remaining lecturers drawn from the University. The regional approach to the training program advanced by AGRA comes with a number of benefits, including creating a critical mass of soil scientists in the region, producing communities of practice across the participating countries, enhancing networking and partnership between universities, and bringing experts from industry and national agricultural research organizations in the region. These experts support students' research, supervise fieldwork, and foster joint applications for research grants. This approach is replicated in all the AGRA-supported universities (see Figure 11.2, Map of Africa)

- b) *The PhD training model:* The PhD training programs at SUA and KNUST enrolled 42 students, exceeding the business plan target of 40. The Doctoral program runs four years and entails coursework for one year and three years for field research and thesis writing. This is essential to raise the quality of the current PhD programs. Both universities developed appropriate curricula and launched their training programs by October 2009. The curriculum for SUA was developed with the assistance of RUFORUM, an inter-university consultative forum for the Eastern and Southern Africa region. Similarly, curriculum development for the KNUST program involved a regional consultative process (with personnel from other universities, national research programs and CGIAR centers).
- c) *The MSc training model:* AGRA-funded MSc training programs (soil science, plant breeding and policy) run for two years, with one year of course work and theses proposal development and, in the second year, theses research and writing. Most of the students are attached to national agricultural research stations or CGIAR centers to conduct theses research, which is usually related to priorities identified by national research programs. Soil science MSc training programs are hosted at 11 universities: Kenyatta University-Kenya, University of Nairobi-Kenya, Makerere University-Uganda, University of Zambia, Lilongwe University of Agriculture and Natural Resources-Malawi, Haramaya University-Ethiopia, Eduardo Mondlane University-Mozambique, Institut Polytechnique Rural de Katibougou-Mali, Sokoine University of Agriculture-Tanzania,

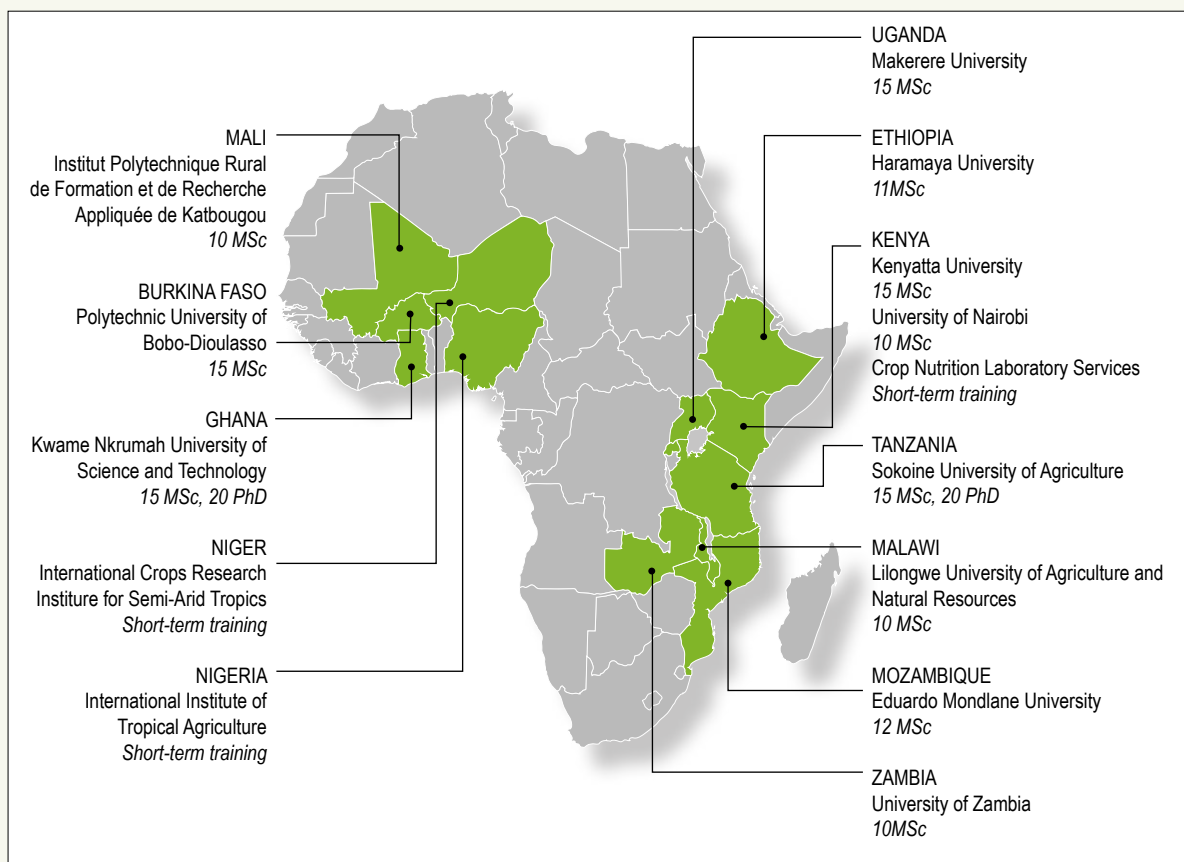
Université Polytechnique de Bobo-Dioulasso-Burkina Faso, and Kwame Nkrumah University of Sciences and Technology-Ghana. The choice of the 11 universities was driven by their history and their institutional capacity to offer regional training of post-graduate students in soil science.

- 4) **Vocational training:** AGRA has also supported the vocational training of 200 laboratory technicians that work in university laboratories and national agricultural research institutions in 13 sub-Saharan Africa countries; this includes agricultural extension staff trained at mid-level colleges that offer diplomas and certificates. Extension workers are expected to facilitate the provision of and access to advisory services, knowledge, information, and technologies all along the agricultural value chain, using appropriate and cost-effective delivery approaches, channels and tools.
- 5) **Quality assurance:** AGRA-supported soil health training builds in awareness of the importance of quality assurance and enhancement to ensure high standards in teaching and research at

AGRA-supported universities. It is committed to improving learning outcomes, and this requires strengthening institutional capacity, both human and infrastructural. In this context, the Soil Health Program invested in infrastructure rehabilitation (laboratory and computer facilities). The Program attracted top-notch visiting professors from within and outside Africa to support the teaching and faculty re-tooling at the partner universities. This intervention helped to ensure high-quality research during the entire thesis development, writing and defense process. Adopting such a practical approach assures that the host universities deliver regionally competitive training programs.

- a) *Student and staff exchanges:* To help lecturers continue functioning efficiently and productively, and to contribute meaningfully towards high-quality education, the Soil Health Program awarded a grant to facilitate exchanges between African universities and Wageningen University. Faculty and doctoral students were able to stay current in their fields and, hence, able to face new professional, academic, and societal challenges. Through a grant awarded to WUR,

**Figure 11.2.** AGRA's Soil Health Program training partners across sub-Saharan Africa



AGRA was able to train 44 SUA and KNUST faculty and doctoral candidates in Europe. This had a profound effect on improving lecture content and delivery in key subjects at the two PhD regional hub universities.

- 6) **Gender focus:** Attracting enough women to nearly all forms of agricultural training remains a challenge. AGRA's goal was and is to build a strong pool of female agricultural researchers, innovators and leaders, and in soil health training it established a 50% target for female enrollment. To achieve that target, a number of actions were taken, such as placing advertisements in print media, in e-media (AGRA and university websites), and proactively searching for qualified female candidates using headhunting services and through referral networks. The program put in place a financial incentive for nursing mothers and their families, as well as mentoring and leadership training by partnering with the African Women in Agricultural Research and Development (AWARD) program. AWARD facilitated searches for potential qualified female candidates through their networks, targeted advertising, and by reaching out to affiliated training institutes to let them know that women would receive a high priority in admission and financial support decisions, including women with children.
- 7) **Partnerships are critical to producing high quality professionals:** The key to the success of AGRA's soil health training was developing effective networks and strong partnerships for quality assurance, scalability and sustainability. Establishing targeted and effective partnerships among various institutions in support of teaching and research was vital, as was the development of joint programs. Strong partnerships were forged with agricultural universities and advanced research organizations within and outside Africa. AGRA supported partnerships between institutions in different countries to enable them to undertake teaching, joint research, curriculum reviews, develop improved teaching methods, and share new ideas and relevant expertise. This approach can improve the quality of teaching and research within delivery institutions, as well as provide opportunities for students to interact among themselves and with supervisors and professionals in their prospective fields.

AGRA-supported training programs are implemented in partnership with a number of development agencies and organizations. Scientists from within NARS and the CGIAR provide professional and technical expertise by co-supervising students, and in some cases delivering lectures. Soil health training activities were closely coordinated with education programs being funded by the Bill & Melinda Gates Foundation and The Rockefeller Foundation, as well as other

donors, and were implemented in partnership with a number of institutions in the region: the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM); African Women in Agricultural Research and Development (AWARD); and various universities, NARS and CGIAR centers. RUFORUM is involved in a number of AGRA-supported training initiatives and has provided useful insights about the challenges and opportunities offered by local universities in delivering graduate training activities. In the USA, AGRA has developed partnerships with the Universities of Maryland and Baltimore, and with Columbia University in New York. In Europe, a strong partnership has been developed with Wageningen University in the Netherlands. These partnerships help to improve the quality of graduate training provided by assisting in curricula development, staff and student exchange programs, and by providing expertise related to selected research topics.

## Key Achievements 2010-2015

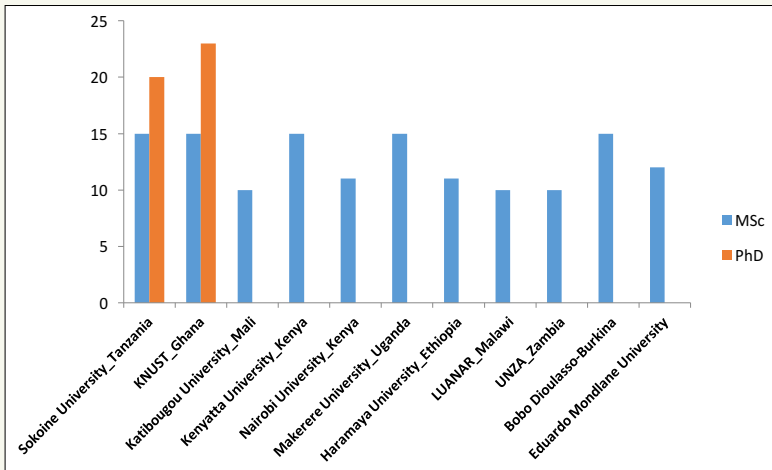
AGRA's capacity building efforts are showing transformative achievements in the agriculture sector in Africa. Its soil health training has made significant strides since 2010. AGRA has supported 11 African universities in developing and delivering an academic program for MSc and PhD training in soil science and agronomy, and about 50% of the students enrolled are women. A total of 182 students (43 PhD and 139 MSc) have been enrolled in AGRA-supported universities located in its 13 focal countries (see Figures 11.2, 11.3, and 11.4). Of these, 93 MSc and 22 PhD students graduated by November 2015. The MSc students on average took two years to graduate, and four years for the first cohort of the PhD students. All graduates found employment, with most being re-absorbed back into the national agricultural research and education institutes (Figure 11.5).

Soil health graduates are considered change agents in their respective countries. They contribute to existing efforts aimed at increasing agricultural productivity and household incomes, and their employers are likely to be universities, development NGOs, agricultural research institutions, and ministries of agriculture (Figure 11.5). These graduates will continue to play important roles with many employers as the agriculture sector still lacks a critical mass of young professionals that can bring about agricultural transformation in Africa, especially soil scientists, agronomists, extensionists and technical staff.

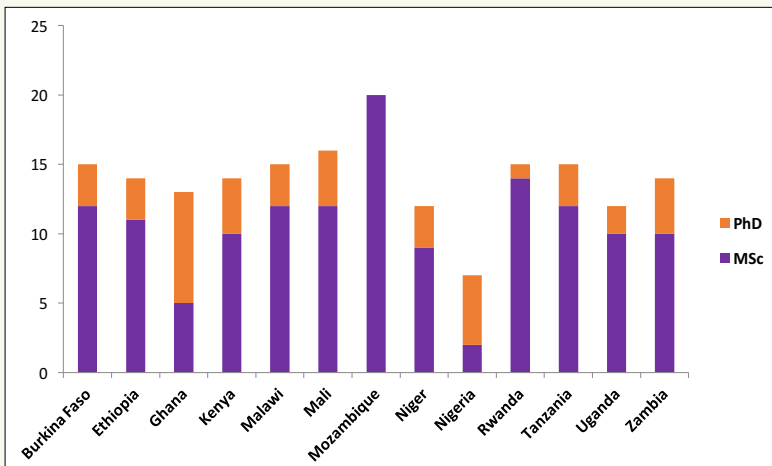
## Student and staff exchange programs

Through the AGRA-WUR partnership, the Soil Health Program supported the development of individual scientists through student and faculty exchange programs. A total of 46 participants (5 faculty and 41 doctoral students) benefited from exchange training programs undertaken in the Netherlands, Ethiopia and Belgium.

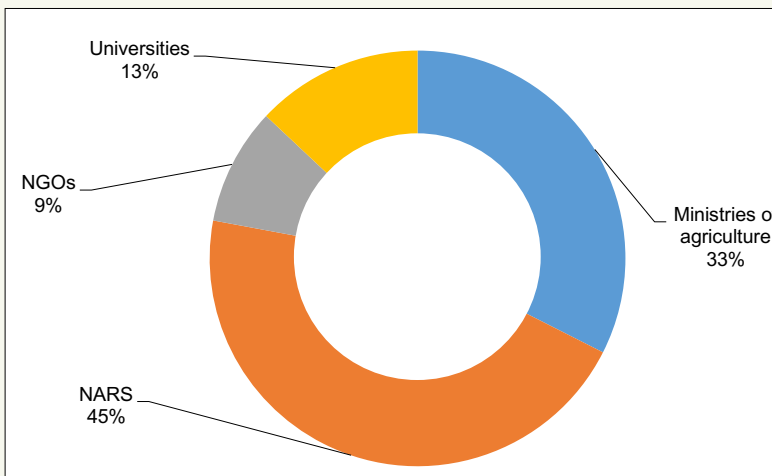




**Figure 11.3.** Distribution of students by University, as of June 2016 (AGRA, 2016)



**Figure 11.4.** Distribution of students by program and home country, as of June 2016 (AGRA 2016)



**Figure 11.5.** Distribution of students by workplace, as of June 2016 (AGRA, 2016)

This partnership has helped to improve instructional quality and research in the participating institutions over a 3-year period. The partnership is also expected to facilitate the development of sustainable research networks between scientists based in sub-Saharan African countries and those outside Africa.

The training was tailored to create product-oriented agricultural scientists and has yielded such dividends as exemplified in the Box below.

## Agricultural Products and Services Derived from Homegrown Training

### Ethiopia

The fertilizer trials conducted by MSc students funded by AGRA at Haramaya University, in partnership with the Ministry of Agriculture, have contributed significantly to the formulation of new fertilizer blends in the country that more effectively address declining soil fertility than does the conventional use of urea and di-ammonium phosphate in the country. The blended fertilizers contain important micronutrients as Zinc and Boron.

### Sustainability of AGRA's MSc and PhD training programs

AGRA-funded training initiatives are showing promising signs of enduring through efforts to attract additional donors. The MSc training programs at Kenyatta University and the University of Nairobi (Kenya), Katibogou Polytechnique (Mali), Kwame Nkrumah University of Science and Technology (Ghana), and Eduardo Mondlane University (Mozambique) have all attracted students funded by their respective governments and other donors (this includes self-sponsored students).

## Lessons Learned

To prepare for the future of agricultural education, it is important to draw lessons from the use of the T-skilled model approach. This section describes and analyses the training model and lessons learned over the past six years (2010-2015).

- 1) **Low career interest in agriculture:** Traditionally, agriculture is not an attractive discipline to African students due to, among other things, a lack of remunerative employment opportunities. Consequently, there are comparatively few

students – and especially women – enrolled in agriculture-related fields. Such low enrollment hinders Africa's attempt to improve agricultural productivity. With agriculture, and specifically with soil science, students struggle to get good jobs, which discourages enrollment. One way to invest in making agriculture disciplines more attractive is to upgrade the curriculum to include non-traditional course modules that foster the kind of entrepreneurial thinking that appeals to youth. This suggests a need to create robust organizations where these students could have job security and a good salary. At the high school level, intensive evidence-based awareness creation is needed about the advantages of choosing soil science as a career. More importantly, ways to enhance graduates' employability include forging strategic linkages with private agribusinesses and agricultural industry to help ensure internships, practical research, and placement after graduation.

- 2) **Attracting qualified students:** A major challenge has been achieving gender target of 50% women. This challenge led to delays in the admission of soil health training in some universities. It also meant staggering student admissions over two cohorts. This flexibility helped with attracting qualified students and reduced the workload that would have been created had all been admitted at the same time.
- 3) **Weak graduate student supervision and mentorship:** Most universities have very few academic staff that can supervise and mentor students, and most are also overloaded with teaching large numbers of undergraduate students. Using qualified NARS and CGIAR scientists as co-supervisors help to mitigate this supervisory challenge. Faculty generally do not allocate enough time to mentor, guide and support students outside of normal teaching hours. To overcome this, regional training workshops on mentorship and supervision for faculty were rolled out at KNUST and SUA.
- 4) **Enhanced linkages between education and industry:** There is need to strengthen linkages between institutions of higher learning and industry. Industries can provide insights into the skillsets needed for specific agricultural professionals. If there is no strong connection between employers and universities, universities will continue to produce graduates with irrelevant skillsets for industrial needs. To have impact, there is need to overhaul the curricula offered to better align with industrial and societal needs. To achieve this, AGRA working closely with the universities identified and entered into a memorandum of understating with a number of relevant agricultural research institutions and industries to facilitate students' field research. Students were attached to national agricultural

research institutions, the International Fertilizer Development Center (IFDC), CGIAR centers, and fertilizer blending industries, to mention a few. Increasingly, the industry needs graduates with enterprising skills – innovative, creative, self-driven and confident. In this context, curriculum reviews involved diverse stakeholders, including industry representatives, in order to meet current and future needs of both the industry and of society.

- 5) Laboratory equipment upgrades and usage for teaching: Universities need to upgrade their laboratory equipment to the industry standards required for experiments and other scientific research. Furthermore, laboratory technicians and faculty must also be competent in the use of modern laboratory equipment and in training students at a high level. Technicians should also be trained on how to maintain, service and do small repairs on lab equipment.

To this end, AGRA invested approximately USD 2 million in upgrading laboratory equipment and training lab personnel across 13 AGRA focal countries in order to improve quality of laboratory services. AGRA engaged the services of three institutions: The International Institute of Tropical Agriculture (IITA), Ibadan-Nigeria, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niamey-Niger, and Crop Nutrition Laboratory Services (CROPNUT), Nairobi-Kenya. The training model adopted by these institutions covered three areas: 1) training in basic soil and plant analysis for laboratory technicians, supervisors and managers; 2) Good Laboratory Practices and Laboratory Information Management System (GLP-LIMS) for soil and plant analysis; and, 3) in-country training of technicians in their home country/institutions to build their capacity to organize training in their own countries using local resource persons, and also to follow up on on-site training outcomes. Over 200 laboratory technicians were trained by the end of 2015. This has contributed to improving the quality of laboratory services and enhanced farmer access to testing services, from which they can make more informed decisions regarding which agricultural inputs are required to improve crop yields

## Conclusions and Recommendations

AGRA funding of soil health training for post-graduate students and technicians has improved the individual and institutional capacity of the universities and trained soil scientists. These investments have also resulted in institutions that have physical infrastructures and human capacities that attract students funded by other donors (and even those who are self-sponsored). To ensure sustainability, African governments need to invest in building the capacities of youth in agriculture, if a meaningful agricultural transformation is to be realized. African nations stand to benefit greatly from better-educated graduates – those who possess the required skills and knowledge needed to compete successfully in a knowledge-based global economy.

The improvement in soil science curricula has rejuvenated university training programs and, combined with refurbished laboratories, is making soil sciences an exciting field for young people. This progress needs to be reviewed frequently. Educational institutions must produce graduates that are employable and/or can use their skills for self-employment. While the TAP model adapted by AGRA's Soil Health Program offers a good starting point for strengthening capacity in higher education institutions in Africa, it requires long-term support for replicability and sustainability.

## Recommendations

- 1) **There is a need to increase investment in capacity building:** African governments, development partners, and other stakeholders should focus more attention on promoting and investing in the rapid expansion of Africa's human capacity to lead and bring about an agricultural transformation.
- 2) **There is a need to build a new generation of agricultural scientists, laboratory technicians and extension agents:** Education, science, and innovation are fundamental to the scalability and sustainability of agricultural development in Africa. There is a continuing need to invest in the new generation of agricultural professionals, ensuring that they are well grounded both in theory and practice in order to transform African agriculture. This must be driven by a new generation of faculty focused on producing graduates who are innovators and entrepreneurs, and that comprise a strong and balanced mix of women and men.

- 3) **Curriculum reforms:** Education has to constantly evolve and grow to meet the ever-changing needs of the agriculture sector, including agribusinesses. Universities must review their curricula periodically and effectively engage youth in agribusiness and agriculture. University curricula need to be relevant to the market, to society, and to industry in order to attract youth to agriculture.
- 4) **Innovation is key to the scalability and sustainability of agricultural development:** Innovation must include the commercialization of research products by industry. This process needs to be inclusive and consultative, including farm communities that agribusinesses serve. Proactive involvement of researchers and development specialists is necessary to create innovative services, processes, and new methodologies and practices.
- 5) **Increased Investment in institutional capacity development:** To achieve recommendations 1 to 4, investments in human capital and institutional capacity are essential. This will require strong commitment by national governments, the private sector, donors, regional bodies, and development partners.
- 6) **Partnerships are imperative for sustainability and scalability.** Effective investment in agriculture depends on strong partnerships across all sectors. This would need better linkages within and between universities, national governments, national agricultural research institutions, international agricultural research institutions, and other development partners to deliver improved teaching, research, innovation, and the development of a new generation of agricultural scientists.
- 7) **Enhanced implementation of policies aimed at improving tertiary education:** Many good educational policies are in place at universities and within national governments, but implementation remains a bottleneck. There is a clear need to revise current implementation mechanisms and strive to change the mindset of policy makers, faculty and students.

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# 12 Knowledge Management for Improving the Impact of Agricultural Investments in Africa through Country Soil Health Consortia

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## Key Messages

- 1 While a great deal of knowledge has been generated from decades of agricultural research, soil quality has continued to decline and average crop yields remained far below expected levels
- 2 Existing knowledge is scattered across various locations and resides with individual scientists and institutions while increasing crop production requires integrated packages of information on soils, fertilizer application, crop varieties, agro-ecological zones, economics, and input-output markets
- 3 Consolidation, synthesis and dissemination of such knowledge is critical for optimizing the impact of existing agricultural information
- 4 The establishment of country soil health consortia has enabled better packaging and use of existing knowledge and created a platform for supporting extension, learning institutions, policy makers and private sector organizations

poor adoption of good agronomic practices (AGRA, 2013) as a result of limited integration and flow of available information across institutions and various levels of individual crop value chains (AGRA, 2013). This circumstance often leads to duplication of research efforts, dissemination of conflicting information, and limited application of the best knowledge for making decisions (Toenniessen et al., 2008). The resulting confusion leads to either low uptake or inappropriate implementation of good agricultural practices.

A study by the International Plant Nutrition Institute (IPNI) and IITA in 13 sub-Saharan Africa countries concluded that over 60% of agricultural stakeholders working directly with farmers, including extension workers, lacked a good understanding of the practices they were promoting (AGRA, 2013). Among policy makers and private sector fertilizer and seed suppliers, the understanding of requirements for optimal crop performance was less than 5%. The respondents associated these widespread knowledge limitations to the poor flow of agricultural knowledge from those who generate it (mainly researchers) to potential users (extension workers, policy makers, private sector organizations, and farmers). Moreover, existing information is often poorly synthesized and interpreted for local application and remains dispersed across multiple locations with individual scientists and institutions. The development of good agronomic practices requires the integration of information about soil types, inherent soil fertility, fertilizer application (types and rates), crop varieties, agro-climatic zones, economic considerations, and input-output markets. Legacy data from various countries confirmed that over 90% of existing agricultural knowledge is usable mainly by researchers (Table 12.1). The impact of such knowledge on food security and household incomes will remain low unless mechanisms are developed to make it accessible by farmers, extension workers, private sector organizations, and other agricultural value chain actors.

It is against this background that AGRA's Soil Health Program (SHP) supported the establishment of Country Soil Health Consortia (CSHC) to collate, harmonize and package existing soil health knowledge, mostly on integrated soil fertility management (ISFM) practices.

## Introduction

Much soil and crop management knowledge relevant to transforming African agricultural production has been generated through decades of research, yet the yields of many major crops have remained at less than 30% of their yield potential in most African countries (<http://www.yieldgap.org>). This is mainly due to the

1 International Plant Nutrition Institute (IPNI), c/o IFDC-East and Southern Africa Division, P.O. Box 30772-00100, Nairobi, Kenya

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4 CSIR-Soil Research Institute, Academy Post Office, Kwadaso, Kumasi, Ghana

5 International Institute of Tropical Agriculture (IITA), PMB 5320, Oyo Road, Ibadan, Nigeria



**Table 12.1:** The status of publications and other communication materials addressing research, extension and policy in four countries at initiation of the CSHC

Classification of materials	Tanzania (N = 6,000)	Zambia (N = 2,500)	Kenya (N = 6,450)	Malawi (N = 900)
Research	91%	95%	80%	91%
Extension	6%	3%	7%	6%
Policy	3%	2%	3%	3%

**N = total number of publications and other communication materials collected for synthesis and harmonization (Source: Consortia legacy data)**

The CSHC were formed in 13 African countries<sup>6</sup> to provide a platform for: compiling existing data and publications; developing effective knowledge products; and disseminating synthesized and appropriately interpreted knowledge to extension workers, researchers, policy makers, seed producers, and fertilizer suppliers.

This chapter discusses the structure and outputs of the CSHC relative to capacity for providing extension advisory services and agricultural policy makers with appropriate and well packaged information and knowledge aimed at taking agricultural information beyond the research plot and field demonstration level.

## The Country Soil Health Consortia Model

There have been many efforts to develop various kinds of agricultural networks prior to the advent of the Country Soil Health Consortia (CSHC) model. The formation of such partnerships is driven by recognition that no single institution has sufficient capacity and resources to address the multiple challenges inherent in transforming agriculture in sub-Saharan Africa. Examples of these networks include the Soil Fertility Management and Policy Network (SoilFertNet), the Soil Fertility Consortium for Southern Africa (SOFECSA), the African Network for Soil Biology and Fertility (AfNet), and the Future Agricultures Consortium among others. These networks generated considerable information, but their impact on smallholder farmers was limited. The key reasons for this included:

- 1) Failure to address the multiple issues emanating from various agricultural value chain players;
- 2) Centralized management of the networks, mainly from CGIAR centers, which inhibited national ownership;
- 3) The concentration of some networks, such as SoilFertNet, AfNet and SOFESCA, on developing technical scientific publications without

corresponding strategies focused on the delivery of useful information to farmers, extension workers, policy makers, and other non-scientific agricultural stakeholders (Bationo et al., 2007); and

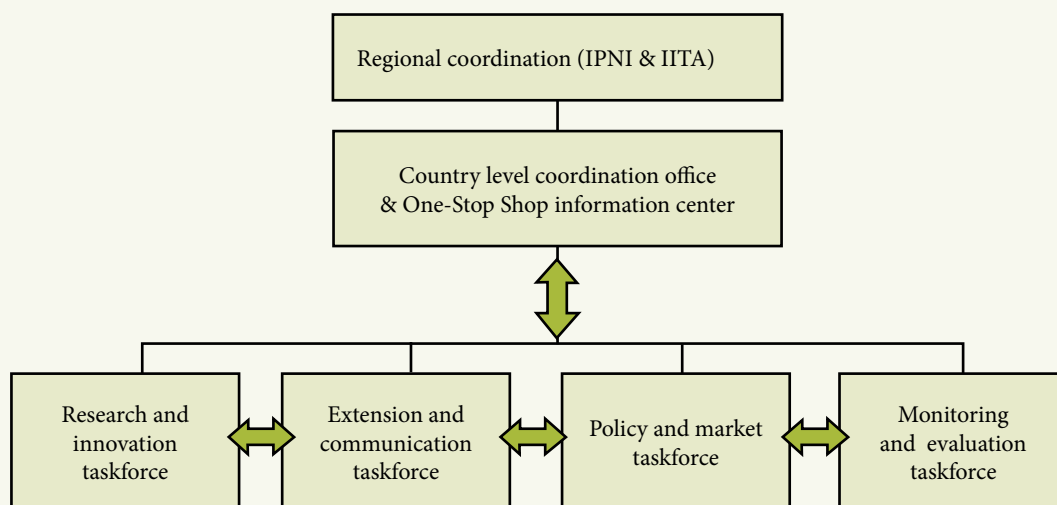
- 4) The networks failed to integrate a wide array of knowledge that had been generated through earlier research and by other institutions that were not members of network

The CSHC model differs from these earlier platforms in several ways, including:

- 1) The existence of a full consortium network of institutions (including non-research institutions) spreading across all agro-ecological regions within each country;
- 2) The establishment of one-stop shop information centers in all the consortia countries;
- 3) The consolidation of both legacy and new (raw) data from all country level agro-ecologies for use in database creation and development of data-driven communication products;
- 4) Clear dissemination strategies involving public and private extension systems, partner media houses, and consortia websites; and
- 5) Support for data-driven policy formulation through the improved flow of information between scientists and policy makers.

The CSHC bring together soil scientists, agronomists, plant breeders, seed scientists, policy makers, extension workers, communication experts, and other relevant stakeholders drawn from across regions of the country. These partners come from NARS, academic institutions, national and private extension systems, CGIAR centers, development agencies, NGOs, farmer organizations, and private sector entities. CSHC activities are undertaken by four taskforces. The linkages and flow of information between these taskforces are shown in Figure 12.1.

<sup>6</sup> Burkina Faso, Ethiopia, Kenya, Ghana, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Uganda, Tanzania and Zambia



**Figure 12.1:** Regional to country level structure of the CSHC in the 13 focal countries (arrows between taskforces represent interactions, information flows and feedback loops)

In brief, the structure and functions of the taskforces are:

- 1) **Research and innovation taskforce** – This group is made up of a mix of agronomists, soil scientists, seed scientists, and agricultural economists from NARS, universities, CGIAR centers, and NGOs. This taskforce is charged with responsibility for developing harmonized research protocols, evaluating the quality of agronomic and economic data, and developing recommendations for specific agro-ecological zones and crops.
- 2) **Extension and communication taskforce** – This group is made up of government, private, and NGO extension agents, extension trainers, and agricultural communication experts. It partners with the Africa Soil Health Consortium (ASHC), a project funded by the Bill & Melinda Gates Foundation, and is tasked to produce relevant extension knowledge products and farmer guides in various local languages across all 13 CSHC countries. It develops extension materials and approaches that are based on experience with farmers and best practices for country specific farmer-extension engagement. The extension modules and farmer guides are based on data vetted by the research and innovation taskforce.
- 3) **Policy taskforce** – This group includes representatives from national and regional policy organs within a country, such as, for example, the Tegemeo Institute of Agricultural Policy and Development at Egerton University in Kenya and the Kenya Institute of Public Policy Research and Analysis (KIPPRA), an autonomous public institute based in Nairobi. This taskforce supports the formulation of agricultural policies to facilitate adoption of good agricultural practices. It also

engages with decision makers through policy dialogues and shares policy information with them for use in national agricultural policy debates and policy development.

- 4) **Monitoring and evaluation taskforce** – This taskforce is composed of monitoring and evaluation experts from the CSHC member institutions, government economists, and project managers. It is responsible for assessing and reporting back on the progress and impact of the consortia.

## Delivery Strategy for the CSHC Model

The CSHC partnership rests on and is strengthened by an institutionalization agreement that allows member organizations to claim co-ownership of outputs. A consortia secretariat was established in each of the NARS of the 13 participating countries to coordinate the activities of partners and taskforces, as well as the development of country level one-stop shop agricultural information centers (Figure 12.2).

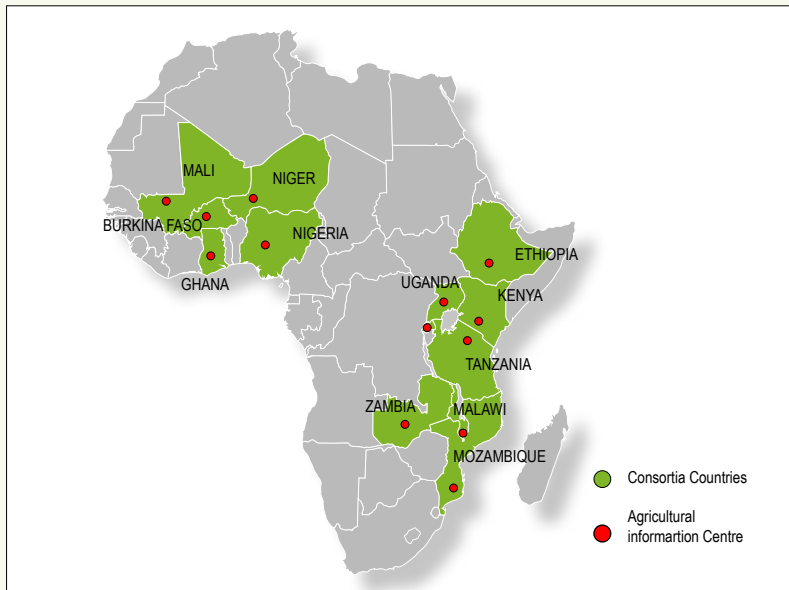
At initiation, the regional and national secretariats conducted a survey to ascertain the agricultural research data and publications that had been developed in each participating country for the period between 1980 and 2015. The publications and raw datasets from these projects were vetted for quality and catalogued/collated for easy reference, access and synthesis.

A one-stop shop agricultural information center was established within the secretariat institutions (Figure 12.2) to act as a national repository for all the knowledge gathered and the materials that are developed by the CSHC.



On the basis of synthesized data, the research and extension taskforces develop demand-driven extension products – bulletins, extension training modules, farmer guides, illustrations, and information sheets. The role of research group in this process is to ensure quality (i.e., that the science is not distorted) and the role of the extension group is to ensure that the messages are presented in formats that are appropriate for extension workers.

Based on the results emanating from data syntheses, the policy taskforce develops targeted policy instruments. The policy group links this information to various policy makers who use it to take informed decisions on fertilizer subsidies, fertilizer and seed quality regulations, and the need for investing in capacity building among other important agricultural policy issues.



Location of Secretariat & agricultural information centers		
Country/Region	Location	Institution
East and Southern Africa Regional coordination center	Nairobi-Kenya	IPNI
Ethiopia	Addis Ababa	MOA
Kenya	Nairobi	KALRO
Uganda	Kawanda	NARO
Tanzania	Arusha	SARI
Malawi	Lilongwe	LUANAR
Zambia	Mt. Makulu	ZARI
Mozambique	Maputo	IIAM
West Africa Regional coordination center	Ibadan-Nigeria	IITA
Nigeria	Zaria	IAR
Ghana	Kumasi	SRI
Burkina Faso	Ouagadougou	INERA
Niger	Niamey	INRAN
Mali	Bamako	IER

**Figure 12.2:** The CSHC countries and location of one-stop agricultural information centers

The CSHC also partners with over 60 media companies through the extension and communication taskforce to facilitate dissemination of consolidated information to various stakeholders across the countries. In addition, the consortia developed a regional website and national-level websites for the dissemination of appropriate agricultural information at a national, regional and international levels.

## Achievements

In addition to producing a range of agricultural knowledge products, consortia activities include dissemination of information on best ISFM practices and support of various kinds to extension services, policy makers and private sector organizations.

### The one-stop shop centers and use of consortia communication products

The one-stop information centers host datasets and various farmer guidebooks about how to implement agricultural practices, including ISFM and their suitability to different agro-ecological conditions. A summary of information held in four one-stop information centers is presented in Table 12.2.

The consortia taskforces developed over 100 synthesized knowledge products in response to stakeholder demand and existing information gaps. Relatively more materials were developed for extension workers and policy makers (Table 12.3). Various projects, government departments

and NGOs acquired about 140,000 extension guidebooks, which were used to provide advisory services to farmers in Tanzania, Zambia, Kenya, Rwanda, and Malawi. These materials are essential for supporting agricultural extension service providers. There are very few extension workers relative to the number of farmers needing support – the average extension-farmer ratio in CSHC target countries is estimated to be about 1:1000, compared to the recommended ratio of 1:400. In addition, extension workers have limited opportunities for upgrading their skills in response to emerging agricultural challenges and opportunities. The materials thus help extension staff to reach more farmers with useful information and technologies, including guides for training of trainers, implementing farmer field schools, and other extension activities. The consortia also provided support to policy makers by developing and disseminating various policy communication products (Table 12.3). For example, the crop suitability maps and soil acidity maps developed through the Kenya consortium were used by the Ministry of Agriculture for fine-tuning fertilizer recommendations by regions and crops through the IFAD-funded Kenya Cereal Enhancement Programme (KCEP), which was implemented in 13 Kenyan counties. The training modules developed by the Rwanda consortium were adopted by the Rwandan educational system for training its students. This is important, not only for promoting the use of best agricultural practices, but also for building a cadre of scientists with the right skills to guide appropriate uptake of ISFM. Appropriate skills are a pre-requisite for taking technologies beyond the demonstration stage.

**Table 12.2:** Snapshot of the type of information held in four one-stop shop information centers, as of October 2015

Country	Location	Summary of materials held in One-Stop Shop Center in easily accessible format
Tanzania	Selian Agricultural Research Institute (SARI)-Arusha	Cereal-legume interactions, crop response to fertilizer use, crop suitability maps, legume inoculation, lime use, organic-inorganic interaction, conservation agriculture, policy briefs, extension training modules, farmer guides for various crops, videos
Rwanda	Rwanda Agriculture Board (RAB)-Kigali	Crop response to fertilizer, crop suitability maps, agroforestry in maize production systems, soil and water conservation, soil fertility maps, management of acidic soils, rice and salinity, fertilizers and cereal production, legume-cereal interactions, legume seed inoculation, lime use, conservation agriculture, policy briefs, farmer and extension training modules, government policy documents, farmer guides for various crops, videos
Zambia	Zambia Agricultural Research Institute (ZARI)-Lusaka	Soil fertility gradient maps, fertilizer recommendations, crop response to fertilizer, conservation agriculture, agroforestry, cereal-legume interactions, climate-smart agriculture, legume inoculation, liming, network of input-output dealers, ISFM training module for extension workers, farmer guides for various crops, videos
Niger	Institut National de la Recherche Agronomique du Niger (INRAN)-Niamey	Fertilizer recommendations, training modules for extension workers, farmer field school guides, success stories, agricultural input-dealers map, and fertilizer, pesticide and seed regulations

**Table 12.3:** Proportion of the targeted communication products developed by selected consortia countries by mid-2015

Target stakeholders	Tanzania (N = 25)	Zambia (N = 23)	Kenya (N = 17)	Malawi (N = 20)	Burkina Faso (N = 20)
Extension	60%	65%	42%	50%	49%
Policy	35%	30%	55%	35%	14%
Fertilizer recommendations and blending	5%	5%	3%	15%	37%

\*N = total number of communication products developed per country

## Dissemination of agricultural information

Between 2013 and 2016 the consortia reached an estimated 20 million stakeholders in the initiative's 13 focal countries, providing packages of appropriate ISFM information through media (radio, TV), agricultural exhibitions, conferences, newsletters and websites. Farmers, extension agents, policy makers and private sector organizations were the primary target beneficiaries for disseminated information. Farmers and extension agent access to appropriate knowledge is crucial for clarifying which technologies work best for different crops and regions. In addition to providing insights into which technologies work in different regions, the consortia knowledge packages provide details on the "how" and "why" of various ISFM technologies, thus facilitating the process of going beyond demos.

**Dissemination through media: the case of Tanzania and Zambia** – The Tanzania soil health consortium partnered with nine media companies: the Citizen Newspaper, Independent Television, Star Television, the Nipashe Newspaper, Tanzania Broadcasting Corporation, the Daily Newspaper, the Mwananchi Newspaper, Radio Free Africa, and Radio One. The information disseminated through these companies included, for example, projected yields and economic benefits of various ISFM interventions, and information about appropriate ISFM practices to improve the production of cereals, legumes and other major crops.

The Zambia consortium partnered with seven media companies for widespread dissemination of harmonized agricultural messages: the Zambia News Information Service, National Agricultural Information Service (NAIS), Agricoop News, Zambia Daily Mail, Jamia Radio, Radio Phoenix, and Prime TV Zambia. Through these partnerships, 19 journalists were trained in how to best present agricultural information, and more effective working relationships developed between the scientists and journalists. Estimates by the media companies indicate that through these partnerships the consortia reached between 8 and 10 million stakeholders in Tanzania and Zambia with a wide array of ISFM information.

## Use of websites for dissemination of consortia outputs

Websites are more appropriate for disseminating information to stakeholders in more remote locations beyond the normal coverage of major media platforms, and who may not have access to the one-stop information centers. The CSHC unveiled a regional website ([www.soilhealthconsortia.org/](http://www.soilhealthconsortia.org/)) and 12 country websites. These sites feature educational material, extension manuals, newsletters, and videos generated by the consortia teams. They also link users to other agricultural sites and databases, such as Nutrients for Soils, the Fertilizer Catalogue, FAOSTAT, AGRA, IITA, IPNI, the COMPRO project, the N2-Africa project, and the Africa Soil Health Consortium. The Google analytic results for November 2015 showed that a month after launch there had been 5,000 visitors to the consortia websites and 700 downloads.

## Consortia role in supporting capacity of the extension workers

The CSHC has so far strengthened the capacity of more than 2,000 extension workers across its 13 focal countries using the human resources and knowledge developed through the consortia network. Mainstream training of extension workers often relies on textbook examples that do not reflect local conditions and focus mainly on general agronomy. Furthermore, weak linkages between extension workers and researchers in most African countries result in extension personnel not having the latest information about new technologies. The CSHC used country specific knowledge to bring extension workers up to speed on soil fertility, fertilizers, agronomy, policy issues, market issues, production economics, and private sector issues. This broad package of knowledge is a fundamental building block for delivering holistic agricultural content to farmers. The country-to-county areas of focus for capacity building were based on existing weaknesses identified by the extension and communication taskforce. Tanzania and Zambia are used here to highlight the potential impact of this approach.

In Tanzania, over 40% of extension personnel currently working in Tanzania were first trained in the 1990s. As with most other African countries, Tanzania's investment in in-service training is inadequate. In 2015, the Tanzania soil health consortium trained 358 extension workers on a wide array of good agronomic practices. The training addressed maize-legume intercropping, crop rotation, acidic soils and lime requirements, climate-smart agriculture, and the economics of production. Further, 20 types of crops and agro-ecological zone-specific communication products were shared with the extension staff to use for retraining other extension workers. The trained extension workers used the materials and new knowledge they acquired to facilitate similar training efforts in the Southern Highlands, and in the Northern and Central Regions. It is estimated that the knowledge and skills of more than 1,000 extension workers were upgraded through this "Training the Trainer" model. Similar activities were implemented in Zambia, Rwanda and Uganda, pushing the total number of trained extension workers to about 3,500 between 2013 and 2015. Using the conservative estimate that an extension agent is able to reach an average of two farmers each working day translates into about 7,000 farmers being reached each day with better information packages – and this further implies that over 5 million farmers are reached over the course of a year.

### Consortia role in supporting the policy making process

Agriculture growth requires supportive policies. The Tanzania consortium attracted the attention of high-level policy makers, including Ministers, Members of Parliament, Regional Commissioners, District Executive Directors, and Ward Councilors, who were made aware of agricultural technologies appropriate for different regions. The consortium contributed to high-level policy dialogues at the invitation of policy makers and shared six policy briefs with regional commissioners, heads of government agriculture committees, and the Tanzania Fertilizer Regulatory Authority for use in strengthening the country's agricultural policies. The government is using these briefs and other information outputs in the development of bills to better regulate fertilizer quality and to establish a code of practice for private fertilizer blending plants.

Similarly, the Zambia consortium is facilitating development of appropriate fertilizer policies that are informed by harmonized soil fertility response data from the consortia research and innovation taskforce. The Zambia consortium also developed agricultural extension modules that the government is using to upgrade its agricultural extension training policy. Similar initiatives have taken place in Malawi, Uganda and Kenya.

## Implementation Challenges

Initiating the country soil health consortia was complicated by the need to build a network of partners who are normally competitors. This competition was evident even among scientists working in the same institutions who worried about sharing data and losing credit. Similar competitiveness was evident among members from the private sector. Fertilizer companies, for example, initially found it difficult to share fertilizer market data with other consortia members. CSHC managed to strengthen engagement and build confidence between different partners through data-sharing policies, demonstrating the potential benefits of contributors to the consortia, and institutionalizing the consortia through formal agreements between lead institutions. It was also challenging to bring soil science and social science disciplines together, which usually contextualize issues differently and do not have much experience working together. For example, communication experts/journalists were not used to working with soil scientists. Even within developmental disciplines, policy experts and economists were not familiar with the working culture of the soil scientists, and vice versa. These professional disparities in perceptions were counteracted through a series of preliminary workshops to highlight the existing disconnects and the potential synergies. A good example of this is the journalists training done in Malawi and Zambia on how to best report agricultural information.

## Lessons Learned

Several important lessons have been garnered from the CSHC initiative to date:

- 1) Strong multi-stakeholder partnerships can indeed be created to produce and disseminate targeted knowledge packages that facilitate the growth of all agricultural sub-sectors concurrently. This model also enables robust capacity building in agriculture by capitalizing on the multi-disciplinary experience of consortia members and stakeholders. It is impossible for any single institution to amass the human and financial capacity required to provide all of the agricultural support services provided by the consortia. The sustainability of the CSHC and its impacts rests on the close linkage of its outputs with extension, learning institutions, and private sector organizations.
- 2) The CSHC was effective in building the capacity of extension workers in its target countries, using the Train the Trainer approach to do so. It also developed training materials for the trained extension agents to use in training their colleagues.



The experience showed that this is an affordable model for large-scale capacity building of frontline extension workers. In addition, the relationships between extension agents and researchers in various countries were rebuilt through the consortia partnership. Since these are mainly public employees on long-term contracts, the impact of the consortia training and re-built research-extension linkages will be evident for many years to come.

- 3) The adoption of consortia training materials by learning institutions implies that the knowledge generated will be transmitted across generations. As highlighted earlier, some of the Rwanda consortium materials are being used for technical training by the country's educational system and listed as reference materials for other regular agricultural courses. The Kenya and Zambia consortia have recently produced similar materials.
- 4) Policy documents developed with the support of the CSHC will continue to impact agriculture for a long time. The consortia policy documents are in use by various government departments and private sector entities to strengthen fertilizer regulations. For example, through a partnership between the government of Kenya, Moi University, and IFDC, the knowledge generated by the Kenya consortium (soil fertility maps and policy briefs) will facilitate fertilizer blending initiatives through investments by the government of Kenya and Toyota Tsusho Fertilizer Africa Limited (TTFA). The consortia partners supported setting up the TTFA and will also help with the interpretation of crop response data. Further, the IFAD multi-county Kenya fertilizer recommendation/subsidy known as KCEP, which targets eight Kenyan counties, was developed using the Kenya consortium soil fertility databases. Similar initiatives are underway in Tanzania, Uganda and Zambia. Through these fertilizer initiatives, the consortia will have an enduring impact on private fertilizer blending businesses by ensuring the production of high-quality fertilizer products, and on agricultural production through the availability of appropriate fertilizer blends in the market.
- 5) The consortia model is applicable in other African countries that are not members of the current platform. Most of these countries produce limited communication products for non-scientific audiences, and struggle with disconnects between researchers, extension professionals, policy makers and private sector entities. The consortia model is therefore replicable in Senegal, DRC Congo, Liberia, Southern Sudan and Sierra Leone, among many other African countries where such challenges are evident.

- 6) The model represents a cheaper way of achieving multiple outputs simultaneously. With a budget of about USD 4 million, the East and Southern Africa and West Africa consortia reached an estimated 20 million stakeholders with useful information, and supported over 6,000 extension workers with educational materials and direct capacity building. This implies that the cost of reaching a stakeholder through the consortia platform approach was less than USD 1.00. It is estimated that a single institution approach would have cost more than USD 20 per stakeholder reached. This illustrates the great value of partnerships in driving agricultural transformation in Africa.

## Conclusion

The CSHC model is an effective way to bring important stakeholders who traditionally have worked in isolation into partnerships that improve the flow of information across agricultural value chains. It is allowing for widespread dissemination of harmonized ISFM technologies to all interested stakeholders. The knowledge generated and disseminated is enabling extension workers to provide high-quality advisory services to farmers, and policy makers to make decisions that are based on appropriate information and compelling evidence.

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# 13 The Journey of AGRA's Soil Health Program – A Synthesis of Lessons Learned

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## Introduction

Sub-Saharan Africa failed to benefit from the improved crop varieties that saw food supplies grow so significantly in Asia and Latin America because the main biophysical constraint on crop production – the depletion of soil fertility on smallholder farms – was not addressed (Sanchez, 2002). To a large extent, nutrient mining due to continuous cultivation of farmlands using little or no fertilizer has caused this problem. In fact, nutrient mining has depleted African farmlands of about 8 million tons of soil nutrients per year, an annual loss valued at over USD 4 billion (Toenniessen et al., 2008). AGRA's Soil Health Program (SHP) was established in 2008, with funding from the Bill & Melinda Gates Foundation and The Rockefeller Foundation, to address soil fertility issues. The Program's main focus was on increasing fertilizer supply and use, which was rooted in integrated soil fertility management (ISFM) practices that both reflect local knowledge and are well suited to local agro-ecological conditions.

In a quest to reach 4 million farmers with ISFM technologies, AGRA's SHP developed the Going Beyond Demos (GBD) value chain innovation. The Program's theory of change was that in order for farmers to adopt and use ISFM practices to increase soil productivity and achieve sustainable yield increases in ways that are economically viable for smallholder farmers, inefficiencies in the value chain must be addressed. Farmers require access to quality inputs and the financing to purchase them. At the same time, incentives must be in place to encourage farmer investments in improved seed, fertilizer, land and labor. Stable output markets provide income to producers and serve as a key investment incentive when input cost-benefit ratios are favorable and risk is low. Farmers will adopt new production practices when there are large benefits in terms of increased crop production, which can improve food security and reduce reliance on purchased food.

The first 12 chapters of this book have chronicled the implementation of the GBD innovation and associated scalable models, and identify major achievements to date. This chapter draws lessons from the SHP journey by asking three questions: *What worked well? What did not work well?* And *what are the opportunities that can guide future investments?*

## What Worked Well?

### The SHP architecture

The structuring of the Program into three sub-programs – ISFM Scale-out, Fertilizer Supply and Policy, and Education and Training – provided opportunities for the SHP to focus on investments that ensured farmer access to knowledge and quality inputs for improving soil health. It also enabled interventions in support of ISFM scaling out and building necessary research capacity. This allowed the Program to address four key objectives:

- 1) To create physical and financial access to appropriate soil nutrients and fertilizers;
- 2) To improve access to locally appropriate ISFM knowledge, agronomic practices and technology packages;
- 3) To help shape national policy environments that encourage investments in fertilizer and ISFM; and
- 4) To strengthen the capacity of national institutions to deliver on their own objectives.

The SHP sub-programs engaged stakeholders at local, national and regional scales – creating systemic changes at three critical levels: the farming system, country and regional levels. Such systemic changes are desirable because they lead to more sustainable investments. For instance, the fertilizer policy interventions, which focused on interventions around fertilizer regulatory frameworks, led to policy reforms as well as checks and balances on fertilizer products that are delivered to farmers across the entire country. Favorable fertilizer policy environments and regulatory frameworks are required to ensure that the fertilizer supplied to farmers is both affordable and of high quality. Moreover, affordable financing for fertilizer purchases, as well as knowledge about how to use it properly within an ISFM framework, are needed to increase fertilizer use efficiency. These realities led to the GBD value chain approach that was enabled by SHP's organizational structure.

The training sub-program made significant investments in support of curriculum reviews by participating universities, with contributions from national and regional stakeholders. When this work began, most universities and colleges were treating soil management as the use of either chemical or organic fertilizers.

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Knowledge of ISFM was fragmented, necessitating the revision of curricula at institutions of higher learning, as well as research on various aspects of ISFM in local agro-ecologies. The 182 students that have been trained will certainly bring changes in their various institutions, but more importantly the changes to soil health curricula will create greater subject matter expertise in the 11 participating universities across Africa (Chapter 11).

## The GBD innovation

This was an institutional innovation which recognizes that, while demonstrating improved soil management practices on farmers' fields is essential, demonstrations alone are not enough to result in widespread adoption of promising technologies (Chapter 2). A number of other value chain interventions that address systemic problems limiting adoption must be considered at the same time. For quite a long time, a number of institutions have tried to take ISFM technologies to scale, but with very little success. The problem is that these initiatives focused almost completely on creating awareness.

AGRA's Soil Health Program realized that increasing awareness was just a starting point, and that Going Beyond Demos had to be the vehicle for taking ISFM technologies to scale. The first step towards implementing the ISFM framework involves farmers recognizing the need to use fertilizer and improved seed. Unfortunately, the cost of financing inputs is a major constraint for most smallholder farmers in sub-Saharan Africa. Such financing typically comes with interest rates ranging from 20-30% per year – far too costly for resource-poor smallholders.

Lack of affordable financing prevents farmers from investing in agricultural technologies that can potentially increase productivity. This is particularly important when it comes to fertilizers, which are more expensive in Africa than anywhere else in the world (generally USD 600 to 800/MT). For example, a study in Ethiopia confirms that access to credit is a major constraint to fertilizer adoption (Croppenstedt, 2003). This implies a need to influence policy makers to focus on reducing the high costs of fertilizer. Increasing public-private partnerships to deliver more affordable high quality fertilizer products requires government attention, as does improving crop marketing systems. The development of agrodealers and AGRA's support of the African Fertilizer Agribusiness Partnership (AFAP) are important aspects of this effort (Chapter 9). SHP has invested in training agrodealers and strengthening their networks in 12 focal countries. The exception is Ethiopia, where fertilizer supply is driven by the government. AFAP's role is, among other things, to provide support to fertilizer suppliers and hub agrodealers through Agribusiness Partnership Contracts (APCs). These are agreements under which eligible

international, regional and local agribusinesses can apply for AFAP assistance as they make inroads into African fertilizer and other agribusiness markets. APCs are thus a major means of collaborating with private sector organizations that want to enter the fertilizer market.

Innovations in financing fertilizer purchases by farmers are critical as well. The GBD initiative deployed such options as: contractual arrangements between out-grower and commercial farms; revolving funds managed by farmer associations or by microfinance institutions; and credit guarantee schemes. Through these options, which often involved collective negotiations on interest rates and repayment schedules, farmers were able to access more affordable credit. A good example is the Cashless Credit scheme run by the Centre for Agriculture and Rural Development (CARD) in Ghana that enabled close to 5,000 farmers to access inputs. This led to production of 13,000 MT of paddy rice valued at USD 4.84 million (Chapter 7).

The GBD used multiple approaches to create awareness. Establishment of demos and field days were the entry points. However, due to the fact that extension advisory systems were dysfunctional in many areas – which limited farmer access to appropriate production knowledge and market opportunities – the SHP-sponsored demos were complemented with other extension methods. For example, in the absence of good and reliable extension services, SHP supported the training of lead farmers and private extension providers to fill the gaps.

In addition, the use of such ICT-based technologies as radio, mobile phones and video documentaries was also promoted. The main efforts entailed participatory videos (including the use of tricycle mobile vans), interactive radio programs involving community listener groups, and mobile phones, especially short message services (SMS). The tricycle video approach in Ghana has ensured that more women farmers and youth are reached with services. The potential of video as a complement to other extension approaches is an enormous advantage when it comes to scaling up. These multiple approaches enabled a very high success rate in reaching target farmers, ranging from 80-100%. In some cases the field projects surpassed their targets as, for example, did the scaling out of micro-dose technology in Burkina Faso, Mali and Niger (Chapter 5). One key lesson learned was that there is no "one-size-fits-all" and different participatory extension approaches and methods are needed to disseminate technologies to farmers.

To facilitate provision of services to farmers, SHP supported projects aimed at strengthening existing farmer organizations (FOs) to become more effective in delivering knowledge to their constituents, as well as to

improve their members' access to input and commodity markets. Where farmer organizations did not exist, these projects facilitated the establishment of new ones. Strong farmer organizations tend to be more attractive to financial institutions. The FOs' available collective collateral is greater, and loan repayments are also higher for strong organizations. Farmer groups were important to enhancing commercialization and raising marketing capacity through the aggregation of produce, which reduces transaction costs. Thus, farmer organizations are the natural entry points for most grantees involved in the GBD initiative.

## The scaling up/out models

All program delivery mechanisms had one common feature – the potential to reach scale. Various models were used, but the key ones featured in this book are the Anchor Farm Model, Out-grower Schemes, Agrodealer Networks, Public-Private Partnerships, Microdose-Warrantage Systems, Country Soil Health Consortia, and the development of T-skilled Agricultural Professionals through post-graduate training in African Universities. The models that worked were tested for replicability and sustainability. Most stakeholders have been looking for models that can be used to take soil management technologies to scale, but there has been limited knowledge to draw upon. The presentation of these models in this book will help practitioners and stakeholders seeking to scale up appropriate soil health technologies.

For example, the Anchor Farm Model that involves large commercial farms linking value chain actors and direct service providers to surrounding smallholder farmers has been a great success in reaching scale in Malawi (Chapter 3). The Anchor Farm serves as a hub for extension service providers, input dealers, financial service providers, and buyers and processors. While large commercial farmers are not AGRA's target beneficiaries, they can be used as intermediaries to reach surrounding smallholder farmers. The model has since been replicated in other districts in Malawi and in other countries (Rwanda and Tanzania).

The post-graduate training used a unique model focused on developing T-skilled Agricultural Professionals through training of MSc and PhD students in Africa, which significantly reduced the cost of training compared with overseas options (Chapter 11). The trained graduates return to strengthen their organizations with knowledge of soil science, ISFM and in some cases soil and water management. To improve the quality of this training, effective networks and strong partnerships were developed. The SHP training sub-program has received technical input from Wageningen University Resource (WUR) Centre, the Netherlands, and the University of Maryland, in partnership with Columbia University, USA.

The training program has made a particularly strong contribution to increasing the participation of women in ISFM-related work, with 51% of enrolled students being women. The design of the program recognized the critical roles played by women in environmental and natural resource management, as well as poverty reduction. Concerted efforts were made to ensure that at least 50% of the post-graduates sponsored by AGRA were female. The program put in place a financial incentive for nursing mothers and their families. Inequality is a significant issue at the smallholder farmer household level. While women play a considerable role in smallholder agriculture, they face challenges in accessing resources (financial and land) and often have a lower level of education compared to men. Together, these factors give women less capacity to act in agricultural value chains. Research from such institutions as the UN Food and Agriculture Organization and the International Food Policy Research Institute (IFPRI) has shown that agricultural growth is enhanced when both men and women are able to participate as equal economic drivers. This makes ensuring that gender dimensions are addressed at the macro- and micro-levels across the value chain a critical driver of agricultural transformation.

Finally, Country Soil Health Consortia are designed to bring together soil scientists, agronomists, plant breeders, seed scientists, policy experts, extension workers, communication specialists and other relevant stakeholders. This approach helps to harmonize agricultural messages going to farmers and these efforts have started showing positive results in a number of countries (Chapter 12).

## The ISFM technologies and impact

The ISFM scale out program was consistent in demonstrating and promoting the adoption of ISFM technologies. The core of the ISFM framework is the use of inorganic and/or organic fertilizers, improved seeds, and good agronomic practices. A number of practices were promoted, including fertilizer microdosing, conservation agriculture, inoculation of legumes, cereal-legume rotations, intercropping, and liming to correct for soil acidity.

ISFM technologies are resilient to climate change threats and to pest and disease outbreaks. Interventions with respect to improved seed focused on tactical decisions, such as the use of early maturing varieties or the timing of planting in line with rainfall predictions (Roobroeck et al., 2015). The deep root systems of such legume crops as pigeonpea are drought tolerant and resilient to other weather extremes associated with climate change. ISFM practices involving organic inputs benefit the conservation and restoration of soil carbon stocks, thereby mitigating carbon dioxide emissions from soils.

For example, the incorporation of crop residues by maize farmers has reduced soil carbon losses by 10-20 MT of carbon per hectare over a period of 20 years (Zingore et al., 2005).

ISFM enhances fertilizer use efficiency through the inclusion of organic nutrient sources, such as in cereal-legume rotations or intercropping. A large-scale evaluation in the moist savannas of Nigeria has demonstrated that ISFM systems consisting of maize and soybean rotations, coupled with strategic use of NPK fertilizers, returned approximately USD 130/ha more than the conventional practice of maize monoculture (Akinola, 2009). Greater net income of the ISFM system was attributed to lower production costs and favorable markets. Building soil organic matter is essential for improving soil water-holding capacity, increasing its buffering capacity (its ability to hold nutrients in place and not lose them to leaching) and, in turn, increasing the use efficiency of fertilizers (obtaining more grain per kg of applied nutrients). Good soils typically have soil carbon of 2.5 to 5% on a dry matter basis. Fertilizer microdosing that uses spot fertilizer application tremendously increases the recovery of nitrogen by crops (Sime & Aune, 2014; Kisinyo et al., 2015).

The cropping systems under ISFM also address gender needs. First, legume crops are considered a “woman’s crop”. These include soybeans, pigeonpeas, cowpeas and beans. Women farmers often refer to pigeonpea as “our beef”, a reference to the crop’s high and easily digestible protein (18-26%); it is also rich in calcium, magnesium and potassium, and thus helps in controlling malnutrition in children. Second, legumes provide women with an opportunity to earn cash because they often fetch relatively high prices compared to cereals. Additionally, crops like pigeonpea can contribute significantly to household energy needs, with its woody stems substituting for fuel wood and reducing both the time women and children must spend looking for fuel wood and reducing deforestation.

ISFM technologies have a high potential to close yield gaps. From AGRA’s perspective and for maize, the first step is to go from 1.0 MT/ha (the typical yield produced by smallholder production systems in Africa) to at least 3.0 MT/ha. This is considered by some (Sanchez, 2015) as the start of the Green Revolution. Raising maize yields to 3 MT/ha can be readily achieved with currently available commercial fertilizers, specifically nitrogen (N), phosphorus (P) and potassium (K). This is particularly so in soil that is not overly acidic or saline, and has no major physical and biological constraints. However, where soils are acidic, lime can be used to correct the soil pH (Chapter 8). When farmers start

getting yields of 3 MT/ha they will have a surplus that can be taken to market. While cultivation of legumes has helped with the supply of nitrogen through N fixation, it appears this is secondary to farmers’ main reason for growing legumes – to generate cash. This is why a lot of success stories appearing along the crop value chain depict farmers who start acquiring such assets as livestock, motorcycles and improved housing. About 40% of the farmers using ISFM are women, and the yield gaps under rainfed conditions of farmers directly reached by SHP and its partners are closing fast. For example, the cereals and legume crop yields produced by these farmers have increased by over 100% and 50%, respectively (from baselines of 1 MT/ha for cereals and 0.5 MT/ha for legumes).

## What Did Not Work Well?

### Farm input financing

The GBD innovation facilitated the availability of funds as individual and group loans. Approaches used included:

- 1) The project providing credit guarantees for farmers;
- 2) The project advancing funds to farmers through farm input suppliers;
- 3) Brokering arrangements between farmers and buyers; and
- 4) Supplier providing credit.

The results from these approaches were mixed. In Ghana, the credit facility worked very well, with a 100% repayment rate. In Mozambique, one of the projects developed a revolving fund that achieved a rate of repayment of less than 30%. This poor performance was attributed to the project being led by a public institution that directly distributed the inputs to farmers, who in turn perceived this as a free government input. The lack of private sector engagement in the financing process clearly contributed to the poor performance of this revolving fund. In Malawi, high interest rates on loans (30-40%) prevented farmers from getting loans. The project used a revolving seed bank to help farmers’ access seed of improved cultivars and, fortunately, farmers were also able to access government-subsidized fertilizers.

### Legume seed availability

A number of projects faced serious shortages of legume seed. Most of the time, seed companies were reluctant to produce improved legume seed because farmers often end up sowing saved seed during the next planting cycle. SHP tried to overcome this problem by linking the country projects to AGRA/PASS investments in the formal seed sector; however, legume seed was still not sufficient. The projects circumvented this problem by

engaging the informal seed sector. ICRISAT has over the years invested in the development of informal legume seed systems by moving from certified seed to Quality Declared Seed. The quality of such seed is generally good and its price is normally lower than certified seed, which has enabled a number of farmers to access seed of improved varieties.

## Market arrangements

In order to secure good market prices for commodities, country projects facilitated pre-season contracts between farmers and buyers. However, these arrangements did not materialize in many areas because of side selling on the part of farmers and a failure to agree on prices. The contracts were also not legally binding in many countries, which led to mistrust. There is still a need to find ways of making the pre-season contracts work for both farmers and buyers. Policy makers could help this process a great deal if they would work to legalize the contracts, so as to protect both parties involved.

## Partnerships

In an effort to scale up ISFM practices using a value chain approach, the Program recognized the need for partnerships among value chain actors to help farmers with access to knowledge and to farm inputs and the credit needed to purchase them. Such partnerships are also seen as an effective way to create needed output market incentives. It is clear that no single institution or project will likely be able to facilitate all value chain services and therefore coordinated multi-stakeholder partnerships are critical. While some partnerships were successful, such as the Zambia effort to promote soybeans (Chapter 3), there were others that did not materialize. In order to succeed, such value chain partnerships require the identification of relevant stakeholders and potential partners who can commit to supporting farmers with capacity building, in developing effective farmer organizations, in improving marketing skills, and in creating linkages between commodity and input markets. In Zambia, success required a great deal of partner profiling and defining of stakeholder roles, coupled with several consultative meetings that included signing clear and mutually beneficial MoUs.

## What Opportunities Can Guide Future Investments?

The GBD approach that AGRA's Soil Health Program took has provided important lessons and created new platforms that could inform future investments in agriculture. Given the desire to engender a business mindset among small-scale agricultural growers across Africa – as opposed to the all too prevalent “subsistence”

mindset – it is critically important to bring productivity enhancing soil health interventions to scale. This will require building farmer groups or organizations. Such arrangements may initially increase project costs, but in reality this approach has the potential to create strong linkages with essential service providers, such as microfinance institutions, buyers, and extension staff. The likelihood of well-established and well-trained farmer organizations continuing beyond the project life span is also higher.

Private sector-led value chains are key to scaling up new ISFM technologies and sustaining their impact. Agrodealers and small- to medium-scale agricultural enterprises (SMEs) need agribusiness advisory support services related to business planning. They need, for example, information on client/farmer analytics that comprise profiles of farmers with respect to their enterprises, revenue streams, lifetime customer value, and profitability. Over the past decade, AGRA has built large networks of agrodealers and SMEs on which investments by others could be leveraged.

Access to credit boosts the readiness of farmers to adopt technological innovations. An essential condition for adopting soil health technologies such as ISFM and conservation agriculture is access to farm inputs, produce markets, and financial resources. To a large extent, adoption is market driven as commodity sales provide cash incentives to invest in the new technologies. Policy interventions that institutionalize microfinance activities can help resolve issues to do with access to credit. Low rates of market participation correlate with low adoption of sustainable agricultural intensification. Major efforts are therefore needed to make agriculture commercialization more attractive to farmers. Policy makers should support farm input subsidies and financing that targets smallholders, especially if linked with the private sector in public-private partnerships.

While ISFM technologies could potentially reduce the effects of drought, they need to be supplemented with other measures, such as weather-indexed crop insurance. Interventions by extension service providers that can enhance the soil water management skills of farmers also need to be scaled up.

Country soil health consortia are providing forums for dialogue among a wide range of stakeholders on issues related to scaling out of ISFM technologies. Country consortia have developed as one-stop shops for agricultural information that is available to the general public. The consortia, which include government agencies, are playing a catalytic role in scaling up and sustaining ISFM technologies. For instance, the consortia in Malawi and Kenya are supporting fertilizer policy through soil fertility mapping and the development of



fertilizer recommendations in response to government requests. Future investments can build on these resources. The World Bank Group has already expressed interest in tapping into the consortia one-stop shops of agricultural information across the 13 countries in which they are active.

Going beyond demos comprises the kind of integrated approach embraced in AGRA's new strategy (2016-2020) for catalyzing an African agricultural transformation. Notwithstanding the challenges, there are many opportunities that the GBD initiative has created. The main ones include: strong partnerships developed between institutions that are needed for the different value chains to succeed; stronger farmers that are now knowledgeable about ISFM technologies and are willing and able to respond to market forces; and a growing number of "good practices" for helping smallholder farmers access needed inputs (including affordable financing).

Effective extension support is needed to facilitate farmer adoption of new agricultural technologies, including ISFM practices, so that farmers can better understand the agronomy involved. Presently, the extension staff-to-farmer ratio in most African countries is less than 1:2000, as compared to the international recommendation of 1:400. Furthermore, the knowledge and skills of many extension staff is constrained by a lack of regular in-service training and exposure to new ideas through national and regional workshops. To optimize returns from ISFM, policies are needed that will both enable existing extension staff to regularly upgrade their capacities, as well as increase the ratio of extension staff to farmers. Again, there is a need build the capacity of farmer groups and lead farmers who can fill the gaps in extension support. Approaches like demonstrations and field days, radio, and mobile videos helps to reach farmers in large numbers. Table 13.1 summarizes AGRA's SHP extension training to date, on which future investments could be leveraged.

ISFM and cereal-legume cropping systems make production not only resilient, but also profitable. With the existing high demand for such grain legumes as pigeonpeas and soybeans, it is possible to develop policies that could link legume producers both to local and to international markets, and hence increase production and financial returns. Governments can enable smallholder access to these markets by facilitating their access to market information, removing regional trade barriers, controlling prices by increasing import tariffs, and avoiding harvest-time market gluts by using warehouse receipt systems to store surpluses and maintain stable and remunerative local prices. Moreover, programs for training farmers on value addition activities such as direct oil extraction and processing could be embedded within market policies. This would enable farmers to achieve better returns through the sale of final products to consumers and distributors. Only profitable farming is likely to induce the farmer investments in fertilizers and improved seeds needed to boost yields (Mudimu, 1996; Tiffen et al., 1994).

The Soil Health Program's investments in AFAP and in fertilizer policy reforms and regulatory frameworks in sub-Saharan African countries could complement the operationalization of the African Fertilizer Financing Mechanism (AFFM) that has been created by the African Development Bank (AfDB) and advance the goals laid out in the 2006 Abuja Fertilizer Summit Declaration. Fertilizer quality control is critical in promoting blended fertilizer.

## Final Thoughts

The journey of the AGRA Soil Health Program has been an eye opener with respect to taking soil technologies to scale. The program has gained a lot of experience and learned important lessons from the successes and failures of the projects it supported across 13 African countries. The GBD approach – which arose from the realization that creating awareness of appropriate soil fertility

**Table 13.1:** Summary of AGRA SHP training activities (2009-2015) across 13 countries

Training activity	Quantity
Extension staff trained	5,392
Lead farmers trained	142,108
Farmer Organizations trained	16,660
Facilitators using the Digital Green approach (use of video) in Ethiopia, Ghana, Mozambique, and Tanzania	200
Total number of demos established	155,000
Total number of farmers aware of ISFM technologies	4.9 million

management and good agronomic practices alone was not enough to lead to wide scale adoption by smallholder farmers in Africa – is a key institutional innovation for improving soil fertility in Africa.

The program identified various scaling out models and approaches that have potential for replication across the agro-ecological zones of Africa. They include the anchor farm model, the hub-agrodealer model, and catalytic public-private partnerships. These models recognize the need to address the systemic problems that hinder smallholder farmers from increasing productivity of their farms. These challenges range from poor access to production inputs (improved seeds and fertilizers), weak extension and advisory services, lack of credit, and limited participation in major output markets. Addressing these challenges requires a value chain approach that brings on board key stakeholders to forge strong and enduring partnerships.

Private sector-led value chains are key to scaling up and sustaining impact. There is need to support agrodealers and SMEs with agribusiness advisory services that help them to be more effective in planning the activities of their enterprises, such as client/farmer analytics (i.e., farmer profiles on the basis of enterprises, revenues and profitability, and their value as lifetime customers. Over the last 10 years, AGRA has built networks of agrodealers and SMEs on which other investments could be leveraged and expanded. Initiatives such as the country level soil health consortia are important for facilitating integration of various agricultural stakeholders and knowledge, with the aim improving how information is packaged and the flow of knowledge across various levels of crop value chains.

Access to credit and to output markets boosts the readiness of farmers to adopt soil health technology innovations such as ISFM. Policies that support and institutionalize microfinance activities targeting smallholder farmers can help solve the problem of how to access credit. Major efforts should also be made to make agriculture commercialization more attractive to smallholder farmers. Policy makers should support targeted farm input subsidies and finance reforms that benefit smallholders, especially if linked with the private sector through public-private partnerships.

Farmer organizations (FOs) provided a good way to engage farmers and link them to input and output

markets. These FOs also proved to be the best avenue for reaching a large number of farmers with ISFM technologies and training them in their use. When strengthened, these groups were able to leverage economies of scale in accessing inputs and delivering produce to markets. They also gained bargaining power, which enabled them to more effectively negotiate supply contracts and better prices, and to access more affordable credit that could be repaid through organized systems at the point of sale. However, for this potential to be unleashed, the technical, institutional, managerial and policy capacities of FOs need to be strengthened. When these capacities are addressed, farmer organizations can more effectively meet the needs of their members.

The integration of cereals with legumes is an essential ISFM technology that leads to soil fertility improvement, increased incomes, and better nutrition. However, scaling out legume-based systems is seriously constrained by the availability of improved legume seeds and of rhizobium inoculum. This is because seed companies are reluctant to produce and aggressively market legume seeds in the same way as cereals, especially hybrid maize. This requires exploring alternative approaches (such as farmer groups, public institutions, and CGIAR centers), at least until demand grows to a point where the private sector can engage effectively.

While ISFM technologies could potentially reduce the effects of drought, other measures are also badly needed, such as weather-indexed crop insurance schemes. Extension service interventions that can enhance the soil-water management skills of farmers also need to be scaled up.

Finally, many African countries lack effective fertilizer policies and regulatory frameworks. Sound policies and regulatory frameworks are needed to encourage increased fertilizer use and sustainable agriculture. As the production of fertilizer blends aimed at addressing emerging secondary macronutrient and micronutrient soil deficiencies moves forward in Africa, quality control issues become increasingly critical. Good policies provide incentives for those involved in the industry to abide by the rules – and appropriate penalties for those who do not. The experience of AGRA's Soil Health Program has shown that developing and implementing such balanced policies takes considerable time. Thus, policy related projects should be planned with longer time horizons.

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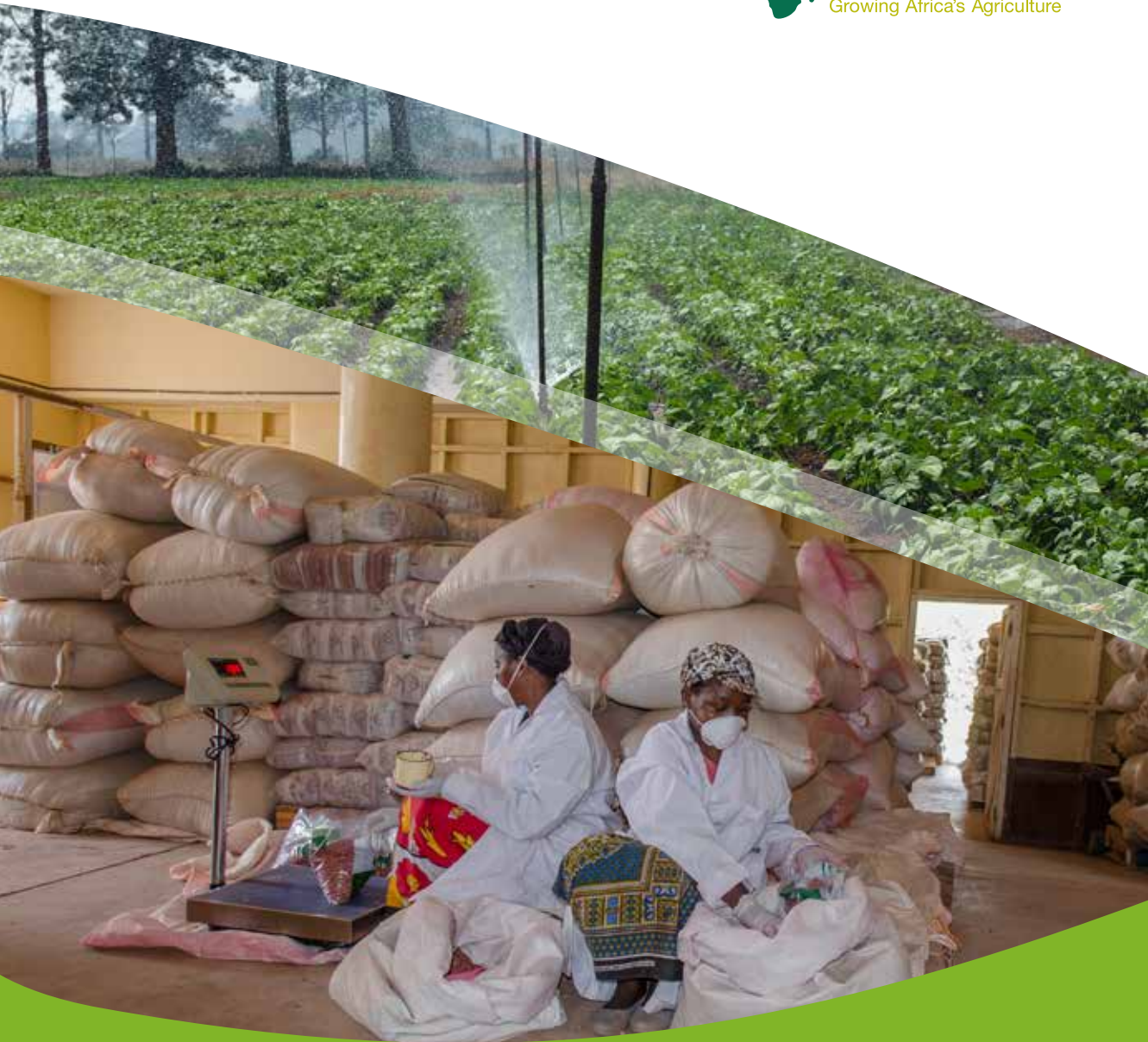
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