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SCALING UP OF DROUGHT-TOLERANT MAIZE IN ZAMBIA

REVIEW OF SUCCESSFUL SCALING OF AGRICULTURAL TECHNOLOGIES

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E3 Analytics and Evaluation Project

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ACRONYMS

BFS	Bureau for Food Security (USAID)
CF	Conservation Farming
CFU	Conservation Farming Union
CIMMYT	International Maize and Wheat Improvement Center
COMESA	Common Market for Eastern and Southern Africa
CSO	Central Statistical Office (Zambia)
DR	Document Review
DTM	Drought Tolerant Maize
DTMA	Drought Tolerant Maize for Africa (CIMMYT program)
E3	Bureau for Economic Growth, Environment and Education (USAID)
FDI	Foreign Direct Investment
FGD	Focus Group Discussion
FISP	Farmer Input Supply Program
FRA	Food Reserve Agency
FTF	Feed the Future
GAP	Good Agricultural Practices
GRZ	Government of the Republic of Zambia
Ha	Hectares
HH	Household
IAPRI	Indaba Agricultural Policy Research Institute
IMF	International Monetary Fund
Kg	Kilograms
KII	Key Informant Interview
MAL	Ministry of Agriculture and Livestock (Zambia)
MNC	Multi-national corporations
MSI	Management Systems International
MSU	Michigan State University
MT	Metric tons
NGO	Non-governmental organization
OPV	Open Pollinated Varieties
PHL	Post-Harvest Losses
PROFIT+	Production, Finance, and Improved Technology Plus program (USAID)
QDSS	Quantitative data collection from secondary sources
SADC	Southern African Development Community
SCCI	Seed Control and Certification Institute
SIDA	Swedish International Development Agency
USAID	United States Agency for International Development
ZMK	Kwacha (Zambian currency)
ZNFU	Zambian National Farmers Union

EXECUTIVE SUMMARY

This report is a case study examining the scaling up of hybrid maize seed through commercial pathways in Zambia from 2000 to 2015. It is the first in a series of studies looking at successful scaling up of agricultural innovations in developing countries. USAID's Bureau for Food Security (USAID/BFS) has commissioned the E3 Analytics and Evaluation Project[1] to conduct these studies as part of its efforts to scale up the impact of the Feed the Future (FTF) food security initiative. The goal of these studies is to produce lessons learned and ultimately guidance for USAID and its country Missions interested in integrating a commercial pathways approach to scaling up into their FTF project designs, procurements, and implementation. This overall research is designed to provide a better understanding of what types of innovations and country contexts are best suited to scaling up through commercial pathways, and what are the activities, strategies, and support necessary to facilitate that successfully.

The innovation being examined in this case study was initially meant to be drought tolerant maize (DTM) varieties developed and released by the International Maize and Wheat Improvement Center (CIMMYT) under the Drought Tolerant Maize for Africa (DTMA) program from 2006 onwards. However, it soon became apparent that it was impossible to separate out the scaling of DTMA from the widespread adoption of certified hybrid maize seed from 2000 to 2015.

Hybrid maize went to scale between 2006 and 2015, peaking at around 60 percent national adoption rates. While the review team does not have annual hybrid maize adoption figures, it appears that most of that scaling occurred in the first half of that period. It appears that national adoption rates rebounded from a low of around 20 percent in the mid-1990s to around 60 percent by late 2015. Adoption rates of DTM appear to be around 10 percent of hybrid maize seed, although the available data are not consistent on this issue. Current adoption rates for both hybrids and DTM are likely higher in the key Southern Province, which is the largest producer of maize in Zambia and the most prone to adverse rainfall patterns.

The intrinsic characteristics of hybrid maize that affected scaling up in Zambia included:

- Positive: certified hybrid maize seed is largely a stand-alone innovation, and did not require farmers to adopt any new agricultural practices or additional inputs.
- Positive: hybrid maize produces minimum increases in yield of 20 to 30 percent and average increases of around 75 percent (2.6 versus 1.5 metric tons/hectare for traditional seed). DTM tends towards the minimum but continues to produce in more adverse rainfall patterns.
- Positive: Hybrid maize in Zambia is available in more than 200 varieties; farmers can match seed characteristics to their own agro-ecological zones, weather forecasts, and risk preferences.
- Positive: Many medium- and long-maturity varieties have huge upsides in terms of yields. In good weather, many farmers can produce four tons or more with hybrids. The return on investment (ROI) in good weather can be three times or more compared with traditional seed, even at low prices. The ROI differential is even higher when government-subsidized fertilizer is used.
- Positive: Farmers can (and do) plant a portfolio of high-yielding varieties and drought-tolerant or early maturing varieties, allowing them to diversify their risk.
- Mixed: At average yields (2.6 mt/ha), market fertilizer prices, and low maize prices ($150/mt), hybrid seed is only marginally more profitable for farmers than traditional seed. Neither are profitable when imputed labor and land rent costs are taken into consideration. However, at

[1] The E3 Analytics and Evaluation Project is implemented by team lead Management Systems International, in partnership with Development and Training Services and NORC at the University of Chicago.

higher prices or higher yields, hybrid maize is quite profitable – in the range of $300 to $1000 or more per hectare.

The characteristics of the Zambian country context that facilitated scaling included:

- Positive: Maize, the main staple cereal, was and remains the most widely grown crop.
- Positive: Farmers had experience in the 1980s in adopting older hybrid maize versions so the concept was nothing new; adoption rates fell dramatically in the 1990s because of structural adjustments in Zambia.
- Positive: The Government of the Republic of Zambia (GRZ) reintroduced a maize subsidized Farmer Input Supply Program (FISP), which has grown rapidly since 2006 to now cover nearly 40 percent of maize farmers. It has been key in making fertilizer affordable for small farmers, as well as exposing them to many different maize varieties. A study by Michigan State University showed that in FISP, participants were nearly two times more likely to be using hybrid maize seed than non-participants.
- Positive: Prior to the scaling taking place after 2005, Zambia already had in place a large and profitable maize seed export industry composed of mostly multinational companies. This was due to ideal agro-ecological conditions, political economy conditions in neighboring countries, a favorable environment for foreign direct investment, and the lack of a state seed agency or parastatal with monopoly status (it was privatized in 1995). From a political economy perspective, the lack of a dominant state seed sector was key to allowing for market pricing, production, and marketing of maize seed.
- Positive: The GRZ, with donor support, put in place in the 1990s an effective and well-respected seed certification system, politically supported by the seed industry, with a reputation for high quality and reliability
- Mixed: There was a reasonably dense presence of agro-dealers, which filled in parallel with the scaling process. However, this network has been largely limited to major transportation corridors and the larger towns on those roads/rails. Farmers in more remote areas face much worse ratios of input to output prices, leading to lower access, profitability, and adoption.
- Mixed: The GRZ reintroduced a maize purchasing program known as the Food Reserve Agency (FRA) around 2000. FRA has grown rapidly in size and importance since 2006. Since then, in many years FRA purchases have accounted for 50 percent or more of net sales. Until the recent devaluation, the FRA essentially guaranteed farmers both a market and a good price for all the maize they wished to sell. This is particularly important for small farmers in remote areas that have no commercial alternative. On the downside, it has created market distortions, crowded out certain commercial buyers, and is a huge fiscal drain.
- Mixed: Zambia, especially Southern Province, is increasingly affected by climate change in the form of either drought or erratic rainfall. While this is increasing the demand for DTM and early maturing varieties, it may be negatively affecting the demand for standard hybrids.
- Negative: Access to commercial maize markets is limited to farmers in close proximity to major roads and towns. For farmers in more remote areas, the lack of markets is a major issue.
- Negative: Apart from FISP, which is not a credit program and only provides quantities of seed and fertilizer sufficient for 0.5 ha, there are no significant public, NGO, or private agricultural finance programs available to small farmers that would facilitate the purchase of inputs.
- Negative: Access to mechanization or animal traction is poor and a constraint on extensive scaling.

The strategy and activities for successful and sustainable scaling up of hybrid maize seed through commercial pathways included:

- Aggressive dissemination and marketing of hybrid maize seed by an increasingly numerous and competitive private seed sector. This effort has focused on demonstration plots and field days, and in the last few years began to make extensive use of radio, newspapers, and targeted promotions.
- Many farmers experienced high cash surpluses from bumper crops produced during the good weather of 2009-10 and 2010-11, and high prices in 2010-13. This made farmers more aware of the upside potential of hybrid maize and created a shift in many farmers' mentality from subsistence to the potential for commercial farming. Not using hybrids is now considered by most farmers to be "taboo."
- The challenge of downstream markets and prices was largely addressed by FRA. Although not explicitly a part of a scaling strategy for hybrid maize seed, this program was intended to promote food security, rural incomes, and rural political support.
- The challenge of affordable access to inputs was partly addressed by FISP. However, it was not explicitly a part of a scaling strategy for hybrid maize seed, but instead was intended to promote food security.
- The donor role has been small in the scaling of hybrid maize, and was confined to support from the Swedish International Development Agency of seed certification and CIMMYT's provision of germplasm, technical assistance, and its own DTMA. CIMMYT played almost no role in the dissemination, marketing, and extension support to farmers. Donor programs played little role in Southern Province; the USAID-funded Production, Finance, and Improved Technology Plus (PROFIT+) project works in Eastern Province.
- Apart from the FISP and FRA programs and seed certification, the role of the GRZ has also been small. Its extension agents help mobilize farmers and organize the demonstration efforts.
- NGOs have participated in or initiated a relatively small number of demonstration projects in the context of other efforts, e.g. conservation farming. The majority of demonstration projects are private-sector led and resourced.

The lessons from the patterns and rates of adoption of hybrid maize in Zambia include:

- Scaling has been more extensive than intensive. Average yields in Southern Province increased from around 1.2 mt/ha in the early 2000s to around 1.75 mt/ha, and the area cultivated in maize has more than doubled.
- Around 40 percent of farmers nationally still do not use hybrids, and many of those who do use hybrids do not plant as much as they would like because of constraints on financial resources.
- Access issues appear to have created a spatial pattern of scaling, where adoption is earlier and higher near major towns and transportation routes.
- Anecdotal evidence suggests that FISP and neighbor-to-neighbor play an important role in the choice of varieties; whether this can be extended to adoption decisions is not clear.

The main conclusions from this case study of scaling up of hybrid maize in Zambia are:

- Maize seed went to scale despite a mixed business case (for less productive famers, low prices, and for those far from markets with adverse input/output price ratios). This may explain why scaling appears to have more or less peaked at 60 percent. Nonetheless, several years of high maize prices, good weather and harvests, or both convinced the majority of farmers to readopt hybrid maize seed.
- The characteristics of hybrid maize that encouraged scaling were its simplicity, the minimal requirement for changes in agricultural practice, the relatively low investment requirements, the easily perceived impact (through demonstration), that it can be adopted at any scale, and the diversity of varieties/characteristics.

- A policy enabling environment that strongly, if passively, encouraged the formation of a vigorous export private seed sector was a key to commercially driven scaling.
- Public support for seed certification, access to seeds and fertilizer (FISP) and a guaranteed market for outputs (FRA) made adoption of the new technology affordable and available for most farmers, at least at some scale, and lowered risks significantly. It is likely true that FISP and, to a lesser extent, FRA have been characterized by corruption, inefficiency, and poor targeting and that they are fiscally unsustainable, at least in their current scale. Nonetheless, the critical roles they played in promoting scaling of hybrid maize from 2006 to date is undeniable.
- The private sector was willing and able to drive and especially accelerate scaling with little donor, government, or NGO support, given the support for inputs and an output market. Scaling probably would have occurred without FISP or FRA, but would not have reached anywhere near the current scale.
- The combination of the intrinsic ease of adoption and affordability of the intervention meant that scaling was able to occur with relatively little effort, apart from that of FISP and FRA, to address constraints on affordability/resources and credit, mechanization, and market access.

I. INTRODUCTION

A. Background and Context of this Report

USAID's Bureau for Food Security (BFS) and the Agency's country Missions have been implementing the Feed the Future (FTF) food security initiative for five years. In many cases, innovations developed and introduced at small scale have since gone to scale, or are in the process of doing so. Yet at the same time it appears that some innovations that potentially could have gone to scale have either not done so, have not reached their full scale potential, or are not fully sustainable at scale.

There are many reasons for this unfulfilled potential, such as a substantial focus on achieving the immediate outcomes and objectives defined in an activity solicitation and award/agreement with an implementing partner. However, there is substantial anecdotal evidence that one of the reasons is that how to scale up through commercial pathways is often not well understood or incompletely integrated into activity designs, procurements, and implementation plans. In other words, it appears that USAID/BFS and Missions could do more in both scaling and sustainability by using commercial pathways.

In this context, USAID/BFS has commissioned the E3 Analytics and Evaluation Project[2] to conduct and synthesize approximately five case studies to better understand how commercial pathways have been used successfully in the scaling up and sustainability of agricultural innovations in developing countries. The goal of this overall study is to produce lessons learned and ultimately guidance for USAID/BFS and Missions interested in integrating this scaling up approach into activity designs, procurements, and implementation. A particularly important goal is to develop a methodology that will allow USAID and its implementing partners to: (a) estimate the speed and level of adoption by farmers; (b) identify the time and resources required to create the institutional foundations and enabling environment that would allow for a transition to commercially driven and/or spontaneous scaling up and diffusion; (c) identify critical levels of initial adoption that would allow for such a transition; and (d) provide for general benchmarks to monitor progress and success in creating the foundations for and a transition to commercially driven and/or spontaneous adoption and scaling.

This overall study is designed to address five research questions:

1. Are there models using commercial innovation and growth mechanisms for bringing new agricultural technologies to scale in FTF countries?
2. What are the essential characteristics of innovations, value chains, and other spaces for identifying where commercial innovation growth and diffusion models are appropriate for reaching potential scale?
3. What determines the shape of the S-curve (e.g., size of critical mass of adopters, speed and timing of technology adoption and diffusion, peak levels of scale reached), and how can these factors be estimated?
4. What types of activities are appropriate to implementing or facilitating a commercial scaling pathway? Examples may include strengthening value chains and distribution mechanisms, using media and other communication forms, and leveraging and strengthening social networks and channels.
5. What are the implications of achieving scale and sustainability using commercial scaling pathways for USAID's project designs, procurement mechanisms, planning, budgeting, cost/benefit analysis, and monitoring and evaluation of FTF programs?

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[2] The E3 Analytics and Evaluation Project is implemented by team lead Management Systems International, in partnership with Development and Training Services and NORC at the University of Chicago.

B. Purpose of this Report

This report examines the successful scaling up through the use of commercial pathways of drought-tolerant maize (DTM) and the Drought-Tolerant Maize for Africa (DTMA) released by the International Maize and Wheat Improvement Center (CIMMYT) after 2006 in particular. As discussed below, during the course of field work for this case study it was recognized that the scaling up of DTM and DTMA was inextricably bound up with the larger process of the scaling up of improved, certified commercial maize seed varieties in general, most of which were hybrid varieties. In this context, the objective of the study was redefined to focus on certified commercial maize hybrids and to extend the time period being examined to 2000 and 2015. The location examined for the case study was Zambia's Southern Province, historically the largest producer of maize in the country and also the most susceptible to drought. However, as both the supply and distribution of inputs (in particular, seeds) and the market for outputs (maize) is national if not regional, the coverage of this study was national when considering the role of the larger maize value chain.

Because this is the first of five planned case studies, it also serves as a pilot study for testing the methodology, which will be revised based on the lessons learned for subsequent case studies. The findings from this pilot are also expected to affect the selection of innovations for future case studies. In piloting the case study methodology, a topic of particular interest was how to collect sufficient data to estimate an S-curve of adoption over time, geography, and demographics that would allow USAID Missions designing and implementing FTF programs to understand the relative role of initial adoption versus second-round or "internal" adoption through spontaneous diffusion. Unfortunately, this case study was not able to collect such data for the period in question, since adoption took place over five years ago. As an alternative exercise, these data are plotted for the earlier period of scaling up of maize seed in Zambia from 1980 to 1990.

C. Methodology Used

The approach developed by the review team for conducting these case studies is grounded in the spaces, drivers, and pathways analytical framework developed by Hartmann and Linn and the scaling up framework authored by Cooley and Kohl of Management Systems International (MSI). These frameworks detail the roles in which spaces, drivers, and pathways contribute to successful scaling. The term space is multidimensional and encompasses the fiscal/financial, political, policy (legal and regulatory), organizational, socio-cultural, agro-ecological, partnership,[3] and learning components that could affect scaling. Drivers are those factors or actors that move an innovation from pilot towards scale, including the individuals or organizations that lead the scaling up effort, their motivation and incentives, and how these interact with the characteristics of the innovation itself and the spaces or context. Pathways are the sector used to take the innovation to scale: the private and public sectors, donors, and other third parties or some combination thereof. This study assesses the respective roles played by each sector, with a special emphasis on the role of the private sector, i.e. the commercial pathway, as that is the primary focus of this research.

The review team developed key components based on the analytical frameworks that will be used to examine the scaling up of the innovation. Below are the key components that will be examined in each case study:

[3] The partnership space looks at the potential organizations whose sponsorship and resources can be enlisted by the lead or driving organizations to support scaling up.

- **Characteristics of the innovation:** the package of components needed to be adopted; knowledge and physical input requirements for effective adoption and implementation; cost, complexity, and sophistication required; changes needed, if any, in farmers' existing agricultural practices; and the relationship to adoption of other innovations, whether complementary, substitutes, or pre-requisites.
- **Adoption drivers and results over time and space:** the reasons for adoption; variation in the degree of adoption and other patterns; socio-economic and demographic characteristics; and the role of different information sources in affecting adoption.
- **Business case for the innovation:** the costs, risks, and returns of adopting, producing, marketing, and distributing the innovation (or innovation package) relative to the motivations and incentives of potential adopters and other private actors in the value chain.
- **The external context or spaces:** In the case of maize in Zambia, a review of initial data collected narrowed the relevant spaces to: the policy enabling environment; the supply chain; the downstream market; the financial resources of farmers and their access to credit; the transportation space (distance to markets and input suppliers); and the organizational capacity of the private sector. The review team determined that the spaces of gender, partnerships, and organizational capacity in other sectors was at best marginally relevant to scaling up in this case and therefore these issues are not discussed in this case.[4]
- **Scaling up strategy and activities:** In the case of maize in Zambia, it turns out that there was not an overall strategy for scaling up held by any one actor or group of actors, but rather scaling was the result of individual and uncoordinated efforts of market actors. The review team narrowed its focus to activities by the private sector and others to: introduce farmers to the innovation and persuade them to adopt it; address gaps or otherwise strengthen the market system and external context that facilitated scaling up, even if that was not their intended purpose; and persuade various actors and stakeholders to drive or support the scaling up process, e.g. subsidies and other risk mitigation efforts.
- **Potential scale of adoption (the market space):** the number of farmers who do or can grow maize given agro-ecological conditions; the effect that the innovation may have on the potential number of farmers growing maize or the area of maize planted; the implications of full-scale adoption for the overall production of maize, its absorption by the market, its impact on maize prices, and the profitability of growing maize.

The methodology for this case study involved four data collection techniques: document reviews (DR), key informant interviews (KIIs), focus group discussions (FGDs), and analysis of quantitative data from secondary sources (QDSS). These approaches were used to collect qualitative and quantitative data from a diverse and large number of stakeholders associated with the maize value chain and the large enabling environment of Zambian agriculture. The sources and key spaces and drivers for the data collected are summarized in Table 1. Each cell notes whether relevant data was provided for a particular topic, ranked on a scale of 1 (X) to 4 (XXXX) as to the importance and utility of the information gathered.

[4] Women participated in several of the FGDs conducted with maize farmers. Women farmers expressed no differences in their reasons for adoption or other factors. The only major difference is that women tend to have less access to resources than men, especially married women, and therefore are more limited in their investments and adoption.

TABLE 1: DATA COLLECTION OVERVIEW

Data Source	Data Collection Methodology	Data Collected					
		Innovation Characteristics	Adoption Drivers and Results	Business Case	External Context	Scaling Strategy & Activities	Potential Scale & Output Markets
Maize Farmers	KIIs and FGDs	XXXX	XXXX	XXX	XXX	XXX	X
Seed Companies	KIIs	XXXX	XXX	XXXX	XXX	XXXX	XX
Agro-dealers	KIIs	XX	XXX	XX	XX	XXX	X
Maize Research Institutions (IAPRI, Golden Valley, CIMMYT)	KIIs, DR	XXX	X	X	X	XX	XX
GRZ MAL Central Office (Extension, FISP)	KIIs, DR, and QDSS	XX	XXX	X	XXXX	X	XX
GRZ Central Statistical Office	KII, QDSS	X	XXX	X			XXXX
GRZ MAL Field Extension Officers	KII	XXX	XXX	X	XXX	XX	XX
NGOs working in Agriculture	KII, FGDs	XXXX	XXX	XX	XXX	XX	XXXX
Seed Producers	KIIs	XX		XX	XXX		XX
GRZ Agencies and Parastatals (FRA and SCCI)	KIIs, DR, QDSS	XXX	XXXX	XX	XXXX	X	XX
USAID and other Donors (Norway)	KII, DR	X	X	X	XXX	X	XX
USAID Implementing Partners	KII	X	XXX	XX	XXX	XX	XX
National Farmers Associations (ZNFU) - National and Local	KII, DR, QDSS	X	XX	XXXX	XXXX	XX	XXX
Maize Mills and Other Buyers	KII			XX	XXXX		XX

Data collection took place in Lusaka and along the main road from Lusaka to Livingstone during a three-week period in September 2015. This road passes through the heart of the major maize growing region of the Southern Province, with the majority of maize production in the province located within 50 km of the road. The review team spent six working days conducting KIIs and FGDs along this route, stopping in all major commercial towns along the way as well as going up to 100 km off the road to meet with farmers. This enabled the team to understand diverse farmer experiences within the Southern Province in terms of proximity to inputs and markets, and of agro-ecological micro-zones.

The review team interviewed a large number of stakeholders, including: 45 maize farmers through 7 different FGDs; 6 seed companies (Zamseed, Pioneer, Pannar, MRI, Klein Karoo, and Kamano); 10 agro-dealers in multiple locations; 3 agricultural research organizations involved in maize breeding or research (Indaba Agricultural Policy Research Institute [IAPRI], CIMMYT and Golden Valley); 3 NGOs (World Vision, Conservation Farmers Union, and Zambian National Farmers Union); 1 large-scale maize miller; and 1 maize seed multiplier (farmer). The team also met multiple times with all the relevant Zambian government ministries and parastatals, including the Food Reserve Agency, Ministry of Agriculture central departments in charge of extension and agricultural inputs, the Central Statistical Office (CSO), and the Seed Certification Institute. The review team also met with USAID/Zambia staff and its PROFIT+ project team, as well as the Norwegian aid team that has been heavily involved in agriculture.

In addition, the review team gathered extensive quantitative data on maize production and cultivation and types of hybrid seed production from IAPRI, the Zambian Seed Control and Certification Institute (SCCI), and most importantly the CSO. The CSO provided annual Excel spreadsheets starting with data from 2000 and continuing annually through the 2014/2015 season. Data from these spreadsheets were used to create a number of time series on production, area planted, yields, fertilizer, amount sold, etc. that form the basis for much of the statistical analysis presented in this report.

Quantitative analysis was complemented by an exhaustive document review of around 40 documents, with the majority related to USAID's activities in Zambia, Michigan State University research, and CIMMYT documents on DTMA.

D. Structure of the Report

Section 2 of this report provides background information on the cultivation of maize in Zambia. It covers the history of the introduction of new maize varieties beginning in the 1980s until the introduction of DTM varieties after 2005, and the various mechanisms and institutions that the Government of the Republic of Zambia (GRZ) has used over the years to support maize production by smallholders. It establishes the need for DTM, looking at the environmental and climatic challenges facing maize farmers in Zambia. This section also includes the primary presentation of two key government programs in the maize sector: the GRZ's Food Reserve Agency (FRA) maize purchasing program and its Farmer Input Support Program (FISP). These are also relevant to the discussion in Sections 4, 5, and 6 given their effect on the size of the potential market, the business case, and the value chain (input supply and downstream markets). Because of their centrality to so much of the spaces and drivers of scaling, they are primarily described in Section 2, with additional relevant details noted as appropriate in the following sections.

Section 3 specifies the technology being scaled, distinguishing DTM, hybrid maize, and improved varieties bundled with other good agricultural practices (GAP). It considers what key characteristics facilitated or constrained scaling up of this technology.

Section 4 looks at the potential scale that improved hybrid maize varieties did and could have reached, i.e. the size of the actual and potential market. This includes whether scaling was intensive (higher productivity on existing land), extensive (expanding area cultivated), or both. It looks at the issue of whether there were potentially any demand constraints on an increase in the production and supply of maize e.g. adverse price effects, as a result of widespread adoption of hybrid maize seed.

Section 5 focuses on the business case for adoption by farmers and the supply chain of maize seed. It examines the benefits-costs and gross margins to individual farmers of adopting (and selling) hybrid maize seed. The section looks at the sensitivity of point estimates to variations in input and output prices, the input mix, and productivity increases across farmers.

Section 6 describes the external context that was relevant to maize cultivation and the adoption of hybrid maize seed, i.e. whether there was adequate space for scaling up. Subsections here include:

- The upstream production, supply, distribution and delivery of maize seed and other physical inputs such as fertilizer.
- The downstream pathways and institutions for farmers to store, process, and sell maize.
- The complementary inputs space, including credit, mechanization, and labor supply.
- The policy and political space, i.e., the policies, laws, and regulations that affect, support, and constrain maize production in Zambia, particularly the role of FISP and FRA. This subsection also looks at the politics, incentives, and motivations of individual and organizational stakeholders to play the roles they did (or did not) play in the sustainable scaling up of hybrid maize seed.
- The political space.

Section 7 describes the strategy and activities that were used to introduce, market, and promote hybrid maize to initial adopters, address gaps in the value chain and other spaces, and facilitate spontaneous diffusion and adoption.

Section 8 quantifies scaling up over time and space. The review team was not able to obtain data to plot an S-curve for the current period of scaling, but did so for the 1980 to 1990 period when scaling also took place.

Section 9 summarizes the main findings, conclusions, and lessons learned from this case study. It focuses on addressing the overall research questions: the characteristics of the innovation itself, context, and strategy that facilitated or hindered scaling up and sustainability. Particular emphasis is given to the role of commercial actors versus other sectors, and the generalizability of the Zambian DTM case to other countries, value chains, and innovations.

E. Team Composition

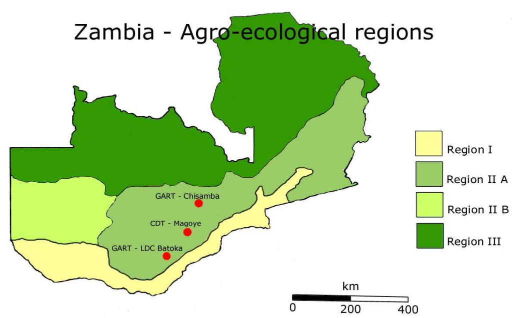
The review team consisted of two experts from MSI, Dr. Richard Kohl and Dr. George Gray. Dr. Kohl is an economist and internationally recognized expert on scaling up, and has been working with USAID/BFS and Missions in improving scaling up strategies for FTF programs and innovations for the past two years. Dr. Gray is agronomist by training and has been working for decades in agriculture in developing countries, including recently with FTF programs in Ethiopia. Additional research and logistical support was provided by Simon Banda, a Zambian national with expertise in agriculture and value chain management, and Gwynne Zodrow, a Technical Manager and monitoring and evaluation expert with MSI.

II. BACKGROUND ON MAIZE IN ZAMBIA

Zambia is a large country endowed with over 70 million hectares (ha) of land, yet agriculture plays a much less important role than in other low and low-middle income countries. Less than three million ha of land are regularly cultivated and this is done mainly by smallholders under rain-fed conditions, using extensive techniques (hand hoeing or limited animal draft power) and operating under traditional tenure systems. As a result, currently only around 10 percent of Zambia's gross domestic product is produced from agriculture, down from roughly 15 percent a decade ago. Almost all smallholders grow some maize and almost all maize (90 percent) is grown by smallholders.[5] Large commercial growers have largely dropped out of production because they are unable to compete with government sales to processors at below-market prices.[6]

Maize is grown in every province of Zambia, though the most suitable for maize production are the Southern, Lusaka, Central and Eastern Provinces because of their milder climate and better rainfall. The agro-ecological region most suited for maize production is Region IIA, as shown in Figure 1. This study focused on the Southern Province, which comprises most of Region I and is both the largest grower of maize[7] and the most vulnerable to adverse rainfall effects.

FIGURE 1: ZAMBIAN AGRO-ECOLOGICAL ZONES



Source: Golden Valley Agricultural Research Trust

The maize crop is sown in late October through December with the onset of the rains and is mature by late April, by which time the rains have ceased. It is harvested during the dry season once it has dried on the plant, from June onwards. Zambia has been regularly prone to droughts (more accurately, insufficient or erratic rainfall) for decades, leading to substantial annual variation in production. As a result, until the recent scaling up of hybrid maize seed created production surpluses, Zambia on average imported about 5 percent of its maize needs.

In recent years, rains have often not come until late November or even December, forestalling the planting. Farmers often delay land preparation until the first rains make the land workable, and wait to decide what seed they will purchase based on the weather forecast and the expected length of the rainy season. If the rain forecast is good, they will plant medium- or even long-maturity hybrids. When the

[5] Commercial farmers (some with access to irrigation) may occasionally grow maize as part of a rotation but have gravitated towards more capital-intensive higher value crops that yield higher returns (these include maize grown for seed).
[6] In the 2013/14 season, large-scale commercial growers produced only 247,188 metric tons out of total of 3,350,671 metric tons nationally, i.e. 7.4 percent.
[7] The relative importance of the Southern Province varies each year, depending on rainfall. In the 2013/14 season, the Southern Province produced 598,000 metric tons on 312,000 hectares – 18 percent and 21 percent of national totals, respectively. For 2013/14, a drought year, that puts it second in terms of area planted, after the Eastern Province, and third in total production after the Eastern and Central Provinces. In 2010/11, the Southern Province was the largest province in terms of both area planted and production: 639,541 mt and 315,655 ha, respectively. This translated to 23 percent and 21 percent of national surface area and production. As can be seen, what changed was yields due to bad weather, not area planted.

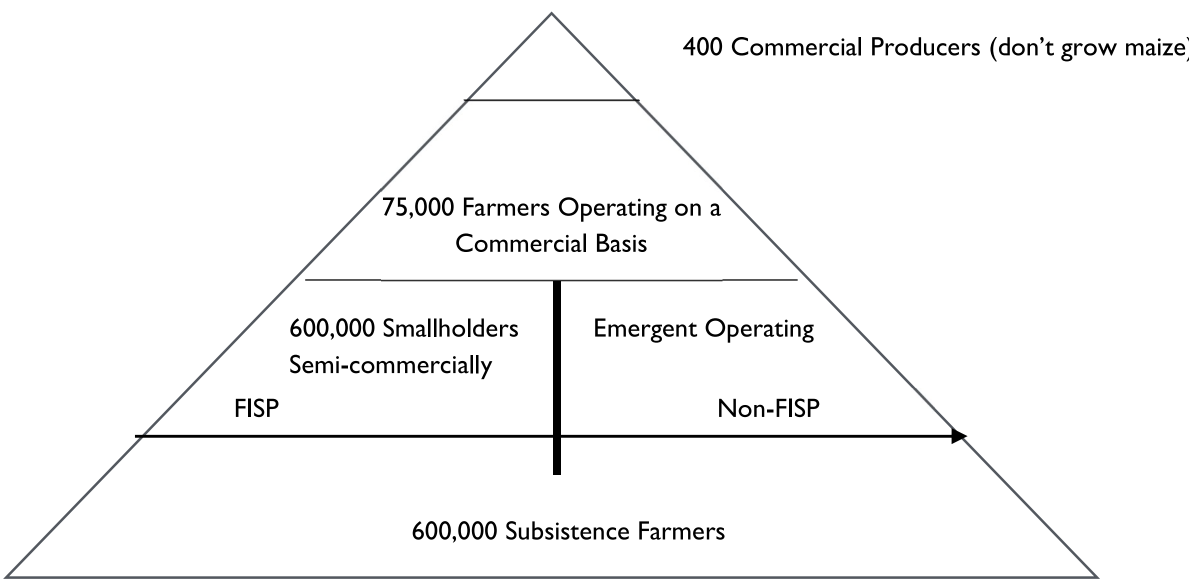
initial rains are delayed or there is a significant gap between the first rain and subsequent rain, farmers often prefer and (re)plant early maturity varieties. Even when there is adequate overall rainfall, the existence of gaps of several weeks in rainfall severely affects yields, especially if they come at critical times in the fertilization and maturation of the cob and the grain. Early-maturing varieties and even drought tolerant maize cannot survive and produce significant yields if rainfall is lacking during these critical periods. Unlike sorghum and millet, maize cannot "pause" in its growth cycle and wait for rain.

Per capita maize consumption in Zambia varies widely by region, depending on whether cassava is also eaten, and between urban and rural households. Figures from the 1990s suggested that per capita consumption was 81 kg nationally and 86 kg in the Southern Province. More recent data for 1999 suggest that average per capita consumption is 131 kg, with 124 kg in rural areas and 146 in urban areas.[8] For this report, the latter figures are used in calculating annual consumption and the impact of scaling on food security.

A. Smallholder Farmers

The distribution and types of Zambian maize farmers are shown in Figure 2. There are four categories: very large-scale commercial producers; emergent farmers; smallholders; and subsistence farmers. The Smallholders and subsistence farmers each account for about 600,000 farmers and combined make up 94 percent of Zambian maize producers. The difference between smallholders, emergent farmers, and subsistence farmers is defined by the extent of commercial orientation (rather than landholding size). Smallholder farm size ranges from less than 2 ha to 20 ha, and target producing a mix of maize for own consumption and a commercial surplus. Subsistence farmers tend to be under 5 ha and operate primarily on a subsistence basis. In remote or unproductive areas, some farmers with access to large areas of land may nevertheless farm on a subsistence basis, while some of those with only small holdings can be seen to operate commercially, especially those close to urban markets or to the line of rail.

FIGURE 2: COMPOSITION OF ZAMBIAN FARMERS



[8] See Antony Chapoto, Jones Govereh, Steven Haggblade and Thomas S Jayne. (2010) "Staple food prices in Zambia." Research Gate, Prepared for the COMESA policy seminar on "Variation in staple food prices: Causes, consequence, and policy options", Maputo, Mozambique, 25-26 January 2010 under the Comesa-MSU-IFPRI African Agricultural Marketing Project (AAMP). January, file:///C:/Users/RichardKohl%20Home/Downloads/AAMP_Maputo_23_Zambia_ppr.pdf

The 75,000 emergent and 600,000 semi-commercial smallholders can be expected to be the primary adopters of certified maize seed. Since together they account for about 53 percent of maize farmers, it suggests that of the roughly 60 percent of maize farmers that have adopted hybrid maize seed, less than 15 percent are subsistence farmers. (This is also confirmed, as discussed below, by the fact that access to FISP and its subsidized inputs is available for smallholders but not subsistence farmers).

Many smallholders plan at the beginning of the rainy season to grow a specific area of maize. Once that planned area has been cultivated and planted, if conditions allow and it is not too late to plant, farmers will often cultivate additional areas in the hope of extra production and as insurance against failure of the early sown crop. Depending on both their own resources and what is available and accessible in the market, that opportunistic area is often planted with home-saved traditional seed or recycled hybrid seed (saved from the previous season). As most farmers buy and use less than the optimal quantities of fertilizer, that fertilizer is usually applied to the initial planting. Farmers' decisions regarding whether to harvest all of the maize they plant depend on market conditions, maize prices, and yields (usually affected by weather).

B. Periodization of Maize Production

The production of maize in Zambia can be divided into four periods: Post-Independence (1964-1973), Initial Support and Government-led Scaling (1974-1992), Structural Adjustment and Liberalization (1993-2001), and Commercially-led Scaling (2002-2015). Each of these periods is characterized by specific policies and market circumstances that influenced all aspects of the maize market – access to and credit for inputs, prices, and the identity of buyers, and therefore area planted, production, yields and profitability. This report does not discuss the Post-Independence period.

During Initial Support and Government-led Scaling, hybrid maize varieties were developed domestically and scaled up through a package of government programs and support to the maize sector, reaching significant scale. In the Structural Adjustment and Liberalization period, government support was eliminated, severely cutback, or ineffective. This led to much more volatile production and prices, and an overall decline in area planted, production, yields, and use of improved certified hybrid seed varieties. After 2001, the Commercially-led Scaling was driven by the reintroduction of government support and a strong private seed sector.

Initial Support and Government-Led Scaling

The development of mining as the driver of the Zambian economy resulted in the rapid urbanization of the population by 1980, and the regime of Kenneth Kaunda relied heavily on the political support of the urban population. In recognition of both the political and food security issues that urbanization created, the GRZ introduced a policy and an accompanying set of programs in the mid-1970s to encourage maize production. This included providing subsidized inputs on credit, a state-owned purchaser of maize, and a parastatal – Zamseed[9] – to undertake the breeding, multiplication, and sale of new maize varieties.

Prior to the creation of Zamseed, maize farmers were planting traditional land races and recycled seeds from varieties that had been introduced in the 1960s. Zamseed developed a business model based upon the recurrent sale of hybrid varieties that it developed from inbred local lines and international germplasm. The resulting improved varieties were not only well adapted to Zambian conditions, but exhibited strong hybrid vigor. All of these varieties were sold exclusively by Zamseed, distributed both

[9] Shareholders were GRZ, The Zambia Seed Producers Association, The Zambia Cooperative Federation, Svalöf and the Swede Fund.

through commercial outlets and through cooperatives as part of government programs. The varieties produced by Zamseed were rapidly taken up by both commercial farmers and smallholders.[10]

Structural Adjustment and Liberalization

During the Initial Support and Government-Led Scaling period, maize yields increased significantly and at its peak in 1989 the area harvested increased to over 1 million ha (peak levels in recent years are closer to 1.5 million ha). At the same time, there were underlying weaknesses in the sector, including: the late delivery of subsidized inputs, the illegal export of these subsidized inputs, and widespread defaults on loans for subsidized inputs. Particularly because of the last factor, these programs were fiscally unsustainable and contributed to the Zambian debt crisis of the early 1990s and the ensuing structural adjustment agreements with the International Monetary Fund (IMF). Structural adjustment forced the elimination or sharp reduction of these programs and eventually the privatization of Zamseed. The result was a decline in use of hybrids, fertilizer, yields, area planted, and production of maize.

For the remainder of the 1990s, the maize market swung repeatedly from surplus to shortage, depending on weather, farmers' access to resources and inputs, and their reaction to results from the previous season. The nadir of the decline in maize production was in 1992, when a severe drought reduced yields across the country, resulting in the lowest level of production ever recorded at less than 0.5 million mt. With a population of roughly 8 million at the time, this compares with minimum food security needs of around 0.7 million metric tons.[11] Maize production recovered somewhat in the following years, but over the course of the 1990s the area of maize harvested declined from a range of 600,000-700,000 ha to 500,000-600,000 ha.

Commercially-led Scaling

The volatility and uncertainty of the Structural Adjustment and Liberalization period led to several GRZ initiatives to help stabilize and support the maize market. After having dismantled the National Agricultural Marketing Board in 1991, the GRZ established the FRA in 1995 to maintain security stocks.[12]

Role of the Food Reserve Agency

The primary stated purpose of the FRA was to create and administer a national strategic food reserve in maize.[13] However, its underlying purpose was to intervene in the market to address real or perceived market failures. This could include dampening swings in the market, buying surplus maize in bumper years and selling into lean years·, and particularly supporting small maize farmers in remote rural areas.[14]

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[10] The process of adoption has been well described in Howard, J and Mungoma, C. "Zambia's Stop and Go Revolution: The impact of policies and organizations on the development and spread of maize technology." MSU International Development Working Paper No. 61. 1996.

[11] Recent data show that per capita maize consumption is roughly around 86 kg per person per year, or a half pound per day.

[12] Governance of FRA included representatives of: small-scale farmers, the Zambia National Farmers Union (ZNFU), the Millers Association of Zambia, the Bankers Association of Zambia and cooperatives. On the government side, representatives were from the Ministries of Agriculture (two); Commerce, Trade and Industry; Finance; and the Attorney General.

[13] The strategic food reserve was to (a) ensure a reliable supply of designated agricultural commodities for the country; (b) meet local shortfalls in the supply of a designated agricultural commodity; (c) meet such other food emergencies caused by drought or flood, or by such other natural disaster, for the purposes of this Act, as may be declared by the President; and (d) correct problems relating to the supply of designated agricultural commodities that result from the manipulation of prices or monopolistic trading practices.

[14] Key provisions of the Act Part IV Crop Marketing, paragraph 10, included:

(b) identify and enter markets in rural areas;

(c) establish or determine prices and create markets for designated agricultural commodities in rural areas ***where involvement by the private sector is minimal*** [emphasis added];

FRA purchases remained nominal until the early 2000s, when they ranged from 50,000 to 75,000 tons per year (see Table 2 and Figure 3). The FRA underwent a transformation in 2006 when an amendment to the Emergency Food Reserve Act legislated a change in its purchasing function. While the FRA had previously purchased limited quantities from traders, it was now mandated to purchase up to 500,000 mt directly from smallholders and traders.[15] In 2006, a presidential election year, the FRA purchased roughly 400,000 tons of maize, and its purchases accelerated after that year given political pressures on the government to purchase maize from all smallholders that might have a surplus to sell.

(d) operate through established market centres in rural areas or farmers' organisations such as co-operatives and associations of farmers; and

(e) export excess designated agricultural commodities

The act also allowed the FRA to operate a system extending input credit to farmers that was payable at harvest, and to create and manage a warehouse receipts system. (para. 15) To the team's knowledge, the FRA never implemented these systems.

[15] The FRA act amendment expanded what the FRA could purchase from maize only to include "any cereal, oilseed, stockfeed and any other agricultural food commodity … essential for food security."

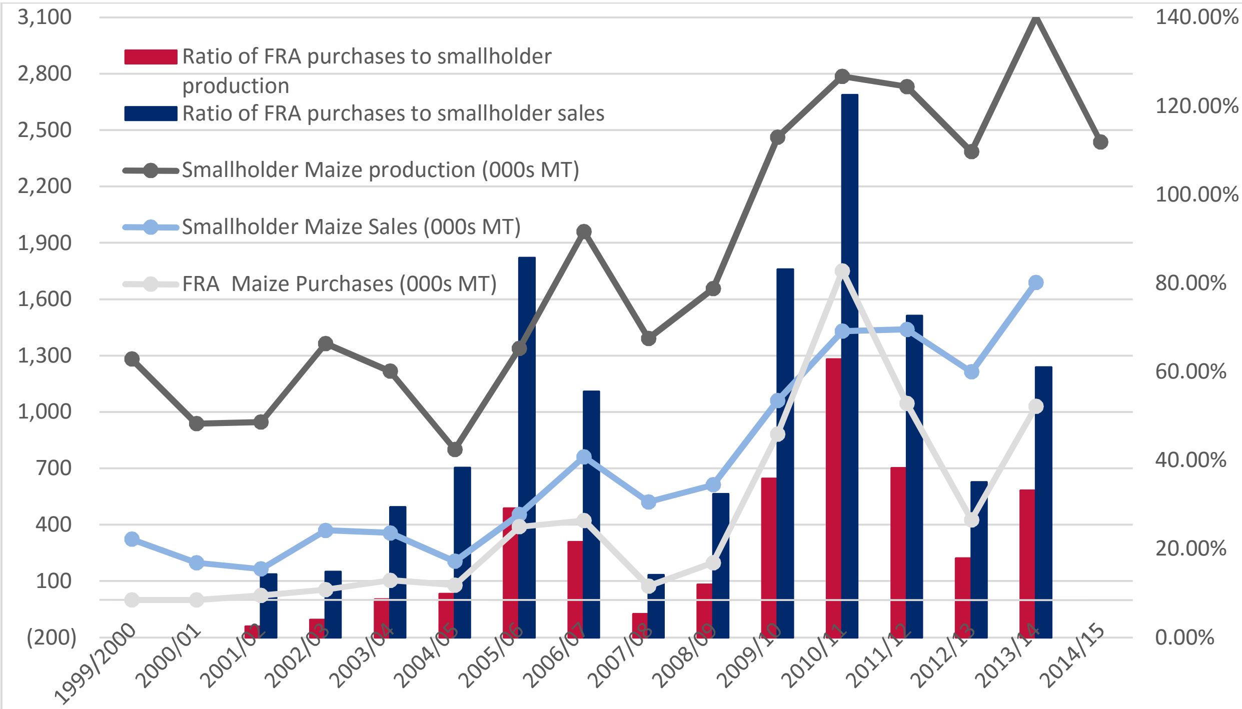
TABLE 2: SMALLHOLDER PRODUCTION AND SALES, AND FRA PURCHASES 1999 TO 2015 (NATIONAL)

	Total Smallholder Maize production (000s MT)	Total Smallholder Maize Sales in Subsequent Marketing Year (000s MT)	FRA Maize Purchases in Subsequent Marketing Year (000s MT)	Ratio of FRA purchases to smallholder production	Ratio of FRA purchases to smallholder sales	FRA Maize prices in US$	Value of FRA annual purchases
1999/2000	1,282	323	--	--	--	--	--
2000/01	938	198	--	--	--	--	--
2001/02	947	165	24	2.5%	14.2%	--	--
2002/03	1,365	370	55	4.0%	14.8%	--	--
2003/04	1,217	357	105	8.6%	29.4%	--	--
2004/05	801	206	79	9.9%	38.3%	--	--
2005/06	1,339	455	390	29.1%	85.7%	--	--
2006/07	1,961	762	423	21.6%	55.6%	--	--
2007/08	1,392	522	74	5.3%	14.1%	--	--
2008/09	1,657	613	199	12.0%	32.4%	$262	$52,059,309
2009/10	2,463	1,062	883	35.9%	83.1%	$271	$239,039,555
2010/11	2,787	1,430	1,752	62.9%	122.5%[16]	$267	$ 468,312,829
2011/12	2,732	1,440	1,046	38.3%	72.6%	$252	$263,231,057
2012/13	2,386	1,214	426	17.9%	35.1%	$240	$102,160,441
2013/14	3,103	1,690	1,031	33.2%	61.0%	$225	$232,204,462
2014/15	2,437	--	--	--	--	$177	--

Source: GRZ CSO and FRA with authors' calculations

[16] There are three possible explanations for this. One is that the data is collected based on smallholder's intentions to sell, rather than actual sales. The second is that smallholders have significant stocks of maize that they carry over from year to year. Finally, there may be some cross-border leakage from Zimbabwe or other countries taking advantage of higher FRA prices.

FIGURE 3: FRA MAIZE PURCHASES VERSUS SMALLHOLDER EXPECTED PRODUCTION AND SALES (NATIONAL)



Source: GRZ CSO and FRA with authors' calculations

Since 2006, the FRA has come to dominate the maize market in Zambia, and certainly for smallholders. The number of depots has increased to 1,200 depots including satellite depots distributed across the country. Annual purchases increased from 400,000 mt in 2002 to over 1,000,000 mt in 2011-12. As a result, the FRA acquired a huge stock of maize that exceeded its management or storage capacity, leading to enormous losses from a combination of poor storage, subsidized sales to mills, and dumping of exports. As Chaputo et al. observed in an article published in 2010:

> *[The] Amendment of the Food Reserve Act, in 2005, resulted in dramatic changes in the level of FRA involvement in Zambian maize markets. Since then, the FRA has opened up over 600 buying depots through the country to buy maize from smallholder farmers at pan-territorial prices, generally far above wholesale market price. In 2006, for example, the FRA paid $192 per ton, and in 2007 they purchased maize at $186 per ton (Govereh, Jayne and Chapoto, 2008). During the presidential election year of 2006, the FRA purchased 390,000 tons of maize from smallholder farmers. This amounted to over 90% smallholder marketed volumes... Since 2005, the FRA has dominated maize trading in Zambia. Controlling the majority of traded maize and becoming overwhelmingly the largest trader in market."*[17]

Role of the Farmer Input Supply Program

In 2002, following a drought and resulting poor harvest in 2001-02, the GRZ created the Farmer Input Support Programme (FISP). This initiative was intended to address problems of access and affordability of inputs, with the GRZ providing a package of subsidized inputs (maize seed and fertilizer) for 0.5 ha to targeted beneficiaries. Famers who wish to participate in FISP submit their request for a specific type of seed to local Ministry of Agriculture and Livestock (MAL) officials, who certify that the farmer is

[17] P.A. Dorosh et al. / Food Policy 34 (2009) 350–366 p.352

qualified. The main requirement for access to FISP resources is that a farmer has to be a member of a cooperative.[18] Qualified requests are then aggregated up at the district and national levels, and approved based on fiscal resources. The GRZ then contracts out with the relevant maize seed producers for the required amounts, which are delivered to government depots at the local level. Cooperatives pick up the inputs at the depots for their members. Interestingly enough, while one would expect that FISP requests would more or less mirror the market share of seed producers and their respective varieties, this is not the case. Small, domestically-owned companies have a much larger market share in FISP than in the commercial market, and the converse is true for large multinational seed companies.[19]

As with FRA, the drought and poor harvest of 2005/06 created political pressures to support small farmers and achieve food security by expanding FISP. There was both a rapid expansion of the number of farmers receiving FISP fertilizer and the size of the subsidy (see Tables 3 and 4). Between 2005/6 and 2008/09, the subsidy increased from 50 to 75 percent, although to try to save fiscal resources the quantity of fertilizer was reduced from 400 to 200 kg. FISP increased from 120,000 farmers in 2002 to 1 million in 2015. This compares with roughly 1.8 million agricultural households, although since in some households both male and female farmers participate in FISP separately, it appears that FISP covers somewhat less than half the households in the country.[20]

TABLE 3: FISP FERTILIZER SUBSIDIES

FOI	Fertilizer Subsidy Rate	MT of Subsidized Fertilizer	Intended Number of Beneficiary Households	Implied Fertilizer per Beneficiary HH in KG
1999/2000	Loan	34,999	--	--
2000/01	Loan	23,227	--	--
2001/02	Loan	28,985	--	--
2002/03	50%	48,000	120,000	400
2003/04	50%	60,000	150,000	400
2004/05	50%	46,000	115,000	400
2005/06	50%	50,000	125,000	400
2006/07	60%	84,000	210,000	400
2007/08	60%	50,000	125,000	400
2008/09	75%	80,000	200,000	400
2009/10	75%	100,000	500,000	200
2010/11	76%	178,000	891,500	200
2011/12	79%	182,454	914,670	199
2012/13	79%	183,634	900,000	204

Source: Documents and interviews with FISP

[18] This is a holdover from when farmer cooperatives were an important part of the socialist/statist development model under the Kaunda regime. In principle, cooperative membership requires purchases of a cooperative share as well as a one-time member fee, although there are often work arounds in practice. Along with the contribution to purchase fertilizer, this can be a barrier to participation by the very poor. In principle, this targeting minimizes the extent to which FISP is supposed to reach the poorest of the poor, and this is confirmed by the review team. Using 2011 data Burke, Jayne and Sitko found that a plurality of FISP resources go to farmers with more than 2 ha, even though the majority of farmers have less than amount of land. William J. Burke, T.S. Jayne, and Nicholas J. Sitko "Can the FISP More Effectively Achieve Food Production and Poverty Reduction Goals?" Policy Synthesis, Food Security Research Project – Zambia, #51, March, 2012, p. 2

[19] As is discussed later, most Zambian seed companies believe that the FISP seed selection process is not open and transparent, but rather subject to political or other influence. These allegations were denied by several MAL officials interviewed.

[20] Several studies have shown that FISP has had a limited impact on reducing poverty. FISP was not designed as an anti-poverty measure, but rather to supplement food security, and as such targets "viable" farmers. From the Zambian policy perspective, viable is not defined by land size but the ability to plant at least 0.5 ha of maize and having a commercial market orientation.

TABLE 4: DISTRIBUTION OF FISP FERTILIZER SUBSIDIES

Farm Size (ha)	% of Households		% of FISP Fertilizer distributed, kg	
Less than 1 ha	31.6	Cumulative	9.8	Cumulative
1-2 ha	31.7	63.3	25.9	35.7
2-5 ha	30.0	93.3	43.9	79.6
5-10 ha	5.6	98.9	16.2	95.8
More than 10 ha	1.1	100	4.2	100

Source: Burke, Jayne and Sitko, as calculated from CSO Crop Forecast data. Farm size is the total of area cultivated and fallow.

C. Scale Achieved in Recent Years

The rapid scaling up of hybrid maize seed coincided with the expansion of FRA and FISP after 2006, with consequences for all measures of Zambian maize. Figures 4 and 5 show basic data on Zambian maize for the Southern Province and nationally, respectively. For the entire country, maize area planted and harvested grew by 256 percent and 206 percent, in part because of the greater variance in area of land harvested. Area planted begin a steady acceleration in 2005/06. What looks like scaling began a few of years later in 2008/2009, with a simultaneous acceleration in yields, expected production, and expected sales. These led to clear changes in the ratios of area harvested to planted and sales to production. Both show a clear upward shift from 2000-2007 to 2008-2015 to much higher and more stable levels. These patterns are present in the Southern Province, but are more difficult to see because the more variable weather patterns caused increased volatility in production, area harvested, yields, and sales.

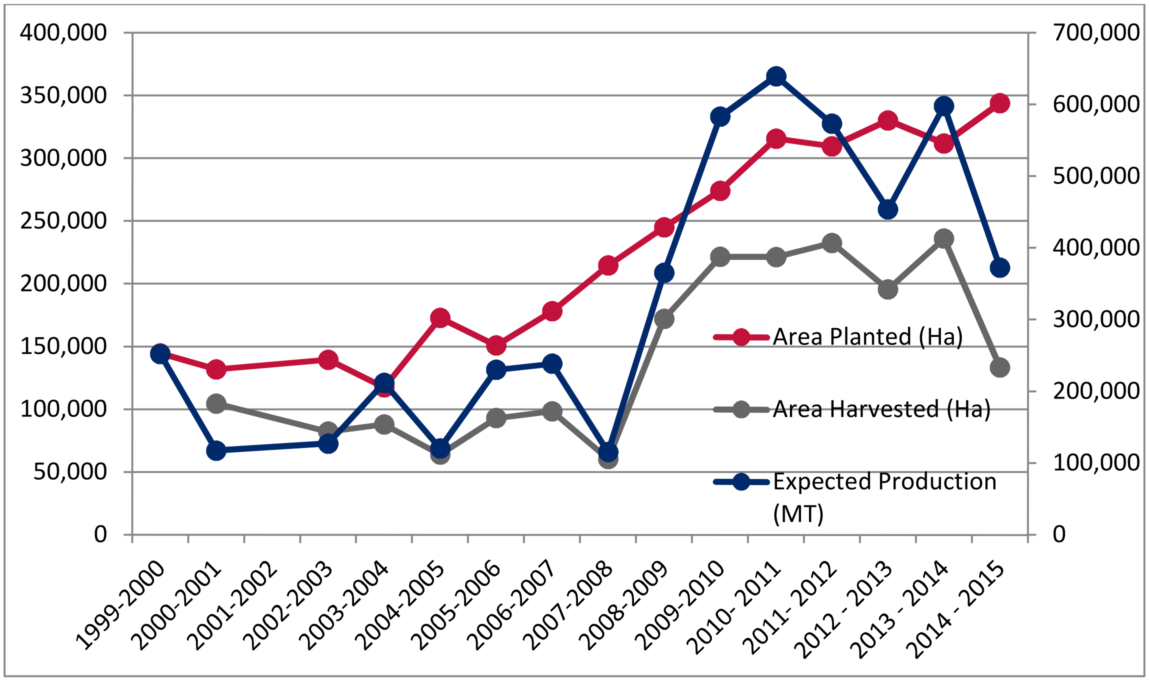
During this period of increased support, both yields and production of Zambian maize increased from 1.38 mt/ha (802,000 mt) in 2001 to a peak of 2.74 mt/ha (3.02 million mt) in 2011, and 2.36 mt/ha (3.35 million mt) in 2014.

This is particularly the case in the Southern Province, where both the province as a whole and individual districts are especially likely to experience adverse rainfall, so that harvest/planted ratios are much lower than national averages. During the seasons from 2002/3 to 2005/06, the ratio of maize area planted to expected area harvested was 58 percent in the Southern Province and 75 percent nationally. After 2008, as adoption of hybrid maize seed and production accelerated, supported by rapidly growing inputs supplied by FISP and purchases by FRA. Consequently, the ratios of maize area planted to expected area harvested rose to 67 percent and 80 percent (2008/09 to 2014/15 seasons).[21] Zambia also became a consistent exporter of maize, ranking 17th globally in terms of volume.[22]

[21] Unless otherwise cited, the source for most of the statistics on maize area planted, production, expected sales, yields is the GRZ CSO. The review team is grateful to the CSO's support in providing these time series data at the national and provincial levels.

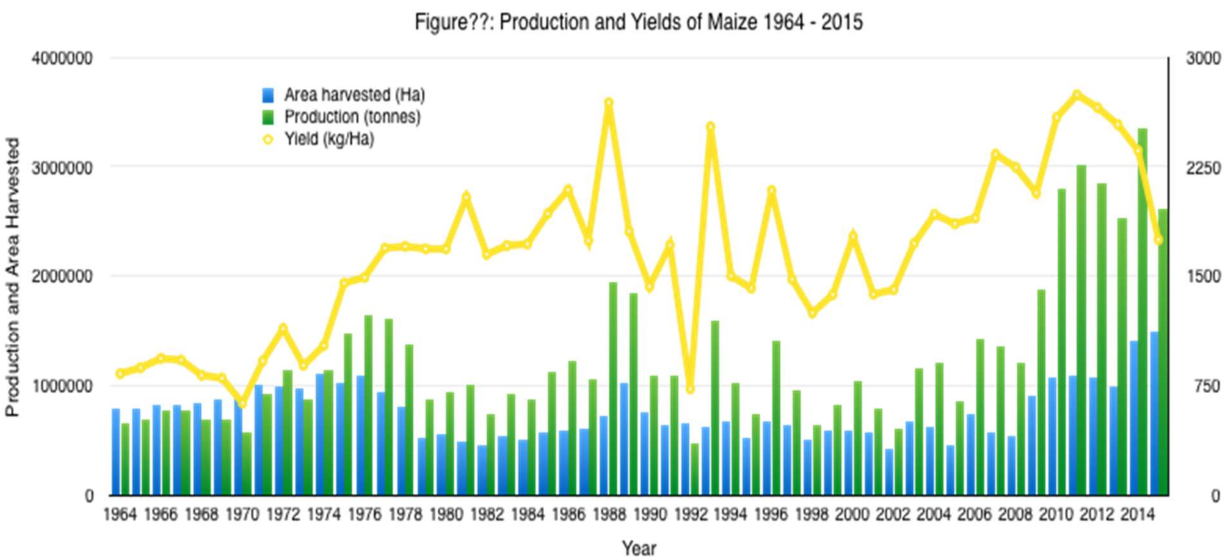
[22] USDA 2014.

FIGURE 4: MAIZE AREA HARVESTED, PLANTED (HA) AND PRODUCTION (MT, RIGHT AXIS) ZAMBIA (SOUTHERN PROVINCE)



Source: GRZ CSO

FIGURE 5: PRODUCTION AND YIELDS OF MAIZE 1964-2015, NATIONAL



Source: FAOSTAT

III. CHARACTERISTICS OF THE INNOVATION

A critical component to studying scaling up is having a clear understanding of the innovation (or technology) under consideration. This includes examining how the technology is embodied in a product or service, as well as whether it is bundled with complementary products and services that presumably are either necessary for successful implementation or have positive synergies with the innovation. This section discusses the maize innovation package that was scaled up in Zambia, as well as its impact on productivity.

For this particular case study, the identification of the technology package underwent an iterative process based upon a gradual appreciation of the development of maize varieties in Zambia. The initial package under consideration was the use of DTMA varieties in Southern Zambia. CIMMYT, which released DTMA, counts two types of maize varieties as DTMA under this program: (1) those that it has developed and released itself, and (2) those that both include genetic material provided by CIMMYT and have done well in its drought tolerance tests.[23]

Definition of the innovation proved to be problematic. Thirteen of the varieties listed had been released for more than five years (i.e., long enough to allow for widespread adoption by farmers). Initial research in Zambia of the earlier releases found that the level of uptake had been small. Only two companies producing maize seed had been distributing these varieties. Moreover, nearly all of the "sales" of these DTMA varieties have been to NGOs distributing them at subsidized prices or for free under donor-funded projects, or through FISP.[24] Thus, they were not selected on their merits by farmers. More generally, even if all of the DTMA maize seed was concentrated in the area of interest (Southern Province), it would not amount to more than 10 percent of the total maize seed sold there. Crop forecast data collected by the GRZ CSO confirmed that as of 2012/13, the four DTMA varieties released up to 2010 were used by no more than 2.5 percent nationally. The market share of later releases was so small that it did not register in the sample of respondents.

Accordingly, the study was broadened to include CIMMYT-generated drought tolerant maize genetics varieties. Unfortunately, it became clear through interviews with commercial seed companies that while CIMMYT breeders might be confident that they could identify their genetics in commercial lines, commercial companies were unwilling to confirm the parentage of their products. Thus, the identification of those varieties that had been bred using CIMMYT genetics was problematic. Moreover, several companies have developed and marketed varieties that they consider to be drought tolerant but which do not contain CIMMYT genetics and have not been subject to the CIMMYT test. Therefore, the review team further broadened the focus of the study to include all drought tolerant maize varieties.

However, it became apparent through interviews with farmers, agro-dealers, and seed companies that in terms of the perceptions of all of those actors it was impossible to distinguish maize that is actually drought tolerant from maize that is merely claimed by its producer to be drought tolerant or even is merely early maturing.[25] As a result, the review team concluded that the most appropriate technology for investigation was simply that of commercially sold improved seed, described throughout the course of this study as "certified seed." This description includes both hybrid seed and OPVs, although in

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[23] Varieties are subjected to "managed drought," i.e. the withholding of water during the period of anthesis. This is the period of both peak water demand by the plant and maximum sensitivity of the plant to water stress. Varieties that can survive this stress period are considered to demonstrate drought tolerance beyond that conferred by a short growing span (i.e. time to maturity).

[24] This was confirmed in interviews with seed companies. All of the main companies selling maize seed were canvassed as to their sales of DTMA varieties, and only two mentioned it as their main maize seed product. One of these was just beginning sales in 2015, and the other noted that volumes had been of the order of 250 MT per year from 2007 to 2014.

[25] In contrast to the procedure of "managed drought" used by CIMMYT to select varieties from a broad gene pool, both local Zambian and Zimbabwean breeders insisted that their own varieties were innately tolerant to drought, having been bred from local maize lines grown for many generations under conditions of intermittent drought stress. Moreover, those breeders also claim a further advantage derived from the adaptation of local varieties to other stressors specific to the Zambian environment, including low pH, aluminum toxicity, and some soil pathogens. As a result, even some medium- to long-season varieties bred locally are claimed to be drought tolerant. There are relatively few varieties sold in Zambia that do not lay claim to this characteristic.

practice the uptake of OPVs in Southern Province has been negligible and, in almost all cases, "certified seed" is equivalent to hybrid maize seed. Therefore, the focus of this study is on the adoption of hybrid maize seed.

WHAT CONSTITUTES ADOPTION?

Adoption of the technology is understood to represent the regular use of certified seed on some (but not necessarily all) of a farmer's land. "Regular use" implies that some type of certified seed is used each year as a matter of principle, unless circumstances prevent. The concept of principle is important, since it implies that a smallholder has accepted the advantage of using certified maize seed and would use it regularly rather than simply test it once and discard it. On the other hand, cashflow considerations may prevent a smallholder from accessing seed, even though they might have done so in the past and would do so again when they were able. Such a hiatus in use should not be considered "disadoption". In practice, this issue was resolved by asking farmers when they had "first adopted" certified seed and explaining precisely what the term "adoption" meant.

A second confounding element is the natural increase in smallholder numbers as a result of population growth. Many new households have adopted certified seed as a standard agricultural practice passed down to them by their forebears. This sort of adoption within the household might not necessarily be considered imitation and yet it has probably accounted for a major part of the substantial increase in demand for certified maize seed that has occurred between 1990 and 2015. The effective doubling of the rural population that has occurred during this period has resulted in a concomitant demand for certified seed, although the average amount used per household may not have changed much. For the purpose of this study, adoption is measured in terms of the proportion of households that have adopted certified maize as opposed to the absolute number. This avoids the confounding element of population growth.

The technology package for the innovation under study – certified maize seed – is fundamentally the regular use of commercially produced hybrid maize seed on some or all of a farmers' maize crop. In Zambia, there was no systematic effort to introduce hybrid maize in combination with any other inputs or new GAP.

However, the use of certified maize seed by smallholders is often associated with a higher rate of use of fertilizer, timely sowing, and greater attention to pest control and weeding.[26] As further discussed below, farmers who are able to access fertilizer have much higher rates of hybrid seed adoption.[27] The majority of farmers in Zambia have access to at least some fertilizer because of FISP's efforts, so there is almost always some bundling of certified seed and fertilizer, even if not in optimal proportions. However, FGDs with farmers indicated that hybrid maize seed has attractive characteristics and superior performance compared to traditional saved seeds, even without the adoption of complementary inputs and practices. Therefore, hybrid certified maize has been observed to outperform traditional seeds, both because it is intrinsically more productive and because it is almost always used with at least some chemical fertilizer thanks to FISP.[28]

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[26] See Nicole Mason and T.S. Jayne "Fertilizer Subsidies and Smallhoder commercial Fertilizer Purchases: Crowding Out Leakage and Policy Implications for Zambia" IAPRI. Working Paper #79, Dec. 2012. Their analysis was confirmed in interviews with the Conservation Farmers Union and in FGDs with farmers.

[27] Mason and Jayne, *op cit*.

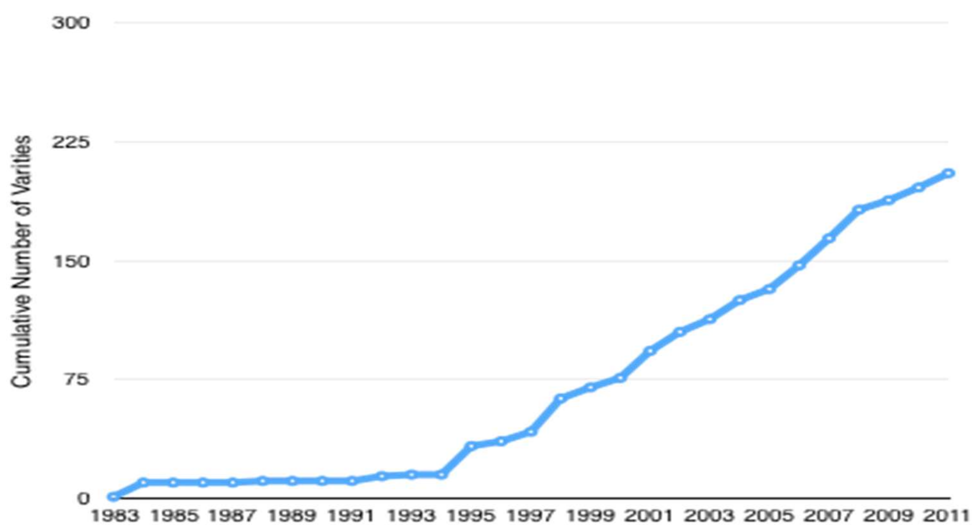
[28] Another study showed that "First, maize yields were significantly positively related to fertilizer use but declined as the application rate increases". This study also found that the impact of fertilizer maxes out at five bags, and the majority of farmers use less than the recommended four bags per hectare. The impact on yields of fertilizer varied widely across farmers, affected by both the amount per hectare and particularly the timeliness of application. For farmers using fertilizer on time, fertilizer was clearly profitable; for others, it was probably marginal. Profitability of fertilizer use was lower because of transport costs for farmers in remote areas: "The relatively remote group face maize-fertilizer price ratios roughly 20 percent lower than for the relatively accessible group." See Z. Xu, Z. Guan, T.S. Jayne, and Roy Black "Factors Influencing the Profitability of Fertilizer Use on Maize in Zambia" POLICY SYNTHESIS FOOD SECURITY RESEARCH PROJECT – ZAMBIA. Ministry of Agriculture and Cooperatives, Agricultural Consultative Forum, Michigan State University and the Market Access, Trade, and Enabling Policies (MATEP) Programme, Lusaka, Zambia. Working paper No.32 (Downloadable at: http://www.aec.msu.edu/agecon/fs2/zambia/index.htm) February, 2009.

A. Certified Maize Seed

While the innovation package has a sole component (i.e., seed), that component is highly differentiated because of the many varieties available. Since 1995, 199 new varieties of maize have been registered in Zambia (see Figure 6) and there are currently more than100 different varieties available to Zambian smallholders. This considerable range is well reflected in smallholders' actual use of different varieties. For reasons of risk aversion, insurance, availability, varying growing conditions, and different uses, many smallholders grow more than one variety – and some grow as many as five varieties. Nevertheless, the market does tend to concentrate on a relatively small number of varieties. "Lorenz" type analysis[29] of that hybrid seed use data shows 6 varieties alone were used by more than 50 percent of smallholders (see Figure 7).

The premium attached to certified maize seed as opposed to cleaned grain is considerable. In mid-2015, a 25 kg bag of certified maize seed, sufficient to plant 1.0 ha, cost ZMK188 - 425 (US$25 - 60). The same amount of maize grain would be worth ZMK 32.5 (US$4.33) if sold on the commercial market. Despite this premium, in 2012/13, 47 percent of growers used a named variety of hybrid maize seed while a further 9 percent used unnamed seed obtained from a commercial company. Of the remainder, only 1.6 percent opted for re-usable OPV seed, and the remaining 43 percent used recycled seed from various sources.

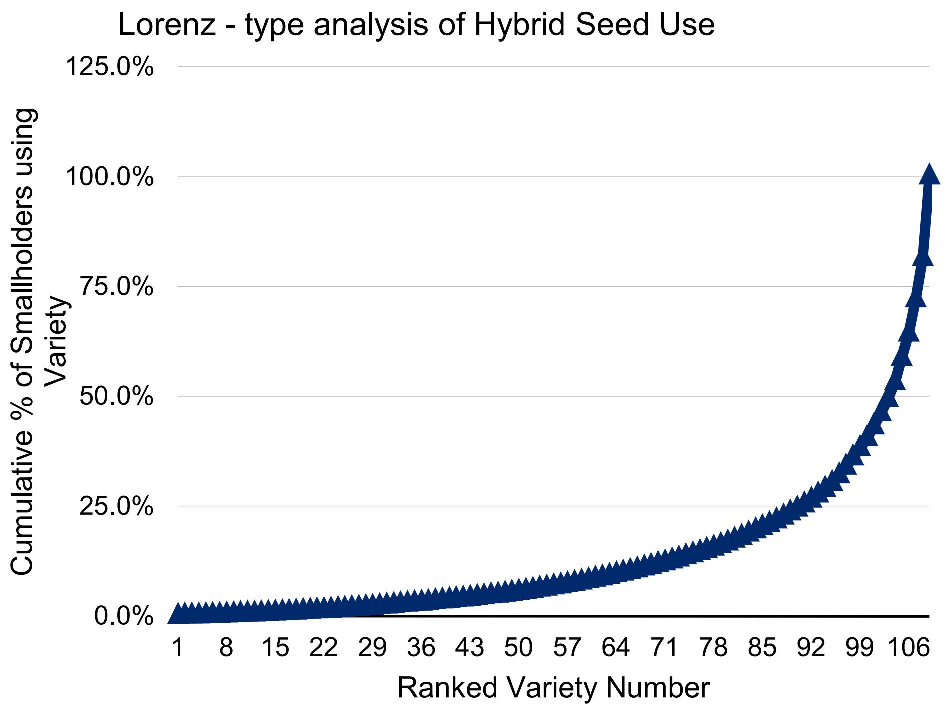
FIGURE 6: NUMBER OF CERTIFIED MAZIE SEED VARIETIES IN ZAMBIA



Source: CSO post-harvest survey data for 2013/14

[29] A Lorenz analysis plots the cumulative number of people or users that account for a percentage of something versus the cumulative share of that something. The most common Lorenz curve analysis is the Gini curve, the source of the Gini coefficient, which plots the cumulative share of income or wealth in country against the cumulative share of the population. In this case the review team plotted the cumulative percentage of farmers using hybrids against the cumulative number of hybrid varieties.

FIGURE 7: LORENZ CURVE ANALYSIS OF HYBRID SEED USE



Source: SCCI

IV. ADOTION DRIVERS AND RESULTS OVER TIME AND SPACE

From a scaling perspective, there are two relevant market factors that affect the widespread adoption of maize seed. The first is whether the supply of seed is able to keep up with demand (i.e. the maize seed market). The second is whether the demand for maize can accommodate the supply without adversely affecting domestic prices, presuming that adoption of hybrid seed leads to greater production of maize. In principle, maize prices should be set by import parity with international market prices, taking into account shipping and insurance costs. Thus, once smallholder farmers begin producing significant surpluses to either crowd out imports for the urban population or even export, the question is whether they can compete effectively at world prices. However, there is strong evidence that GRZ policy has allowed for substantial and variable deviations between domestic and world prices.

Maize is grown in almost all districts of Zambia, so demand for improved maize seed is national in scope. In the 1999-2003 crop years, an average of around 139,000 ha of maize were planted in the Southern Province alone, implying a need for 2,772-3,472 mt of maize seed at 20kg/ha and 25kg/ha, respectively. The area planted accelerated rapidly after 2006 and continues to this day (see Tables 5 and 6). By 2014/15, area planted reached 344,000 ha in the Southern Province and 1,494,451 ha nationally. As can be seen in Tables 7 and 8, for the same year this implied seed needed was 24,800-31,000 in the Southern Province and 27,000-33,746 nationally.

TABLE 5: BASIC MAIZE PRODUCTION DATA, SOUTHERN PROVINCE, ZAMBIA, 1999-2015

Year	Area Planted (Ha)	Area Harvested (Ha)	Expected Production (MT)	Calculated Yield	Expected Sales (MT)	Ratio of Expected Sales to Expected Production	Ratio of Area Harvested to Area Planted
1999-2000	144,550.00		251,946.00	1.74	54,353.00	0.22	--
2000-2001	131,840.00	104,536.00	117,378.56	0.89	29,491.61	0.25	0.79
2001-2002	--	--	--	--	--	--	--
2002-2003	139,468.00	82,260.00	127,277.00	0.91	39,027.00	0.31	0.59
2003-2004	117,476.55	87,934.95	211,975.89	1.80	74,021.33	0.35	0.75
2004-2005	172,746.00	63,987.00	120,518.00	0.70	28,442.00	0.24	0.37
2005-2006	150,875.00	92,941.00	230,105.00	1.53	--	--	0.62
2006-2007	178,162.43	98,466.25	238,569.59	1.34	57,171.50	0.24	0.55
2007-2008	214,610.00	60,372.00	115,421.00	0.54	18,172.00	0.16	0.28
2008-2009	245,099.00	172,133.00	365,226.00	1.49	136,605.00	0.37	0.70
2009-2010	274,183.59	221,530.54	582,983.87	2.13	263,201.85	0.45	0.81
2010- 2011	315,655.31	221,374.49	639,540.90	2.03	297,525.36	0.47	0.70
2011-2012	309,557.00	232,584.00	573,176.00	1.85	271,766.00	0.47	0.75
2012-2013	330,234.00	195,587.00	453,532.00	1.37	196,674.00	0.43	0.59
2013-2014	311,914.41	235,974.24	597,999.41	1.92	264,218.24	0.44	0.76
2014-2015	344,009.00	133,301.00	372,450.00	1.08	132,153.00	0.35	0.39

Source: GRZ CSO

TABLE 6: BASIC MAIZE PRODUCTION DATA, ZAMBIA (NATIONAL), 1999-2015

	Area Planted (Ha)	Area Harvested (Ha)	Expected Production (MT)	Calculated Yield	Expected Sales (MT)	Ratio of Expected Sales to Expected Production	Ratio of Area Harvested to Area Planted
1999-2000	561,492.00	--	850,465.00	1.51	187,783.00	0.22	--
2000-2001	583,850.61	466,893.49	445,487.05	0.76	162,438.94	0.36	0.80
2001-2002	--	--	--	--	--	--	--
2002-2003	699,276.00	557,562.00	1,157,861.00	1.66	591,300.00	0.51	0.80
2003-2004	631,079.90	531,622.60	1,213,600.80	1.92	481,183.50	0.40	0.84
2004-2005	834,981.00	465,832.00	866,187.00	1.04	349,734.00	0.40	0.56
2005-2006	784,524.00	618,955.00	1,424,439.00	1.82	--	--	0.79
2006-2007	872,811.86	586,502.86	1,366,157.63	1.57	622,470.35	0.46	0.67
2007-2008	928,224.00	551,359.00	1,211,566.00	1.31	534,294.00	0.44	0.59
2008-2009	1,125,466.00	911,492.00	1,887,010.00	1.68	820,318.00	0.43	0.81
2009-2010	1,242,268.00	1,080,558.00	2,795,483.00	2.25	1,352,012.00	0.48	0.87
2010- 2011	1,355,764.00	1,101,785.00	3,020,380.00	2.23	1,619,622.00	0.54	0.81
2011-2012	1,274,983.00	1,074,658.00	2,852,687.00	2.24	1,567,256.00	0.55	0.84
2012-2013	1,312,402.00	997,880.00	2,532,800.00	1.93	1,336,141.00	0.53	0.76
2013-2014	1,419,326.00	1,205,202.00	3,350,671.00	2.36	1,912,533.00	0.57	0.85
2014-2015	1,494,451.00	963,818.00	2,618,221.00	1.75	1,457,482.00	0.56	0.64

Source: GRZ CSO

TABLE 7: MAIZE SEED NEEDED AT DIFFERENT USAGE ASSUMPTIONS, SOUTHERN PROVINCE, 2009-2015

	Maize Seed Needed (20 kg)	Maize Seed Needed (22.5 kg)	Maize Seed Needed (25 Kg)
1999-2000	2,891	3,252	3,614
2000-2001	2,637	2,966	3,296
2001-2002	--	--	--
2002-2003	2,789	3,138	3,487
2003-2004	2,350	2,643	2,937
2004-2005	3,455	3,887	4,319
2005-2006	3,018	3,395	3,772
2006-2007	3,563	4,009	4,454
2007-2008	4,292	4,829	5,365
2008-2009	4,902	5,515	6,127
2009-2010	5,484	6,169	6,855
2010-2011	6,313	7,102	7,891
2011-2012	6,191	6,965	7,739
2012-2013	6,605	7,430	8,256
2013-2014	6,238	7,018	7,798
2014-2015	6,880	7,740	8,600

Source: GRZ CSO and authors' calculations

TABLE 8: MAIZE SEED NEEDED AT DIFFERENT USAGE ASSUMPTIONS, NATIONAL 2009-2015

	Maize Seed Expected Production (MT)	Area Planted (Ha)	Maize Seed needed (20 kg)	Maize Seed needed (22.5 kg)	Maize Seed needed (25 Kg)	Ratio: maize seed needed to maize seed produced (20 kg)	Ratio: maize seed needed to maize seed produced (22.5 kg)	Ratio: maize seed needed to maize seed produced (25 kg)
1999-2000	--	561,492	11,229.8	12,633.6	14,037.3	--	--	--
2000-2001	--	583,851	11,677.0	13,136.6	14,596.3	--	--	--
2001-2002	--	--	--	--	--	--	--	--
2002-2003	--	699,276	13,985.5	15,733.7	17,481.9	--	--	--
2003-2004	--	631,080	12,621.6	14,199.3	15,777.0	--	--	--
2004-2005	--	834,981	16,699.6	18,787.1	20,874.5	--	--	--
2005-2006	--	784,524	15,690.5	17,651.8	19,613.1	--	--	--
2006-2007	--	872,812	17,456.2	19,638.3	21,820.3	--	--	--
2007-2008	--	928,224	18,564.5	20,885.0	23,205.6	--	--	--
2008-2009	--	1,125,466	22,509.3	25,323.0	28,136.7	--	--	--
2009-2010	37,550.0	1,242,268	24,845.4	27,951.0	31,056.7	66.2%	74.4%	82.7%
2010-2011	69,166.0	1,355,764	27,115.3	30,504.7	33,894.1	39.2%	44.1%	49.0%
2011-2012	30,003.0	1,274,983	25,499.7	28,687.1	31,874.6	85.0%	95.6%	106.2%
2012-2013	35,190.0	1,312,402	26,248.0	29,529.0	32,810.1	74.6%	83.9%	93.2%
2013-2014	28,968.0	1,419,326	28,386.5	31,934.8	35,483.2	98.0%	110.2%	122.5%
2014-2015	62,579.0	1,494,451	29,889.0	33,625.1	37,361.3	47.8%	53.7%	59.7%
Average 2009/2015	43,909.3	1,349,865.7	26,997.3	30,372.0	33,746.6	68.5%	77.0%	85.6%

Source: GRZ CSO and authors' calculations

CSO statistics on maize seed production are only available from the 2009/10 season. On average, seed production from 2009/10-2014/15 show that 43,909 mt of maize seed were produced annually. Comparing demand with supply, domestic consumption of seed was somewhere between 68 and 86 percent.[30] This suggests that the domestic seed industry was able to keep pace with domestic demand. Given that maize seed production is highly commercialized and uses the same agro-ecological zones as maize, there is no reason to believe that this could not continue were domestic demand to surpass current levels.

On the downstream or market side, initially there was plenty of excess demand to absorb increased domestic production. As previously discussed, from 1990 to around 2006 Zambia suffered from stagnant or declining maize production. Production was highly volatile because of weather, changes in world prices, and the follow-on effects of poor earnings on farmers' resources for the next season. As a result, in one of three years Zambia was food insecure and had to import maize.[31] Presumably this was even more true for a significant proportion of individual smallholder farmers (see Table 8). Between 2000 and 2006, Southern Province on average was not food secure, with a deficit of 28,606 mt, and was in deficit for 4 of the 6 years (based on the available CSO data and the review team's consumption calculations). The rural population was on average just food secure, but again was in deficit for half of these years. Moreover, these calculations likely underestimate demand as they do not take into account any post-harvest losses or losses during transport and processing. Thus, for the second wave of scaling up, there was plenty of market "space" to absorb increased production. The review team's calculations based on CSO data suggest that food security was not reached in the Southern Province until 2009, with the combined effect of a nearly 100 percent increase in the area planted, a 60 percent increase in yields, and good rainfall. For the country as a whole, the pattern was nearly identical.

The combined effects of FRA, FISP, and hybrid maize seed was not simply to increase yields (although that did happen), but also to drive extensive growth in both the area planted and the percentage of that area harvested. Land planted in the Southern Province grew steadily, from 151,000 ha in 2005/06 to 344,000 ha in 2014/15, with similar national trends. Much of the increase in production was from greater harvesting of land planted. This was particularly true in the peak years of 2009/10 and 2010/11, when harvesting hovered around 75 percent of planted land, as opposed to 55 percent earlier and later. The maize harvested to planted average ratio for the Southern Province was 56 percent for 1999-2008 versus 67 percent for 2008-2015. Nationally, the ratio rose from 72 percent to 80 percent. The lower ratios in the Southern Province are consistent with that province being more prone to adverse rainfall, and the fact that many small producers are working land that has either poor soil quality or is in agro-ecological zones where the adequacy of annual and timely rainfall patterns is highly uncertain.

V. BUSINESS CASE FOR THE INNOVATION

The starting point for this analysis of the scaling up of certified maize seed in Zambia presumes that the innovation already exists, and seeks to understand why various actors played (or did not play) particular roles in the scaling process. Since the overall study examines cases of successful scaling through commercial pathways, the primary focus is on the economic and financial incentives behind adoption, use, and the other roles in the maize sector and value chain. The incentives of non-commercial actors

[30] This figure is in direct contradiction to what the review team was told by most seed companies, that 80 percent of maize seed produced in Zambia is exported. The review team is not able to reconcile these figures.

[31] Dorosh et al first submitted their paper in late 2007, and at that time concluded: "Given erratic rainfall, and less than 5% of cropped land under irrigation, Zambia's maize crop fails to satisfy national market demand, on average, in one year out of three. In years of poor harvests, when drought, reduced planting area, or input supply bottlenecks constrict output, Zambia has imported maize."

are examined in Section VI, especially the sub-section on Politics and Policy. The analysis of the business case for certified maize seed covers three areas:

1. The adoption, repeated purchase, and use of seed by smallholder farmers;
2. The production of the certified seed (hybrid or OPV) by commercial companies; and
3. The introduction, marketing, and distribution of maize seed – in this case, mostly by private seed companies and agro-dealers

A. Farmers (Seed Users)

The financial case for using certified maize seed is not overwhelming, at least not at current maize prices of around $150/mt. Table 9 presents an analysis of gross and net revenues based on crop budget data.[32] This analysis shows that net revenues for using certified maize seed were only marginally higher than traditional seed (from US$113/ha to US$123/ha, or about 8 percent). The reason for this small increase is that the higher gross revenue is counterbalanced by substantial increased costs for fertilizer, seed and labor.

The case gets much stronger if higher prices are used and the impact of FISP subsidies is taken into account for those farmers who are getting yields above the average levels for hybrids (i.e. above 2.7 mt/ha).[33] Maize prices have fluctuated widely since January 2009, between US$330/mt and $US150/mt, with an average price of US$225/mt since that period and US$170/mt over the past year. Any one of these factors alone substantially increases the profitability of using hybrid maize seeds, and if taken together, it becomes quite profitable.

TABLE 9: COMPARATIVE CROUP BUDGETS AND SENSITIVITY ANALYSIS FOR CERTIFIED MAIZE SEED IN ZAMBIA

	Traditional Seed	Certified Base	Certified 1.8 MT Yield	Certified 3 MT Yield	Certified 4 MT Yield
Market Fertilizer Prices, $150 per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$0.15	$0.15	$0.15	$ 0.15	$ 0.15
Gross Revenue (US$/ha)	**$ 223**	**$ 394**	**$ 271**	**$ 450**	**$ 600**
Total Variable Costs, of which:	$ 110	$ 271	$ 271	$ 271	$ 271
Fertilizer	$ 34	$ 132	$132	$132	$132
Fertilizer Price per 50kg bag	$ 34	$ 34	$ 34	$ 34	$ 34
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$106	$106	$106
Net Revenue (US$/ha)	**$ 114**	**$ 123**	**$ (0)**	**$179**	**$329**

[32] Costings were generated from the CSO 2014/15 Post Harvest Survey for maize production to compare the gross margins of certified seed and traditional varieties. Data were calculated from Zambia Maize Budget Results (8.23.2015) provided by Ryan Vroegindewey. These calculations do not take into account the cost to farmers of their own labor, the imputed rental cost of land, or any imputed interest costs on the extra investment required to raise hybrid maize.

[33] The results from the sample of farmers who participated in FGDs (see Table 10) showed that out of 32 farmers reporting yields for the 2015 harvest, 5 were producing above 3 mt/ha and 7 were producing more than 5 mt/ha (16 and 22 percent, respectively). Higher yields with certified hybrid seed were especially common in the good harvest years of 2010-2013.

	Traditional Seed	Certified Base	Certified 1.8 MT Yield	Certified 3 MT Yield	Certified 4 MT Yield
Net Revenue relative to Traditional Seed		**108%**	**0%**	**158%**	**290%**
FISP Fertilizer Prices, $150 per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$ 0.15	$ 0.15	$ 0.15	$ 0.15	$ 0.15
Gross Revenue (US$/ha)	**$ 223**	**$ 394**	**$ 271**	**$ 450**	**$ 600**
Total Variable Costs, of which:	$ 110	$ 178	$ 178	$ 178	$ 178
Fertilizer	$ 34.0	$ 40.0	$ 40.0	$ 40.0	$ 40.0
Fertilizer Price per 50kg bag		$ 10	$ 10	$ 10	$ 10
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$ 106	$ 106	$ 106
Net Revenue (US$/ha)	**$ 114**	**$ 215**	**$ 92**	**$ 272**	**$ 422**
Net Revenue relative to Traditional Seed		**189%**	**81%**	**239%**	**371%**
Market Fertilizer Prices, $225per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23
Gross Revenue (US$/ha)	**$ 335**	**$ 590**	**$ 406**	**$ 675**	**$ 900**
Total Variable Costs (excludes Land and Labor), of which:	$ 110	$ 271	$ 271	$ 271	$ 271
Fertilizer	$ 34	$ 132	$ 132	$ 132	$ 132
Fertilizer Price per 50kg bag	$ 34	$ 34	$ 34	$ 34	$ 34
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$ 106	$ 106	$ 106
Net Revenue (US$/ha)	**$ 225**	**$ 320**	**$ 135**	**$ 404**	**$ 629**
Net Revenue relative to Traditional Seed		**281%**	**119%**	**356%**	**554%**
FISP Fertilizer Prices, $225per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23
Gross Revenue (US$/ha)	**$ 335**	**$ 590**	**$ 406**	**$ 675**	**$ 900**
Total Variable Costs (excludes Land and Labor), of which:	$ 109.8	$ 178.5	$ 178.5	$ 178.5	$ 178.5
Fertilizer	$ 34.0	$ 40.0	$ 40.0	$ 40.0	$ 40.0
Fertilizer Price per 50kg bag	$ 10	$ 10	$ 10	$ 10	$ 10
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$ 106	$ 106	$ 106
Net Revenue (US$/ha)	**$ 225**	**$ 412**	**$ 228**	**$ 497**	**$ 722**
Net Revenue relative to Traditional Seed		**363%**	**200%**	**437%**	**635%**

	Traditional Seed	Certified Base	Certified 1.8 MT Yield	Certified 3 MT Yield	Certified 4 MT Yield
Market Fertilizer Prices, $300 per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30
Gross Revenue (US$/ha)	**$ 447**	**$ 787**	**$ 542**	**$ 900**	**$1,200**
Total Variable Costs (excludes Land and Labor), of which	$ 110	$ 271	$ 271	$ 271	$ 271
Fertilizer	$ 34	$ 132	$ 132	$ 132	$ 132
Fertilizer Price per 50kg bag	$ 34	$ 34	$ 34	$ 34	$ 34
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$ 106	$ 106	$ 106
Net Revenue (US$/ha)	**$ 337**	**$ 516**	**$ 271**	**$ 629**	**$ 929**
Net Revenue relative to Traditional Seed		**455%**	**238%**	**554%**	**818%**
FISP Fertilizer Prices $300 per metric ton					
Yield (Kg)	1,489	2,624	1,805	3,000	4,000
Price (US$/kg)	$ 0.30	$ 0.30	$ 0.30	$ 0.30	$ 0.30
Gross Revenue (US$/ha)	**$ 447**	**$ 787**	**$ 542**	**$ 900**	**$1,200**
Total Variable Costs (excludes Land and Labor), of which	$ 109.8	$ 178.5	$ 178.5	$ 178.5	$ 178.5
Fertilizer	$ 34.0	$ 40.0	$ 40.0	$ 40.0	$ 40.0
Fertilizer Price per 50kg bag	$ 10	$ 10	$ 10	$ 10	$ 10
Seed	$ 4	$ 23	$ 23	$ 23	$ 23
Hired Labor	$ 69	$ 106	$ 106	$ 106	$ 106
Net Revenue (US$/ha)	**$337**	**$608.5**	**$ 337**	**$ 722**	**$1,022**
Net Revenue relative to Traditional Seed		**635%**	**899%**		

Source: Zambia Maize Budget Results (8.23.2015) provided by Ryan Vroegindewey of the MSU Department of Agricultural, Food, and Resource Economics for USAID. His calculations are based on CSO 2014/15 Harvest surveys. These calculations do not take into account the cost to farmers of their own labor, the imputed rental cost of land, or any imputed interest costs on the extra investment required to raise hybrid maize.

There are several lessons from this analysis. First, the yield bump from the combination of hybrid maize seed and market-priced fertilizer at low (current) maize prices leaves farmers no worse off than if they used traditional maize seed at average yields. This means that those farmers who are unable to get close to 2.5 mt or better with hybrid maize are better off with traditional seed, and this finding is consistent with the fact that nationally, approximately 43 percent of growers still use recycled or traditional varieties of maize.[34] It also explains why extensive growth in the use of hybrids took off from 2010-14 for the other 57 percent. During this period, maize prices remained above US$216 and were as high as US$311 in the first quarters of those harvest years. Combined with the good yields of 2010-2012, these were bonanza years for maize farmers, and probably led to soaring adoption rates.

[34] CSO Post Harvest Survey Data 2012/13.

Farmer's responses to a standard set of questions posed in the FGDs[35] revealed that they may grow maize as a cash crop as well as for food security reasons. The business case is different for each situation. The likelihood of generating a cash surplus from sales will depend upon the balance between maize production and household consumption. Those households with smaller areas or with more members will be less likely to generate a cash surplus and can be expected to rely to a greater extent upon home-saved seed.

TABLE 10: RESULTS OF FGDS WITH FARMERS IN SOUTHERN PROVINCE, SEPTEMBER 2015 (N=45)

			# of Farmers						
Hectares Planted Last season	**# of Farmers**	**KG Planted**	**Commercial Seed**	**Traditional Seed**	**Recycled Seed**	**Years using Commerc. Seed**	**# of Farmers**	**Yield in Tons**	**# of Farmers**
1 or less	16 (36%)	**10 or less**	7 (16%)	13 (29%)	12 (27%)	**0-3**	10 (22)	**less than 1**	7 (22%)
1.1 to 2	21 (47%)	**11-20**	19 (42%)	4 (9%)	1 (2%)	**4 to 7**	12 (27%)	**1.1 to 3**	13 (41%)
2.1 to 5	7 (16%)	**21-40**	12 (27%)	1 (2%)	1 (2%)	**7.1 to 15**	15 (33%)	**3.1 to 5**	5 (16%)
>5.1	1 (2%)	**Over 40**	7 (16%)	0	0	**over 15**	8 (18%)	**over 5**	7 (22%)
Sample Size	45		45	45	45		45		32

Risk and return come into play here. The break-even yield for certified seed is 1.8 mt versus 0.73 mt for traditional seed at $150/mt, at market prices for fertilizer. This explains why farmers with larger areas are diversifying between high-yielding hybrid maize, drought tolerant maize, and traditional maize. If maize prices are high or they are producing 3-4mt/ha, farmers growing hybrid maize can earn many times what they would make with traditional seed. Conversely, if prices and yields are low, as in the case of irregular rainfall, they can barely cover the costs of using DTM or early maturing varieties and generate enough to eat. This latter scenario was the case in the 2014/2015 season.

FISP fertilizer subsidies affect the risk/return calculations for farmers at the margins. Those subsidies make the use of certified seed more risk free, especially with DTM. According to the review team's calculations, farmers will at least break even at nearly any yield above 1.1 mt, and at average hybrid yields get returns nearly double those from traditional seed – even at prices of $150/mt.[36]

The effect of maize seed prices on sustainable adoption is difficult to untangle. Seeds cost $1.50-$4/kg, with the recommended utilization from seed companies increasingly moving from 25kg to 20 kg/ha. This implies a cost of anywhere from US$30 to US$100 for commercial seeds. At

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[35] While the review team did not conduct a formal survey of smallholder farmers, those farmers participating in the FGDs were asked a standard set of questions about whether they used hybrid maize seed, how much they used, when they first adopted it, why they adopted it, what variety(ies) of hybrid seed they used, have they changed hybrid varieties in recent years (and if so why), what other types of seed they use, and what kinds of yields they were getting.

[36] The value of fertilizer subsidies is around $90, which is likely to be quite significant to small producers with limited financial resources and low yields (2 mt or less), but much less significant for those farmers planting multiple hectares or getting higher yields.

the higher end, this is a significant share of total costs. Yet farmers' behavior relative to seed prices is complex. Many FGD participants – usually those cultivating larger land areas – reported that they would prefer to buy the best seed possible, i.e. the most expensive.[37] Thus, there are (at least) two distinct markets for hybrid maize seed. This finding may also explain the huge impact of FISP in affecting hybrid seed adoption rates (81 percent of FISP recipients versus 45 percent of non-FISP recipients). However, the effect of FISP may be more through the availability of highly subsidized fertilizer that allows for hybrid seeds to be productive, rather than through the seed prices themselves.

This analysis of crop budgets brings to light the importance of the FRA program. As discussed earlier, FRA had a major effect on farmers' adoption decisions by providing access to a guaranteed commercial market, absorbing surplus production in the case of bumper crops, and paying significantly above market prices. As seen in Table 11 and Figure 8, FRA prices were around 50 percent above world prices in 2009 and 2010, at around US$270/mt in Q2-Q3 (when FRA does most of its buying). This suggests that the FRA may have set artificially high prices in those early years of its existence (and in the context of the spikes in world food prices of that era) to encourage farmers to produce more and achieve domestic self-sufficiency.

TABLE 11: WORLD AND FRA MAIZE PRICES IN US$[38]

	Annual Average	Q1 average	Q2 average	Q3 average	Q4 average
World Maize Prices					
2009	$ 165.57	$ 166.09	$ 176.49	$ 151.56	$ 168.13
2010	$ 183.81	$ 162.88	$ 157.41	$ 176.13	$ 238.81
2011	$ 292.09	$ 280.71	$ 311.63	$ 305.25	$ 270.77
2012	$ 298.21	$ 277.50	$ 270.46	$ 327.14	$ 317.74
2013	$ 260.37	$ 304.61	$ 291.38	$ 246.19	$ 199.28
2014	$ 193.57	$ 209.55	$ 216.70	$ 174.75	$ 173.25
2015	$ 171.15	$ 174.67	$ 169.24	$ 169.26	$ 172.04
FRA Prices in $					
2009	$ 262.09	$ 239.73	$ 254.97	$ 273.07	$ 280.60
2010	$ 270.70	$ 280.69	$ 260.21	$ 269.07	$ 272.83
2011	$ 267.35	$ 274.67	$ 272.83	$ 265.31	$ 256.60
2012	$ 251.68	$ 250.06	$ 253.27	$ 254.97	$ 248.43
2013	$ 239.67	$ 242.25	$ 239.28	$ 240.80	$ 236.36
2014	$ 225.16	$ 236.71	$ 215.62	$ 228.35	$ 219.94
2015	$ 177.50	$ 199.74	$ 189.21	$ 163.02	
FRA less World Prices					
2009	$ 96.52	$ 73.64	$ 78.47	$ 121.51	$ 112.48
2010	$ 86.89	$ 117.81	$ 102.80	$ 92.94	$ 34.03
2011	$ (24.74)	$ (6.03)	$ (38.80)	$ (39.94)	$ (14.17)

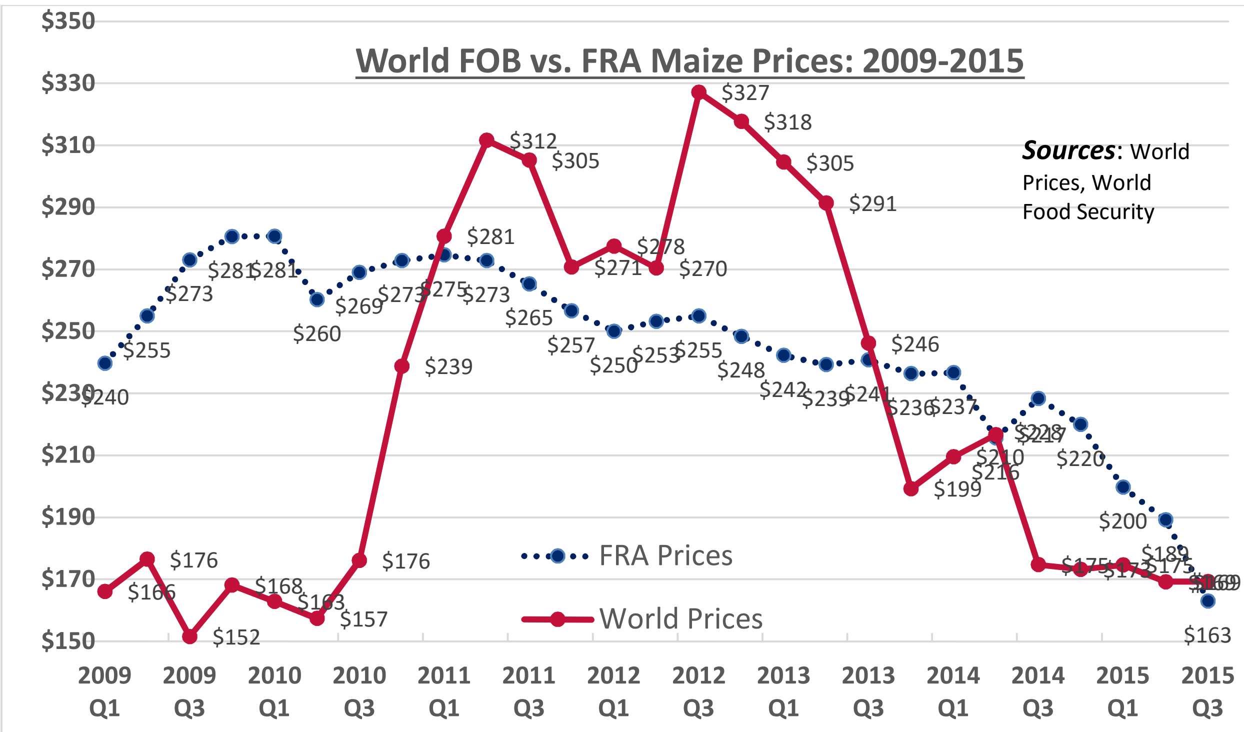
[37] Conversely, farmers who were more resource-constrained reported that they preferred to buy the cheapest seed. This apparent contradiction is consistent with findings by Smale and Mason, who in noting the importance of resource constraints found that farmers' assets are positively and significantly correlated with the extent of hybrid maize use. Their regression analysis found that "the higher the seed price, the more hybrid seed was planted." Ibid, p. 18

[38] While the review team was not able to obtain time series data on commercial market prices for maize in Zambia, it can compare monthly world market prices with those paid by the FRA, converted at Kwacha/$ exchange rates. It is important to remember that the world market prices being used can be considered free on board prices, and as such do not take into account either insurance or freight (i.e. they are not Cost, Insurance, and Freight). Given that Zambia is a landlocked country, these costs are likely to be significant. FRA prices in Kwacha were obtained from the FRA. World maize prices, on a monthly basis, were obtained from the Food Security portal (see http://www.foodsecurityportal.org/api/countries/world-maize-price). As these prices were only available going back to January 2009, that is the beginning of the analysis. Kwacha-$ exchange rates used were obtained on an end-of-month basis from XE currency converter (see http://www.xe.com/currencycharts/?from=USD&to=ZMK&view=1Y).

2012	$ (46.53)	$ (27.44)	$ (17.20)	$ (72.17)	$ (69.31)
2013	$ (20.69)	$ (62.36)	$ (52.09)	$ (5.39)	$ 37.08
2014	$ 31.59	$ 27.16	$ (1.08)	$ 53.60	$ 46.69
2015	$ 6.34	$ 25.08	$ 19.98	$ (6.24)	
			FRA as % of World Price		
2009	158%	144%	144%	180%	167%
2010	147%	172%	165%	153%	114%
2011	92%	98%	88%	87%	95%
2012	84%	90%	94%	78%	78%
2013	92%	80%	82%	98%	119%
2014	116%	113%	100%	131%	127%
2015	104%	114%	112%	96%	0%

Sources: FRA prices: FRA; world maize prices: Food Security Portal; Exchange Rates: www.xe.com. See footnote for details.

FIGURE 8: MAIZE PRICES: WORLD VERSUS FRA



Source: see Table above.

In sum, the business case analysis for farmers shows that the high world and FRA prices of 2009-2013 made adoption of certified maize seed highly profitable, even for yields more often associated with traditional seed. In 2014, FRA prices dropped slightly, to around US$225/mt- still high enough to make production with certified seed profitable at most yields. During this period, there was a rapid expansion of both adoption and surface area planted (i.e. extensive scaling). Farmers learned that planting a hectare of certified maize was like buying a lottery ticket; with good rain and a guaranteed market from FRA with high prices, they could get several metric tons or more and earn a good profit. As harvests were in fact good for the first few years of this period, it paid off, encouraging further adoption by more farmers and planting of greater areas by farmers already planting hybrid maize.

In 2015 the depreciation of the Kwacha brought FRA prices effectively close to the $150/mt used in the base analysis, even after FRA raised its buying price in August 2015. At these levels, as noted above, it is clear that certified seed is profitable for those farmers with yields above 3 mt – without FRA or FISP. If the very small sample of 32 farmers who participated in the FGDs is even remotely representative, this would be at least 40 percent of farmers (and probably much more, as farmers are concentrated by better growing conditions). However, at these prices adoption of certified maize is marginally profitable for many framers. This is especially true for those where markets are poorly developed – either for reasons of access or because of poor maize growing conditions (e.g. erratic or low levels of rainfall), which render the production of a commercial surplus rare and/or unpredictable. The FISP subsidies shift these calculations up somewhat; however, their impact should not be underestimated since it is less the financial value of fertilizer but rather, in the absence of any financing alternatives, the fact that farmers are able to use fertilizer and achieve higher yields. Taken together, these factors show that the business case explains much of the 60/40 split between adopters and non-adopters.

TABLE 12: CROP BUDGETS USING FRA AVERAGE BUYING PRICE 2009-2013, WITH AND WITHOUT FISP SUBSIDIES

	Traditional	**FRA Average Price with Full Market Price on Fertilizer**						
Yield (Kg)	1,489	1,500	2,000	2,500	3,000	3,500	4,000	4,500
Price (US$/kg)	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
Gross Revenue (US$/ha)	$ 384	$ 387	$ 516	$ 645	$ 774	$ 903	$1,032	$ 1,161
Costs (US$/ha)								
Fertilizer	$ 34	$ 132	$ 132	$ 132	$ 132	$ 132	$ 132	$133
Total Variable Costs (US$/ha – excl. HH labor)	$ 110	$ 270	$ 270	$ 270	$ 270	$ 270	$ 270	$270
Net Revenue (US$/ha)	**$ 274**	**$ 117**	**$ 246**	**$ 375**	**$ 504**	**$ 633**	**$ 762**	**$891**

Source: Author's calculations based on crop budgets supplied by Zambia Maize Budget Results (8.23.2015) provided by Ryan Vroegindewey, as above.

B. Seed Production

The business case for hybrid maize seed production in Zambia is strong. Seed is produced on behalf of seed companies by commercial growers with farms large enough to ensure the necessary isolation of the breeding lines. Many of these farms can provide supplementary irrigation, or can produce a seed crop during the dry Zambian winter so that a high yield of the female plants can be almost assured. Table 13 shows recently estimated costs and margin for hybrid seed multiplication by commercial growers.[39] The evidence shows that seed producers earn $1,953/ha on total variable costs (including hired labor but not land), plus interest of $2,036 - nearly a 100 percent return on investment. The value of the seed maize reflects costs of isolation as well as the technical skill and discipline that must be applied in order to produce a pure crop of seed without contamination by other varieties or by weeds. For comparison purposes, Table 13 also includes the gross margin analysis of maize grain production by commercial farmers, showing that the margin is effectively zero. This is consistent with the responses

[39] Given the fact that the majority of the variable costs (fertilizer and agrochemicals) are for imported items, and that a substantial proportion of the maize seed produced is exported, seed contracts are usually executed in U.S. Dollars.

from stakeholders interviewed who work in maize (i.e., seed companies, agro-dealers, the Ministry of Agriculture, and research institutions) that no commercial farmers produce maize grain in Zambia.

TABLE 13: GROSS MARGIN ANALYSIS OF CERTIFIED SEED PRODUCTION 2014/15

Item	Unit	Rate/ha	Unit Price	Amount US$/ha)	Rate/ha	Unit Price	Amount US$/ha)
		Seed Maize Crop			Commercial Maize Crop		
Revenue	**--**	--	--	--	--	--	--
Maize Grain	**MT**	7	570.00	3990.00	7.5	181.1	1358.25
Total Revenue	**--**	--	--	3990.00	--	--	1358.25
Variable Costs	**--**	--	--	--	--	--	--
Seed	**Kg**	25	2.97	74.25	30.00	1.76	52.80
Pesticides	**Lt**	9.8	8.52	83.50	2.40	8.05	19.32
Fertilizers	**Kg**	851	0.63	539.96	725.00	0.63	458.42
Packaging	**Bags**	90	0.27	24.30	150.00	0.27	40.54
Labor	**Mandays**	130	3.02	392.60	30.00	3.02	90.60
Insurance	**% of output**	0.02	3990.00	79.80	0.01	1358.25	9.51
Land Preparation	**Liters**	100.7	1.39	140.00	106.00	1.39	147.68
Harvesting	**US$/ha**	1	85.00	85.00	1.00	85.00	85.00
Machinery R&M	**% of fuel**	0.5	125.00	62.50	0.50	132.80	66.40
Transport	**US$/Mt/km**	525	0.20	105.00	525.00	0.20	105.00
Irrigation	**Mm**	250	0.54	169.00	--	--	--
Total Variable Costs	**--**	--	--	1755.91	--	--	1075.27
Interest on TVC	**% of TVC**	0.16	1755.91	280.94	0.20	1075.27	215.05
Gross Margin	**--**	--	--	**1953.15**	--	--	**67.93**

Source: ZNFU data for 2014/15

The business case from a seed company's perspective is somewhat different. According to interviews with six Zambian seed company executives, including both multinationals and domestic companies, a new variety must achieve profitability – equivalent to scale – within five years or it will be discontinued. If a single variety is obliged to carry all the costs of the seed company, these same executives suggested that a minimum volume of 250 mt is needed to ensure sustainability. However, some companies continue to produce certain varieties because of customer loyalty, cross-selling to higher value varieties like horticulture seeds, or because it allows them to cover the various niche markets for maize (i.e. present a complete set of varieties). In Zambia, many of the 40 hybrid varieties continue to be produced at less than 25 mt.

According to the 6 seed company executives and 10 agro-dealers interviewed, the wholesale price of maize seed is approximately US$1.50-$4/kg. From this price, the seed company must cover its costs of seed multiplication (paid to growers), processing, distribution, and administration. As noted above, the amount paid to growers is approximately US$0.50-$0.60, and around 10 to 20 percent goes to agro-dealers (as discussed below). A substantial margin appears to remain available to cover the costs of the seed producing company, though it must include supporting or amortizing research and development. In practice, the uncertainty of the market can erode profits because of the time lags involved in producing three-way hybrid crosses, predicting demand, and the introduction of new competing varieties. For most of the larger Zambian producers, 80 percent of their sales are exports to other parts of Africa – which diversifies the risks of selling to the domestic market substantially. The fact that the number of maize seed companies selling into the Zambian market continues to increase suggests that even after accounting for all of these costs and potential losses, an attractive margin of profit remains.

C. Seed Processing, Distribution, and Sales

The gross margin analyses (see Table 13) also show that at US$0.57/kg, the price paid to growers of maize seed is approximately 31 percent of the retail price of US$1.76/kg paid for seed by growers of commercial maize. The difference of 69 percent covers the costs of seed processing (cleaning, dressing, and bagging) distribution, and retail. According to interviews with agro-dealers, they can purchase maize seed in limited quantities but can get additional seed rapidly (i.e. within the week) from seed companies to meet changing demand for varieties from farmers. Thus, there is little risk involved in selecting varieties to sell. According to both seed companies and agro-dealers, the legal requirement for all certified seed to be returned at the end of the season for recertification has effectively obliged sales to agro-dealers to be conducted on a consignment basis. Thus, from the agro-dealer's perspective, there is little risk. Supplier credit covers all goods received up to the time of sale and is reconciled at intervals (varying from weekly to monthly). This facility enhances agro-dealer liquidity and means that the retailing of maize seed has minimal negative impact on the agro-dealers' cash flow.

The mark-up on maize seed varies from 10 percent (for agro-dealers carrying small volumes without any exclusivity) to 20 percent (for those selling large volumes of a specific company's seed on an exclusive basis). Thus, provided a dealer has adequate storage space, it makes sense to stock maize seed – since every sale contributes to revenue. The apparently high profitability of seed retailing has led to substantial market entry putting pressure on the volumes of individual agro-dealers. In several towns visited by the review team, the number of agro-dealers has doubled in the last five to seven years.

According to interviews with 10 agro-dealers, a very small number of agro-dealers make any effort to sell or deliver beyond their brick- and-mortar location. The markup of 10 to 20 percent is inadequate to justify hiring a truck to sell small quantities to rural smallholders, unless a substantial volume of product sales can be guaranteed.

The case is slightly different for seed companies – especially newer, smaller companies with little brand recognition or market share. According to interviews with seed company executives, a few of the smaller domestic companies[40] have been willing to cover the cost of this kind of outreach to smallholders to establish market share. In one case, individual agents have been sponsored to canvass growers as to their needs and to order small quantities from the producer, while another has sponsored the development of container-based rural outlets selling other commodities as well as seed. To ensure sustainability, some companies have liaised with NGOs to offer training to rural agents in both specific product use and more general business practices.

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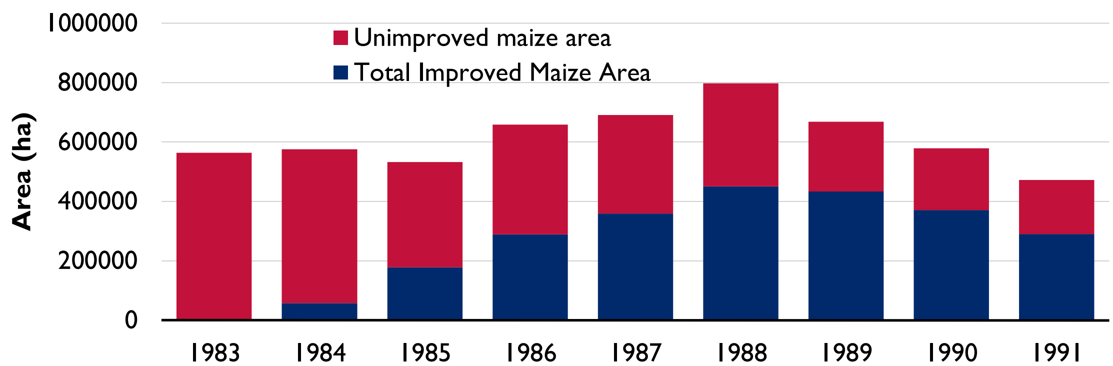
[40] There are currently 15 seed companies operating in Zambia. Seven are small domestic companies (AFGRI, Progene, Kamano, Capstone Seeds, Advanta, Klein Karoo, and Afriseed) established in the last decade to take advantage of and profit from the growing demand for certified, high-quality maize seed. The two large domestic companies are Zamseed and MRI, although MRI was bought by Syngenta in 2013. The large multinationals present in Zambia are: Pioneer, Pannar, SeedCo and Dekalb/Monsanto.

VI. THE EXTERNAL CONTEXT OR SPACES

A. Supply Chain of Maize Seed and Other Inputs

The private sector maize seed supply chain in Zambia was sufficiently broad to facilitate scaling up during the second wave of scaling from 2006 to the present. In many other Asian and African countries, the supply (production) of seed has been limited because of subsidized competition from the public sector and parastatal producers with control of key intellectual property rights or access to germplasm and breeder seed. These factors were not present in Zambia. Private seed producers have been active in Zambia since the privatization of Zamseed in the mid-1990s, with the steady entry of existing multi-national seed companies as well as new domestic firms over the last 20 years (see the previous footnote). Similarly, while retail input distribution is still limited in areas far from major towns, it is relatively dense along those roads and has been growing rapidly as demand has increased. Farmers who live close to those roads can easily access a large number of maize seed varieties.

FIGURE 9: TRENDS IN AREA PLANTED AND USE OF IMPROVED SEEDS, 1983-1991



Maize Seed Industry and Seed Utilization

Development of the maize seed industry in Zambia has paralleled the trends in maize production. The establishment of Zamseed in 1981 as part of the GRZ policy to support domestic maize production resulted in the rapid improvement of maize breeding[41]. Between 1983 and 1992, Zamseed release 11 hybrids and 2 OPVs.[42] The most rapid adoption occurred in Region II, the plateau region that covers much of Southern Province except for the lower lying river valleys. In 1990, Zamseed sold 13,343 mt of maize seed, 97 percent of which consisted of hybrid varieties.[43] By that time, improved maize varieties had been widely adopted by both large- and small-scale farmers. In this period, adoption of hybrid maize seed peaked in 1989 at roughly 60 and 75 percent of area planted in nationally and Region II, respectively.[44]

As part of the structural adjustment period, the amendment of the Plant Variety and Seeds Act in 1994 and 1995 removed the monopoly status of Zamseed and it was privatized through a management buy-out in 1995. The Act permitted the importation of new varieties, and opened a new, more liberal

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[41] An excellent and detailed history of the period from the 1970s through 1995 can be found in Julie Howard and Caroline Mungoma, "Zambia's Stop and Go Revolution: The Impact of Policies and Organizations on the Development and Spread of Maize Seed Technology". Michigan State University International Development Working Papers #61, 1996.

[42] It is a measure of either the conservative nature of smallholders or the excellence of these varieties that as of 2012/13, 9 of the 10 varieties released in 1983/84 were still in production.

[43] The OPVs, which were largely the result of a USAID intervention, accounted for 2 percent (MMV400) and 1 percent (MMV600) of sales in 1991.

[44] Howard et al.1992

chapter for the maize seed sector characterized by a relatively open playing field. Despite limited demand, a number of companies were willing to invest and by 1996, four new companies were selling maize seed in the country besides Zamseed. By 2000, Zamseed's market share fell to 65 percent and has declined further since.[45]

The arrival of new companies resulted in a rapid increase in the availability in the number of maize varieties. While only 15 new varieties were released between 1983 and 1993, another 98 were released between 2003 and 2013 and a further 22 between 2013 and 2015. Recent statistics produced by the GRZ CSO suggest that in 2012/13, these varieties had been adopted by 57 percent of smallholders. If that proportion were applied to the total area of maize harvested in 2015, it would suggest that at a seed rate of 25kg/ha, the total volume of commercial seed sold domestically was 21,300 mt.

Input Distribution

The private sector has been the primary distribution mechanism for improved maize seed. However, FISP has played an important and growing role. Almost all agro-dealers carry the improved maize seed of a number of producers – this was even observed by the review team in small towns where there were are least two – and at times several – varieties for each producer. Only one of the six seed companies interviewed has proprietary agro-dealers. The vast majority of improved certified seed is distributed and accessed through these agro-dealers, whose numbers and reach organically expanded in the province to meet the increasing demand. While NGOs and donor-financed projects, such as in conservation agriculture, played a role in the distribution of maize seed (mostly in its initial introduction), distribution by those actors remains relatively small compared to private agro-dealers.

At the same time, access to seed was constrained for actual and potential adopters who lived far from towns, as few agro-dealers are located in the interior of the province (i.e., off the main roads). For those farmers, long distances and the lack of and cost of transportation at a minimum made acquiring hybrid seed more difficult. As these farmers tended to have fewer resource and farming land in agro-ecological zones is more prone to inconsistent rainfall, lack of access compounded issues of affordability. While the review team did not gather clear evidence that the number and extent of adoption of improved maize seed has been constrained by access, the more remotely located farmers participating in FGDs indicated that this was an issue.

Private seed companies and distributors have responded somewhat to the access issue. As noted earlier, smaller and newer domestic seed companies, eager to find a niche market, offer delivery of seeds directly to farmers in remote areas. In a few other cases, seed companies have set up local seed depots in more remote areas for the same purposes.

While FISP has been important in making improved certified maize seed more affordable and allowing farmers to try different varieties, it has not really addressed issues around access. Until 2015, FISP seeds were mainly available at large public depots in major towns where farmers have to travel to pick them up. In addition, access through FISP has been limited because of the requirements to be a co-operative member, and because FISP has in past years delivered seed weeks after the first rains, the optimal time for planting. Evidence that FISP did not play much of a role in increasing access, as opposed to affordability, is confirmed in the study by Smale and Mason: "seed subsidy receipt is independent … from the [time it takes a household to travel to] the point of seed sales."[46]

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[45] The privatization of Zamseed was accompanied by the loss of key breeding staff which, together with the company's limited experience in selling into open market conditions, may have contributed to the decline in market share.
[46] See Melinda Smale and Nicole Mason, "Demand for Maize Hybrids, Seed Subsidies, and Seed Decision makers in Zambia" HarvestPlus Working Paper, May 2012, No. 8, p. 18.

While many farmers rely on FISP as their source of supply, timely availability of fertilizer has and continues to be a major issue, affecting the productivity of fertilizer use itself as well as the use of hybrid seed. As a result:

> "In remote areas, and given current management practices, fertilizer use appears to be profitable for only a minority of farmers in the relatively remote areas. For farmers in the more accessible areas, profitably of fertilizer use depends on timely availability. If fertilizer is not available on time, even farmers in the more accessible parts of this area of relatively high agronomic suitability for maize production are largely unable to use fertilizer profitably."[47]

Xu et al. report that over 30 percent of farmers received late fertilizer from FISP (1999-2001).[48] Based on the FGDs with farmers, while private deliveries had become quite timely, 15 years later FISP deliveries continued to be late. The behavior of the public system has a negative feedback on the private system. As with seeds, farmers who expect to receive fertilizer will often purchase it, if they have the means, when FISP deliveries are delayed. Yet for private dealers, the existence of the public system combined with uncertainty as to whether public deliveries will be on time makes them less likely to have adequate fertilizer available early in the season to offset delays in public delivery.

Despite these qualifications, FISP has had huge direct and indirect impacts through fertilizer use by encouraging the adoption of hybrid seeds. Mason et al. (2011) estimate that "15% of the increased maize production in 2011 over levels in the mid-2000s was due to increased fertilizer use."

The only other major inputs whose supply might be relevant to adoption decisions of hybrid maize is fertilizer, and to a much lesser extent, herbicide. The supply chain and distribution mechanism for fertilizer significantly overlaps with improved maize seeds. According to the 10 agro-dealers interviewed, while some agro-dealers only sell seed and others only sell chemicals and fertilizer, the vast majority sell both. Given the nearly identical systems, most of the same conclusions can be drawn as with seed, timely delivery, price, and access.

B. Downstream considerations

The scaling up of a technology like hybrid maize seed, if successful, will improve maize yields, production, and farmers' profitability. However, this cannot occur if there is not sufficient demand for this increased production without a negative effect on prices, and with the necessary downstream market infrastructure of buyers, processors, and distributors to bring maize from farmers to the final consumer. This subsection discusses these downstream issues.

Domestic Commercial Markets

The uses of the maize crop include consumption as green maize and maize meal, sale to commercial mills for processing into flours (roller meal and breakfast meal), and stock feed. Zambia also exports maize as both grain and smaller volumes of maize meal to neighboring countries.

The key downstream actors in the maize value chain are toll millers, commercial milling companies, "briefcase traders," and the FRA, which buys maize from smallholders. The toll mills provide a service to households that have either produced or purchased maize. They process both traditional and hybrid varieties of maize and have increased in number over the last 20 years.

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[47] Ibid. p. i

[48] In the earlier period, both public and private delivery of fertilizer were equally late, i.e. 30 percent of the time. Ibid p. 4.

Prior to market liberalization, only the parastatal company National Milling produced roller and breakfast meal.[49] After 1992, a significant number of commercial companies were set up to produce these staple foods. Although only about 10 companies were established in the first decade of liberalization, in the last 4 years 20 new mills have been set up in Lusaka, as well as others in Eastern province, on the Copperbelt, and in Livingstone. According to National Milling representatives, which remains the largest player in maize processing, this trend is anticipated to accelerate, with another 30 mills expected to be in operation by the end of 2017. Such expansion reflects significantly increasing demand. As one commercial miller reported, "we used to have problems selling our product, especially at harvest, but in the last three or four years we have had challenges meeting demand". Overall, that mill estimated that their market had grown by more than 60 percent in the last 5 years.

The commercial companies require large volumes of maize and originally sourced these through a network of agents, large commercial farms, or from traders who had aggregated the small quantities of maize sold by smallholders into the volumes needed by the mills. More recently, mills have found it most lucrative to source maize from the FRA, which one miller described as "our backbone," since it is both the largest purchaser of maize and has often sold to mills at prices well below those of traders.

According to several studies of Zambian maize over the last 10 years,[50] beginning in 2008, FRA policy included a subsidy on the maize sold to commercial mills in order to reduce the price of roller meal.[51] This encouraged the expansion of roller mills and a wider market for cheap roller meal, while simultaneously constraining the profitability of the hammer mills that sourced from more expensive small traders. Although the subsidy was removed in 2013, according to Kueteya and Sitko (2014) it has had a lasting impact on both demand for commercial maize meal (which has increased) and the number of hammer mills operating in urban areas (which has fallen).[52] At the same time, in rural areas the number of small hammer mills that provide a toll grinding service has increased, reducing the need for the pounding of maize by hand and the growing of traditional flint-type varieties that are best suited to that process. This too has favored the adoption of dent-type maize varieties (i.e., certified commercial hybrids as compared with traditional varieties).

Over a period of 22 years, a fully liberalized market for maize has been subject to the gradual reimposition of government controls, leading to a situation in which private sector millers now have a steady supply of maize and access to a growing market, while other private sector stakeholders such as toll millers and traders face strong competition and greater uncertainty over access to international markets. The trend towards increased government intervention in the downstream market over the last 10 years has favored the commercial production of maize by emergent farmers, and increased the market that is available to them. The caveats that are frequently expressed regarding the cost and sustainability of such interventions apply as much to Zambia as to any other country that has embarked upon such programs.[53] Nevertheless, farmers effectively have access to a guaranteed market for as long as the GRZ is willing and able to pay for FRA at something near its recent scale. Moreover, given the inherent natural advantages of soil and climate available to Zambian maize growers, there appears to be

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[49] Per interviews with National Milling management.

[50] These include the studies by MSU cited above as well as by IAPRI. See especially Auckland Kuteya and Nicholas Sitko "CREATING SCARCITY FROM ABUNDANCE: BUMPER HARVESTS, HIGH PRICES, AND THE ROLE OF STATE INTERVENTIONS IN ZAMBIAN MAIZE MARKETS" IAPRI, Lusaka, Zambia, Polichy Brief No 67, May 2014.

[51] Maize purchased by the FRA at ZK65/50kg was sold to commercial mills at ZK60/kg. The FRA thus absorbed the costs of inspection, aggregation, and transport as well as financing 7.7 percent of the cost.

[52] Op cit. This was confirmed in interviews with National Milling management, seed company management, and maize sector researchers.

[53] IAPRI data suggest that the cost to the government of the maize subsidy has exceeded US$140/mt sold to millers, while GRZ support in the form of subsidies to both inputs and production account for 80 percent of government spending on agriculture and are equivalent to 2 percent of GDP.

a market for exports as long as neighboring countries are unable to achieve the same levels of productivity demonstrated by Zambian smallholders, and GRZ policy allows it.

The involvement of the FRA has limited the profitability of the briefcase traders and may also have increased their risk, although one miller noted during an interview that demand exceeded the FRA's capacity to supply the market so that there was always room for other players. Nevertheless, whether as a result of the influence of the FRA or of other factors (such as poor feeder roads or other constraints), both the number of potential buyers for maize and the prices that they are willing to offer have weakened over time. This is especially the case as low FRA prices offered to mills have undercut the profitability of large commercial farmers from growing maize, and they have completely withdrawn from the market.

Supplementing the demand for maize from millers' supplying the consumer market has been demand for maize for feed. With the increase in consumption of poultry meat, demand for maize as a central ingredient of stock feed has increased substantially. Stock feed now represents 30 percent of the throughput of some of the larger mills and is both sold domestically and exported to Namibia and Botswana.

Export Markets

As a landlocked country, Zambia's export markets for a bulky commodity such as maize are limited. In the past, this disadvantage was exacerbated by two highly productive neighboring countries (South Africa and Zimbabwe) that often produced maize surpluses that could be competitively exported to deficit countries such as Botswana, Namibia, Angola, and occasionally Malawi and Mozambique. More recently, however, the effective collapse of agricultural production in Zimbabwe and the impact of drought in South Africa opened up opportunities to export maize into these countries and deficit neighboring countries (as well as Zambia's more traditional export markets in southern DRC). Substantial volumes of maize (up to 300,000 mt, or more than 10 percent of production) were exported by the private sector and the FRA, raising concerns over the impact on local prices and the imposition of export bans in 2012/3 and 2013/14.

C. Credit, Labor and Mechanization: Spaces and Constraints

FGDs with farmers and outside research by the Indaba Agricultural Policy Research Institute, Michigan State University, and others have confirmed that the lack of financial resources is a significant constraint on farmers' adoption of maize seed, and especially the fertilizer needed to maximize its yield potential. The GRZ had credit schemes for purchases of inputs in the 1980s, but they were very expensive, especially because of high default rates. Those schemes contributed to the debt crisis of the early 1990s and were eliminated under structural adjustment, and since then there have been no public sector credit schemes available to small maize farmers. FISP, which has had an important impact on the affordability of a limited quantity of seeds and fertilizer, provides access to those inputs at subsidized rates but not on credit. Small farmers generally are not able to access credit for maize inputs through private financial institutions. Various savings and lending group schemes have an important presence in Zambia, but do not provide credit for farming. While many male farmers have significant savings in the form of livestock, it was a universal consensus among FGD participants that these were not to be sold to fund maize inputs; at best, goats or chickens, but never cows. This cultural factor deserves further research, but was beyond the scope and resources of the review team.

The one credit scheme that helps farmers is the Lima program, organized by the Zambian National Farmers Union (ZNFU) in partnership with a private bank – Zambia National Commercial Bank

(Zanaco).[54] Having started in the 2008-2009 season in the context of program supported by the Swedish International Development Agency (SIDA), the Lima credit scheme provides inputs based on cash collateral from farmers at the beginning of the season, with repayment after the harvest. To participate in Lima, farmers must go through a credit screening because, for farmers to be able to cover the financing costs, they need to be highly efficient.[55] In addition to cash collateral, they must provide a collective co-guarantee from a group of 7 to 30 farmers. As of the 2014/2015 season, the Lima loan portfolio was ZMK82.5 million in the 2014-15 season, or a little over $8 million. It has reached 42 of the 103 districts in Zambia and covers about 36,000 ha of production. Most of the recent expansion in the Lima program has involved helping existing participants expand the number of hectares they cultivate, so the average plot size cultivated by the program increased from around 1 to nearly 2 ha/farmer. According to interviews with ZNFU senior management, the Lima program has been successful in helping small farmers transition to emerging farmer status, often by financing the acquisition of farm machinery and equipment (i.e. mechanization).[56]

While clearly a lack of financial resources has not prevented around 60 percent of farmers from adopting hybrid maize seed, according to both farmers themselves and multiple industry observers it likely has constrained the other 40 percent. This is especially the case for those more remote farmers that face higher transactions costs in buying inputs and selling maize, for whom their input/output price ratio is more adverse. A lack of finance has likely impeded those 60 percent from growing as much hybrid maize as they would if they were not finance-constrained, the extensive growth from 2008-2015 notwithstanding. The majority of farmers who participated in the FGDs indicated that they limit their fertilizer use to their FISP allocation, and a significant but much lower number did the same for seed. Were FISP to be scaled back or its terms to become less favorable, it is likely that credit constraints and the absence of financing would force a potentially important decline of current adoption levels.

Labor and mechanization issues have posed a constraint on extensive scaling by many farmers, especially for traction in land preparation. Tractors are not widely owned by maize farmers (as opposed to farmers growing more traditional cash crops), especially in the Southern Province. Even animal traction is limited because various diseases and plagues regularly wipe out significant numbers of existing animals that are strong enough to pull a plow. In the FGDs, many farmers complained about how their farming was limited by traction, and that while they had once owned oxen, these had died and they could not afford to replace them. As with finance, clearly this has not limited the scaling up that has occurred, but again it has probably constrained scaling up from going even further and faster.

[54] The majority stakeholder in Zanaco is Rabobank, however, as part of the Lima program ZNFU is also a shareholder.
[55] Farmers put down 50 percent of the cost of the inputs they need, and the rest is financed by ZNFU's private sector partners, i.e., the bank. Initially interest rates were at a 27 percent annual rate, but this has come down to 11 percent as farmers have built up credibility with the bank partner. For this to be profitable for farmers, they would need to generate a yield in maize of at least 2.8 mt/ha, which most Lima participants appear to be doing. However, this is well above average maize yields in the Southern Province, which even at the higher rates achieved in the last several years averaged only 1.85 mt/ha from 2007/8 to 2013/14 before collapsing to 1.08 in the drought year of 2014-15. Of course, this reports the average for all farmers; the average for farmers using primarily commercial seed is unknown, but responses from FGD participants suggest it is between 2.9-3.4 mt/ha.
[56] While ZNFU has ambitions to seriously scale up the program, the current level of around 20,000 farmers represents a small fraction of total farmers. Moreover, while originally Lima only covered maize inputs, some of the growth has come from diversification into sunflower, groundnuts, rice, and soybeans – often with the same farmers. Even if Lima exclusively focused on maize, the surface area planted by participants accounts for around 1 percent of the area planted in 2014/15. The Lima scheme and the ZNFU mechanism serve as a potential example of the kind of credit program that could be scaled, although it is unclear what percentage of farmers would satisfy the requirements of cash collateral, credit screening, and co-guarantee.

D. Politics and Policy

The rapid rise of the Zambian maize seed industry can be only partly ascribed to market demand. A key factor for new entrants, especially those from Zimbabwe and South Africa, has been the freely convertible nature of the Zambian Kwacha, which allowed those companies to repatriate much-needed U.S. dollars to their own economies. The revised legislation also guaranteed the intellectual property rights of breeders, while placing only minimal constraints upon registration. The rigorous standards of the SCCI also provided Zambian seed producers with the advantage of a universally respected certification system that allowed their seed to be exported throughout the Southern African Development Community and the Common Market for Eastern and Southern Africa. Finally, Zambian growing conditions are highly suitable for economic and reliable seed production, including both a climate that is more suitable than the climates of either Zimbabwe or South Africa and a cadre of experienced commercial producers, both Zambian and ex-Zimbabwean. As a result, Zambia has become a major exporter of maize seeds to the rest of Southern Africa, and to a lesser extent, East Africa. According to CSO production data, domestic sales of 20,000 - 25,000 mt are only a fraction of total production of 75,000 - 80,000 mt.

According to the Ministry of Agriculture there are five GRZ policies and programs affecting the maize value chain and adoption of hybrid maize seed:

1. Support for and openness to foreign direct investment (FDI) and a key role of the private sector, (domestic and multinational), both in general and in the maize seed sector in particular;
2. Policy goals of food security and national self-sufficiency in maize by increasing productivity and production;
3. Support for guaranteeing a market and price for commercial maize production;
4. Support for providing (subsidized) seed and fertilizer inputs for maize production; and
5. Creating and implementing seed certification and guaranteeing quality and reputation in domestic maize seed and exports.

Most of these priorities are about the incentives of political elites in Zambia, who rely on political support from two key groups: urban consumers and small rural farmers. Foreign donors and multinational investors in Zambia also appear to have played significant roles in the evolution of these policies and programs that supported the scaling up of maize seed.

Financial and market liberalization from 1993 onwards had two important effects for scaling up of maize seed. First, they created an inviting environment for FDI in general. Two key policies were the liberalization of the country's foreign exchange policy in 1993 and the free repatriation of profits by foreign investors. Businesses from South Africa and Zimbabwe could generate the hard currency in Zambia that was at a premium in their own economies. The government, with support from SIDA, created the necessary legislation and institutional capacity for establishing a seed certification system. According to SCCI and the six seed company executives interviewed, this system is world class and rigorous. An added and fortuitous event was the deteriorating political and economic climate in Zimbabwe, which left both Zimbabwean and multi-national companies looking for literally greener pastures. It also led to an outmigration of farmers skilled in seed production and multiplication. Combined with Zambia's central location, ideal agro-ecological zones, and climate, these led to substantial investment in not only retailing and consumer goods by South African companies, but also production of hybrid maize seeds by multinational investors.

In terms of incentives and motivation, clearly much of these innovations were a result of external pressure from the IMF,[57] foreign donors, and the international financial community generally to liberalize Zambian markets, especially agriculture. Zambia was in a serious debt and economic crisis – eventually leading to its debt being forgiven/rescheduled under the Heavily Indebted Poor Countries (HIPC) Initiative. In this context, in the 1990s the Zambian government had little choice under the prevailing Washington Consensus but to liberalize. The crisis significantly discredited the socialist/statist policies of the Kaunda post-colonial regime and strengthened those political and intellectual forces that favored a more liberal policy regime.

The second key political economy aspect was the privatization of Zamseed. In many countries, a state agency or parastatal enjoys monopoly or quasi-monopoly status in the breeding, production, and sale of staple crop seeds and often other inputs. This frequently results in a number of problems adversely affecting scaling of staple seeds: poor seed quality, poor delivery times, inadequate resources for marketing, and inadequate supply and flexibility in adapting to farmer demand. At the same time, by selling seed at highly subsidized prices and retaining control over germplasm/intellectual property and breeder/foundation seed, these state actors and the legal and regulatory regime that empowers them inhibit a dynamic private seed sector from emerging that can meet the supply, timing, and preferences of staple farmers.

Once Zamseed was privatized, there was neither a state actor with vested interests nor the regulatory regime to impede the development of a private sector. Instead, the political economy interests were aligned in the opposite direction. Zamseed, multinational seed companies, and eventually a growing number of other domestic seed companies had strong interests to advocate for maintenance of liberal FDI policies and seed regime and for institutions like SCCI.

At the same time, as in many countries, the second outcome of the debt crisis and structural adjustment period was to create social costs and disrupt production that had depended on the pre-existing institutional regime. In the maize market, liberalization significantly increased uncertainty, leading to marked swings in the volume of maize produced and a decline in production over the 1990s. These swings translated into a persistent lack of food security and regular imports of maize, the staple grain, in years of poor harvest.

Policy-induced food insecurity was amplified by regular droughts, leading to increased political pressure to resume some form of maize input subsidy or credit and purchasing programs. Zambia was one of the first recipients of HIPC debt relief in 2000-2001 (which also happened to be a drought season), with 50 percent of its debt being written off immediately without meeting any policy conditionality.[58] FISP was introduced at this time, and a few years later the 2006 amendment of the Food Reserve Act expanded the role and power of the FRA.

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[57] "When Zambia signed a new agreement with the IMF after a two-year hiatus in June 1989, the debt to GDP ratio was over 200% and led to a period of hyperinflation and the virtual collapse of the currency. In the 1990s, with a change of government and the introduction of a multi-party political system, Zambia set out rapidly down a path of free-market reform, radically overturning the one-party state. As part of the World Bank and IMF's enhanced structural adjustment program, the country quickly undertook a massive privatization of government-owned enterprises, turning 80% of the economy over to the private sector; the kwacha, the local currency, depreciated as the exchange rate and interest rates were floated; trade barriers were lifted; civil service was restructured and downsized; subsidies were stopped and cost recovery measures in the social sector were introduced." See Shantha Bloemen "Debt Relief and HIPC: Zambia" Institute for Policy Dialogue, Columbia University, http://policydialogue.org/publications/backgrounders/casestudies/debt_relief_and_hipc_zambia/

[58] Shanta Blomein, ibid. "With $606 million in debt payments due in 2001, the country was accepted into the first stage of the HIPC program. On reaching what is called a "decision point", it immediately received a 50% debt reduction. Normally, countries are first forced to wait till they have qualified by satisfying certain conditions, usually a three-year process, before they actually get debt relief. But in Zambia's case, not only was the global debt campaign, Jubilee 2000, demanding that HIPC deliver results faster, but creditors knew that the country would simply not be able to meet the payments due in 2001."

The GRZ's broad food security policy was driven by the two political pillars of any government in Zambia: urban consumers and small farmers (all of whom grow maize). As Julie Howard noted in her study of the first period of the scaling up of hybrid maize:

> The need to provide Zambia's politically important urban population' with a dependable source of cheap food, and a desire to improve small farmer incomes, motivated considerable investment in maize … by the government of Zambia (GRZ) and other organizations beginning in the late 1970s.[59]

This is true for the second period of maize seed scaling as well, and remains valid in terms of GRZ policy today.

While not strongly advocated for by private agricultural companies, most of the six seed company executives interviewed indicated that they had only principled objections to FISP. This was given that it is implemented through tenders to private seed companies and helped increase the size of the hybrid seed market. The companies' major complaint was that FISP appears to be subject to significant corruption and cronyism, as the share of maize seed varieties purchased by the program does not remotely reflect market share in the private market. It appears that while seed companies were initially supportive of – or at least willing to tolerate – FRA, those representatives interviewed believe that it has played less of a role in generating seed demand.

Seed company managers interviewed indicated that they have recently become more dissatisfied with FRA, and even increasingly with FISP. Both programs (and the FRA in particular) now account for nearly all MAL expenditures, which prevents the Ministry from providing other needed services like extension support, promotion of growth sectors like soybeans, and FRA-induced distortions to maize markets. The combination of fiscal constraints and private sector opposition has, according to long-time observers of the Zambian maize sector in both seed companies and research institutes, led to the beginning of reforms in FISP (this year a trial of the use of e-vouchers) and they believe that the GRZ is likely to make changes to FRA in the near future.

VII. SCALING STRATEGY AND ACTIVITES

A. Drivers of Seed Variety Development

Certified hybrid maize seed was originally developed and introduced in Zambia by Zamseed. Zamseed received substantial support from the Yugoslavian government, which provided access to germplasm and an expert maize breeder who moved to Zambia permanently. Zamseed hybrids were specifically developed for Zambian conditions by isolating existing land races and then crossing them with the Yugoslavian varieties, as well as CIMMYT germplasm. Other government research stations working on maize seed also played a role, such as Golden Valley, which was an effective extension of the Mount Makulu Central Research Station of the Zambia Agricultural Research Institute.

These institutions received important support from a number of donors and CIMMYT. According to Norwegian Embassy aid officials, SIDA invested in Zamseed (through Svalof and Swed Fund) and has always had an interest in the Zambian seed sector[60]. According to current Golden Valley researchers, in

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[59] Julie Howard, "Improved Maize in Zambia: A Qualified Success Story" Paper prepared for the Mini-Symposium "Assessment of Agricultural Research Impacts and Research Priority Setting in Africa," 1994 Meetings of the International Association of Agricultural Economics, Harare, August 22-29, 1994. P.1.

[60] Efforts to interview SIDA officials directly proved unsuccessful due to repeated schedule conflicts. This information is confirmed by Howard (1996) op cit.

the past this public sector plant research institution seems to have had German support. CIMMYT support was particularly important for the introduction of drought tolerant varieties before and especially after 2006, when this effort was rebranded as DTMA and supported by USAID, the Bill and Melinda Gates Foundation, and others.

CIMMYT's development of DTM technology played an instrumental role in the second wave of scaling of hybrid maize in Zambia. Probably the most important factor was its technical assistance, training, and provision of germplasm to government breeders and Zamseed. This introduction of the hybrid maize seed by Zamseed and Golden Valley showed the multinationals that there was a viable market and allowed them to discover that Zambia was an ideal place for seed production. This pathway was more relevant for the first wave of scaling in the 1980s, prior to DTMA. The other two pathways were through the direct sharing of DTMA varieties and germplasm with companies.

B. Drivers of Introduction and Dissemination

In the first wave of scaling up of certified hybrid maize seed, the initial introduction, dissemination, and marketing was done by Zamseed, which worked closely with MAL extension officers in the field.[61] The strong statist ideology and capacity at the time allowed for a dense extension service – although it was of low quality. In this period, except at the retail distribution level, the private sector played almost no role in the introduction of certified hybrid maize seed.

The initial exposure of farmers to new maize varieties in the second wave of scaling up was done largely by a mix of donor-financed, NGO-implemented projects and private seed companies directly. This mix steadily towards the private sector over the course of the 2000s, as the number of seed companies and the scope of their operations expanded rapidly. In both cases, NGOs and private companies "partnered" with the government extension services, although their role was minimal. Government extension workers – known as camp officers – co-sponsored demonstration plots, field days, and other events to help mobilize the farmers. The costs of these activities were covered almost entirely by private seed companies.

In the critical post-2006 period, the role of NGOs and donor-supported activities is acknowledged by all stakeholders interviewed to have been small. As explained by the CFU, this is because until recently most donor funds were going to aid-related programs, and livelihood or agriculture were derivative of those programs and therefore relatively small. Its impact is difficult to isolate because usually improved maize seed was a small part of a much larger package. Since most of these programs focused on the introduction of improved farming techniques and GAP, as opposed to just technological innovations, they have been fairly long-term (two to three years) and "high-touch", labor-intensive processes involving frequent trainings and contact with field staff. As a result, they are resource and time intensive and have reached a relatively few people. A good example of this, and perhaps the biggest single NGO contributor to maize seed scaling, has been the Conservation Farming Union (CFU). CFU introduced a package of conservation farming components (e.g., minimum tilling and weeding/herbicides). However, the number of people reached by CFU has been relatively small compared with the total number of adopters of hybrid maize seed.

The most important driver of maize seed scaling since 2006 has been private seed companies. These have accelerated their marketing and outreach efforts, multiplied by the fact that the number of seed companies continued to grow steadily, which increased competition for market share.

[61] Julie Howard, (1996) op cit. pp.11-15.

The six seed companies interviewed all seem to have used the same variety of methods, and indicated that they are ubiquitous within the industry. The most important has been the use of demonstration plots with a lead farmer, in which companies provide all of the inputs, extension services, and technical support, while farmers provide the land and labor. These plots are usually combined with several field days to highlight the progression and the growth of the maize during the season to show farmers GAP at key moments in the season (e.g., weeding, top dressing application). Often, and especially when these plots are grown in partnership with the MAL, they contain the varieties of several companies so that farmers can compare the performance of different varieties. The majority of farmers participating in FGDs reported that demonstration plots/field days were most significant to them in terms of both gaining exposure to hybrid maize seed and for their decision-making as to which variety to buy. In respect to demonstration plots, farmers cited the experiences of neighbors and the recommendations of government extension officers for adopting hybrid seeds and the choice of variety.

While the demonstration plots and field days were the primary driver of adoption initially, according to both seed companies and agro-dealers interviewed, in recent years companies have increasingly emphasized branding and promotions. This is due to the fact that rather than trying to get farmers to adopt their hybrid maize seed, companies are more focused on the competition between varieties (i.e., late adopters and market share). The most common efforts include: various types of promotions (e.g., t-shirts, talk time, trial size bags of seeds); radio and poster advertising (often at agro-dealers); and the use of sales agents who go out to talk with farmers, especially those in more remote areas. The first two methods were reported by both several seed company field representatives and agro-dealers to be quite effective, and are usually done in conjunction with demonstration plots. Nonetheless, both agro-dealers interviewed and farmers participating in the FGDs shared anecdotes of farmers who would purchase seeds after hearing something on the radio, seeing a flashy full-color poster, or because of a free t-shirt. This suggests that while the business case may be essential for early adoption and initial scaling, once the efficacy of the innovation is established then traditional commercial advertising techniques may be important.

The sales agent method is more often used by smaller companies. These agents do not have the technical training or expertise of extension agents, and are not involved in providing technical support to demonstration plots – although they do coordinate their activities and events with those efforts. The two smaller companies interviewed reported that the use of these agents has been highly successful in increasing market share and establishing a niche, although they lose money on the effort up front. They often combine this with the willingness to deliver seed to a farmer's door, or by setting up a depot relatively close to their target geographic area, so farmers do not have to travel into town to purchase their seed. With increasing competition, the larger companies are beginning to use sales agents as well.

C. Adoption Rates, Variability, and Continuity

Adoption of commercial seed varieties was universal among farmers who participated in FGDs, but this may have been a biased sample as most of those farmers had participated in CFU projects National data from the GRZ CSO shows that hybrid seed use is at 58 percent nationally over the last few years. The figures in the Southern Province vary widely by district, depending on proximity to major towns, commercial orientation, resources, and agro-ecological zones. For example, in the strongly commercial Mazabuka district, adoption is nearly 90 percent, while the more remote areas of Itezhi-tezhi, Kazangula, and Gwembe Valley are around 40 percent. There is clear evidence of spatial gradient from those farmers close to input sources and output markets to those far away.

All of the 45 farmers who participated in the FGDs reported that they plant hybrid maize seed and have done so for several years. While the precision of their recollection may be in question, a crude average of their responses indicates that farmers have on average been using hybrid maize for nearly nine years (i.e., since 2006). Thus, about half of the farmers who participated in the FGDs had adopted hybrids before the introduction of DTMA varieties and the rapid expansion of maize cultivation, and half since that time. This confirms the study findings that the rapid growth in the size of both FISP and FRA programs since 2006 facilitated the adoption of hybrid maize seed.

Farmers participating in the FGDs were asked what types of maize seeds they planted. About two-thirds of the farmers who responded said that they planted only hybrid seeds, though many planted two or more varieties. The other third planted a mix of commercial seeds and recycled commercial seeds. Both are clearly a sign that famers have learned or choose to diversify their risk and return, as well as evidencing financial constraints. Those farmers who grow multiple commercial varieties often choose one high-yielding medium- or long-maturity variety, as well as a short-term variety, a DTM variety, or both. The high-yielding variety appears to be a gamble in that if there is good weather, farmers can make a lot of money. The second variety is a hedge against adverse weather; farmers will still be able to recover some of their costs and feed their family, even though without a large marketable surplus.

Those farmers who reported that they recycled their hybrid seed said they did so because they could not afford to buy all new seed in the year following a poor harvest year, e.g., following the 2015 harvest. They grow traditional maize either for the same reason (lack of resources), or for their own consumption because they like the taste, texture, and storage qualities better.

This study found that there is great potential in the future for scaling up of DTM varieties. Most maize farmers who participated in the FGDs indicated that they believe that climate change currently affects them and will continue to do so in the future, as rainfall patterns will only get worse. This was particularly the case in those areas that have historically been marginal for maize production due to uncertain rainfall. It is unclear whether a shift from long- and medium-term varieties to DTM will be a purely a 1:1 substitution within a fixed quantity of maize planted, or whether it will lead farmers to plant more or less maize. The review team suspect that which way they go will depend on how resilient DTM proves to be to the specific effects of climate change on rainfall patterns in Zambia, by each agro-ecological zone. It will also depend on the size of the FISP and FRA programs in the future.

D. Factors Driving Adoption

Farmers appeared to be attracted to hybrid maize seed initially by the potential for significantly higher yields and the possibility of moving from maize deficits to security and even cash surpluses. This was true even in the absence of access to fertilizer that would maximize yields. Both farmers and seed companies reported that demonstration plots are cultivated to generate maximum yields using input levels and investment well beyond the reach of most farmers, because that is what sells seed. This is true even when farmers know they will not be able to use those quantities of fertilizer and get these kinds of yields.

Smale and Mason have studied the role of FISP subsidies combined with other factors on commercial maize seed adoption. They found that the important factors are subsidies, farmers' assets, seed prices, participation in FISP, and especially local weather conditions (temperature and temperature range).[62] By contrast, literacy, household labor supply, membership in a farmer group, and distance to a seed source had no significant effect on adoption rates. For those farmers who are adopters, the most important factors affecting the choice of seed varieties were: germination, vigor, drought tolerance, pest, disease and striga resistance, and tip cover. With the probable exception of fertilizer, innovations that serve as

[62] See Smale and Mason, *op cit*. and Melinda Smale and Nicole Mason "Demand for Maize Hybrids, Seed Subsidies, and Seed Decisionmakers in Zambia" <u>HarvestPlus Working Paper</u>, No. 8, May 2012,

complements, substitutes, or prerequisites do not appear to have played a major role in adoption of hybrid maize.

TABLE 14: SIMPLE CORRELATIONS, ZAMBIAN MAIZE, KEY PRODUCTION VARIABLES – SOUTHERN PROVINCE

	Area Harvested (Ha)	Expected Production (MT)	Calculated Yield	Expected Sales (MT)	Ratio of Expected Sales to Expected Production
Area Harvested (Ha)	100%	97%	78%	97%	92%
Expected Production (MT)	--	100%	79%	99%	90%
Calculated Yield	--	--	100%	78%	74%
Expected Sales (MT)	--	--	--	100%	93%
Ratio of Expected Sales to Expected Production	--	--	--	--	100%

Source: Authors' calculations, based on GRZ CSO original maize production, sales and yield data

TABLE 15: SIMPLE CORRELATIONS, ZAMBIAN MAIZE, KEY PRODUCTION VARIABLES – NATIONAL

	Area Harvested (Ha)	Expected Production (MT)	Calculated Yield	Expected Sales (MT)	Ratio of Expected Sales to Expected Production
Area Harvested (Ha)	100%	98%	82%	97%	80%
Expected Production (MT)	--	100%	87%	99%	86%
Calculated Yield	--	--	100%	86%	76%
Expected Sales (MT)	--	--	--	100%	90%
Ratio of Expected Sales to Expected Production	--	--	--	--	100%

Source: Authors' calculations, based on GRZ CSO original maize production, sales and yield data

E. Constraints on Scaling and System Strengthening

As discussed in Section 6, the major constraints on adoption of hybrid maize seed have been access to labor, animal or mechanized traction services, credit or financial resources, and access/distance/cost to inputs and output markets. These four factors have less affected whether farmers adopted the innovation than the degree to which individual farmers adopt (i.e. how much of their maize crop they plant with hybrid seeds, the yields they get, and the amount of their land they cultivate and therefore indirectly plant with hybrid maize seed).

The GRZ did have a policy to promote national food security and self-sufficiency in maize, but apart from the important exceptions of FISP and FRA on inputs and market access, that strategy had little effective implementation into programming or the enabling environment. Most of the actual scaling activities, at least on the introduction, production, marketing, and distribution of improved hybrid maize seed, were done almost entirely by the commercial sector, without support from either the GRZ or donors. However, there was no organized strategy on the part of seed companies collectively to support the scaling up of hybrid maize seed adoption in general, or to address any constraints in the market system that limited scaling up and adoption.

That said, the uncoordinated activities of individual seed companies did result in the steady expansion of the number of agro-dealers in the last 10 years. Nonetheless, they remain geographically concentrated in the major towns long the major road and rail lines. There has been no effort to improve access to traction services or labor.

F. Organizational Capacity and Constraints

The organizations that play a role in the agricultural sector, and maize in particular, are the public extension service, farmers' cooperatives, the ZNFU and its district associations and information posts. As noted above, various NGOs such as the CFU, iDE, and World Vision are active in the sector but play a much smaller role by their own admission. The principal role of the extension system in scaling has been to advise farmers on which maize varieties are suitable for their agro-ecological zones and personal needs. As noted above, many farmers reported that such consultations played a significant role in their choice of which varieties to plant. However, there was a broad consensus among farmers participating in the FGDs that they received little actual technical support from the public sector, and this was confirmed by other market observers.[63] The lack of public extension capacity was either unimportant or partially offset by private services. The review team suspects that the simplicity of maize "technology," which involved simply upgrading an existing technology rather than any real departure from existing agricultural practices, made the weakness of extension services largely irrelevant.

Farmers' associations appear to have played no substantive role in the adoption of hybrid maize, or in the maize sector in general. The exception is the role that cooperatives played in FISP. As membership in a cooperative is required to submit an application to FISP, FGD respondents indicated that many if not most cooperatives exist solely for that purpose and lie dormant the rest of the year. None of the farmers participating in the FGDs reported any associations playing a significant role in adoption.

The ZNFU plays a very limited role in Zambian agriculture, as its membership is largely confined to large commercial and emerging farmers. Membership varies from around 200,000-600,000 depending on the relative prosperity of smaller farmers (i.e., when they have money they join). The ZNFU primarily works through its 75 district associations, which contain 150,000 members, and its 15 commodity-specific associations. In recent years, the ZNFU has enlarged its role beyond lobbying and advocacy for farmers' interests to provide some technical training and support, as well as the Lima program. The ZNFU is far and away the largest and most important farmers' organization; at 200,000 farmers, they represent just over 10 percent of the rural population and probably more than 50 percent of production. Nonetheless, given that there are a few million farmers in Zambia, 200,000 represents a small fraction of that and therefore the ZNFU their efforts have limited impact in terms of sheer proportion of farmers reached.

G. Market Access

According to the farmers participating in the FGDs, perhaps the most important constraint on adoption and scaling after resources has been access to markets. The FRA has had a huge impact on market access, especially for smaller farmers in remote areas, as its depots are deliberately set up to cover much of a district and meet the economic/political needs of those types of farmers. Agro-dealers played a much smaller role. With the growing number of agro-dealers, there has been increasing pressure on their profitability and margins. In interviews with the review team, a couple of agro-dealers said they have begun to act as two-way agents, both selling maize seed and buying maize, to remain profitable.

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[63] Like public extension systems in many developing countries, the Zambian system is highly constrained by too few staff, uneven quality and motivation of field staff, and limited resources in terms of transportation to work with farmers or to run demonstration plots. To the review team's knowledge, little has been done to address these constraints.

H. Handoff to Commercial Actors

As the post-2000 scaling up of hybrid maize seed was driven by private seed companies, there was no need for a transition from donor-supported programs. At the same time, the provision of inputs through FISP and particularly the purchase of maize output by FRA has been critical to successful scaling, particularly by small farmers in remote areas.

VIII. POTENTIAL SCALE OF ADOPTION

Quantification of the scaling process would allow for empirical data to be fitted to the Bass diffusion model. This model has been widely used to describe the adoption process and combines the effects of external and internal factors upon the process of diffusion according to the equation:

$$dA/dt = p.(N-At) + q.At.(n-At)$$

where the rate of change in number of adopters "A" at time "t" is a function of the external innovation coefficient "p," the internal imitation coefficient "q," and the maximum number of potential adopters "N."

Where empirical data can be fitted to the Bass model, it can provide an indication of the relative importance of the different processes of (1) innovation (i.e. adoption of a technology as a result of extension or other sources of information, without reference to the activities of friends and neighbors), and (2) imitation (i.e. the adoption of a technology as a result primarily of its successful use by friends and neighbors). It can also provide an estimate of the time required to the "takeoff" phase (i.e. the beginning of rapid adoption). All of these factors are relevant to any project that might seek to achieve the adoption of an innovation at scale.

Analysis of the adoption of certified maize seed suggests that the scale reached recently, once adjusted for population growth, is equivalent to levels reached in 1989. Zamseed sales that year were 13,343 mt, or the equivalent of 16.0 kg per rural household. Interviews with seed producers suggest that in 2015, the domestic market for maize seed is about 25,000 mt, or the equivalent of 15.27 kg per rural household.[64] The data for these two endpoints do not record the substantial drop in use that had occurred following market liberalization; by 1995, Zamseed sales had fallen to 4,500 mt, equivalent to usage of 4.45 kg per rural household. The 2015 estimated level reflects an increase of 240 percent over the last since 1995.

Quantification of the scaling process, either by estimating an S-curve or of a Bass model, for the second period of scaling up is hindered by the lack of detailed seed usage data. Some data are available from earlier research (see Figure 10).[65] The subjective curve fittings shown in Figure 11 were obtained by trial and error,[66] using a graphic model to vary both "p" and "q," with the constraint that, as inherent characteristics of the innovation and adoption environment, they should be the same for adoption in both Region II and throughout the country. Reasonable fits to both curves can be achieved by setting the

[64] Based on GRZ CSO data (for populations of 7.40 million and 15.47 million), urbanization percentages of 38 percent in 1989 and 2015, respectively, and a rural household size of 5.5 in both years.
[65] The work of Howard and Mungomba in 1996 provides national and regional level data that indicate the rate of adoption of improved seed from its initial introduction in 1983/84 to 1991/92. By manipulating "p", "q" and "N" it is possible to fit Bass diffusion curves (S-curves) to this data.
[66] NB: this process cannot be subject to statistical analysis to determine significance.

maximum levels of adoption at the asymptotes of each empirical curve (74 and 62 percent for Region II and national adoption, respectively), with values for "p" and "q" of 0.045 and 0.01.

FIGURE 10: ADOPTION OF IMPROVED MAIZE VARIETIES AND HYBRIDS

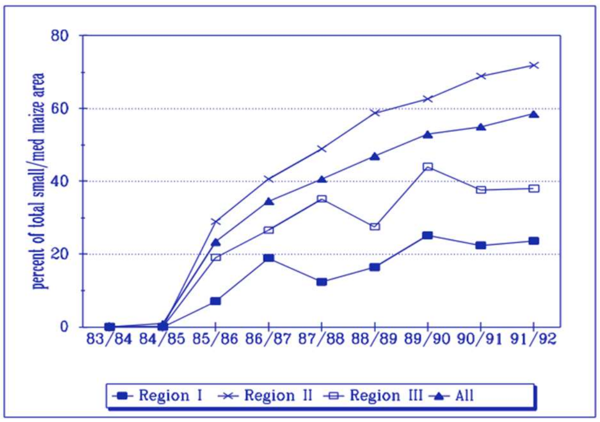
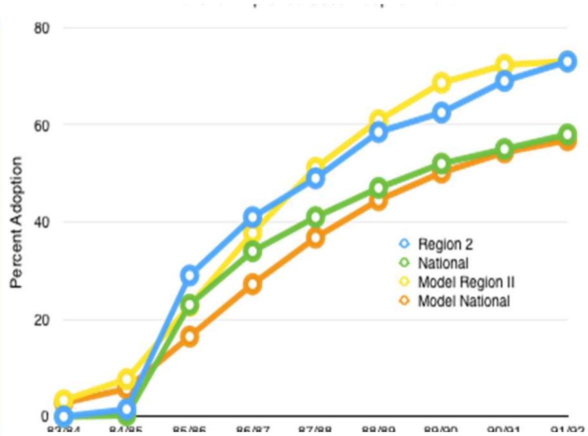


FIGURE 11: ACTUAL AND BASS MODEL FITTED CURVES OF HYBRID MAIZE ADOPTION, REGION II AND NATIONAL



Empirical and Modelled S-Curve fro region II and National Improved Seed Adoption data. Source: Howard and Mungomba 1996

These results show an unusual dominance of the innovation coefficient "p," which is 4.5 times greater than the imitation coefficient "q," suggesting that the impact of external agencies in the 1980s was much greater than that of interactions between smallholders. These S coefficients suggest that the uptake of improved maize seeds was driven primarily by the government-led extension process, combined with government subsidy programs for the use of improved seeds. The results do not suggest that the imitation of farmers by their neighbors contributed as much to the adoption process. This was confirmed by testing increased values of "q" in the model.

In 2000-2015, a somewhat different process was at work. The qualitative data suggest that adoption had already probably recovered significantly by 2002/03, and this is somewhat confirmed by quantitate figures from the CSO and SCCI. In 2002/03, smallholders in Southern Province planted 131,000 ha of maize, of which 73 percent was sown to certified seed, 9.8 percent to traditional varieties and 17.1 percent to recycled seed. This level of usage is equivalent to 10.6kg of certified seed per rural household. This occurred without active GRZ promotion or a significant role of FISP or FRA, and with relatively few active private seed companies. Thus, at least half of the scaling was a rebound effect.

After 2003, a combination of external and internal factors appear to be driving adoption. The proportion of the maize crop sown to certified seed in Southern Province has tended to increase, although the trend was not consistent. Such fluctuating trends over the last 10 years can be most readily reconciled with variations in the maximum potential number of adopters, which are not usually allowed for in a Bass model. On the external side, FISP and private sector marketing clearly had a major influence, probably accounting for the majority of adoption. On the other hand, smallholder farmers participating in FGDs consistently cited the experiences of neighbors as important in their own adoption. Moreover, it may be difficult to untangle these two tendencies, as farmers' participation in FISP may have been driven by neighbors' experiences.

IX. CONCLUSIONS

A. The Innovation

1. **Innovations that are singular, technologically simple, and require little or no additional knowledge for adopters are easier to scale.** The innovation in this case study was hybrid maize seed only and was not accompanied by any new good agricultural practices. It did not require farmers to change their behavior and there was no need for it to be accompanied by extension services or other forms of technical assistance. It also facilitated spontaneous farmer-to-farmer diffusion.

2. **When innovations are not accompanied by complementary components, there is a bias towards extensive (as opposed to intensive) scaling.** While both occurred in Zambia, extensive scaling was more dominant, especially given a lack of constraints on additional land.

3. **Innovations with more easily visible results are more scalable and require less communication and marketing.** The difference in productivity of this innovation is easily visible to even the casual observer on demonstration plots (i.e., it is characterized by seeing is believing). This allowed for relatively inexpensive marketing techniques such as demonstration plots and field days to be effective and facilitated spontaneous diffusion.

4. **Innovations that can be tried with minimal initial effort or investment are easier to scale, as they imply lower risk for the adopter.** Maize seed was nearly infinitely divisible, meaning that farmers could try it in very small quantities, lowering their initial investment or risk. Seed companies have taken advantage of this by offering starter packs of new varieties, either for free or bundled with purchases of better-known varieties.

5. **Innovations that are easily customizable or adaptable to diverse circumstance are easier to scale up.** Hybrid maize seed was available in a large number of varieties, suitable to individual farmers' risk preferences, agro-ecological zone, and weather expectations.

6. **Innovations that permit for risk diversification or mitigation are easier to scale.** The great variety of seeds available allowed farmers to adopt a portfolio approach to benefit from good weather and self-insure against bad weather.

7. **Low costs of initial adoption relative to existing financial resources facilitate adoption, even without access to credit.** Hybrid maize was relatively inexpensive compared to the resources of many Zambian farmers, even without subsidies, so access to credit or financial resources was not a significant constraining factor in scaling.

B. The Existing Context

8. **Very high demand can support scaling because of economies of scale and the likelihood of political support, if needed (assuming that extensive technical assistance or complementary investments are not required).** Maize was the staple cereal in Zambia and grown by almost all small farmers. Improved productivity was of great interest to large numbers of the farmers and the GRZ for food security reasons.

9. **It is easier to scale innovations that are an upgrade of a previous technology, as long as they do not require changes in behavior.** Hybrid maize seed had been scaled before in Zambia,

within the living memory of many farmers, so this was nothing new or radically different from existing practice.

10. **Subsidized input programs can be important during initial adoption and introduction by lowering costs and mitigating risk.** This was the case of FISP in Zambia.

11. **Ensuring a buyer (market) at a profitable price is essential for scaling up**. In this case, FRA lowered the risks for even the smallest farmers in the most remote locations.

12. **Scaling up by building off existing institutions and programs makes it easier to expand these programs as needed.** In the case of hybrid maize, the fact that these programs pre-dated the scaling period meant that they could easily be scaled with additional funding in parallel with the scaling up of the innovation, without requiring new programs to be created or the building of institutional capacity.

13. **Once subsidized, established, and scaled, input and output schemes can take on a life of their own and encourage scaling beyond public policy objectives.** In good years, Zambia has become a net maize exporter, although at a loss to the public sector. Subsidy programs can become quite expensive and politically difficult to limit – let alone phase out.

14. **Scaling up is facilitated when a distribution network already exists and sales of the innovation are profitable for retail distributors.** Zambia already had a reasonably dense agro-dealer network in major towns and along major transportation routes. This facilitated access to inputs for the majority of farmers who live nearby, although access for farmers in more remote areas was a problem and a constraint on scaling up. The network of agro-dealers was able to grow in parallel to the scaling up effort.

15. **Climate change can support scaling up, especially in the initial years, and can facilitate adaptation.** Good weather in the early years gave farmers positive experiences, and subsequent adverse weather increased demand for DTM and for planting a portfolio of varieties.

16. **Lack of access to credit, additional labor, and non-human traction can limit the number of farmers who adopt and the degree of adoption**. In the case of Zambia, around 40 percent of adopters nationwide did not adopt at all, and many adopted less.

C. Adoption Drivers

17. **Adoption is facilitated by competition among producers and/or suppliers.** In Zambia, over a dozen seed companies are competing on price, quality, characteristics, and offering a wide range of differentiated varieties. Near major transport hubs, there are a number of agro-dealers supplying the same or similar varieties. While studying price competition was beyond the scope of this study, it does appear that farmers benefit from this competition, whether in the form of lower prices, greater variety, or special offers and promotions. Under these circumstances, adoption is easier. When distance from road or rail centers increases, competition decreases, creating conditions that are less favorable to smallholder adoption.

18. **Adoption is facilitated when the innovation is highly profitable for farmers under good conditions and allows farmers to break even under poor conditions.** Hybrid maize was highly profitable when world and Zambian maize prices were high, or when yields were high because of good weather. In the early years, both were the case. Hybrid maize is marginally profitable at low (current) prices or with lower yields caused by adverse weather. It is not profitable at low prices and low yields, which was only the case in the 2014/15 season.

19. **Farmers partially adopt innovations when resources are constrained, which can affect the mix between improvements in yield (intensive scaling) and extensive scaling**. In the case of Zambia, extensive scaling was more important as land was easily accessible whereas financial resources were not, and FISP allocations were limited. This suggests that a more nuanced understanding of adoption is required: not just whether farmers adopt, but to what extent, and to what extent they can afford complementary inputs (e.g. fertilizer).

20. **The innovation has to be profitable for producers and distributors.** Hybrid maize was profitable for agro-dealers because of guaranteed margins from seed companies, provision of seed on credit, and a legal requirement that all unsold seed had to be returned to seed companies and recertified. For seed companies, the marginal costs of additional production and marketing to the domestic market of what was historically an export product were quite low. Domestic sales of hybrid maize were highly profitable for seed companies.

21. **The private sector can drive the scaling up of simple innovations as long as they require minimal costs of initial introduction, marketing, and extension support.** Seed companies were already producing for export, and were more than willing initially to meet domestic demand. Once a critical mass was reached, seed companies became more proactive in marketing and stimulating demand.

22. **Private sector-led scaling requires a well-resourced, well-managed, profit-maximizing, and competitive private sector.** Creation of a dynamic private (seed) sector in Zambia was attributable to: a pro-market environment following structural adjustment; the lack of market distortions from a subsidized public sector or parastatal; favorable rules for foreign direct investment and profit remittances; and adequate regulations and provision of key public goods like seed certification.

23. **A positive initial experience can be important for initiating a virtuous circle or spiral of adoption**. For hybrid maize this was instigated by the GRZ in 2005/06 with the expansion and strengthening of input supply and output purchasing programs. Lower costs allowed farmers to try new hybrids cheaply and at small scale, with little risk, capital requirement, or cash flow. Farmers' initial experiences were quite positive because of high international prices and good weather.

D. Strengthening the Context

24. **Scaling up is much easier when value chain institutions are already strong or requirements are low.** For a simple innovation like hybrid maize seed, the existing agro-dealer network was sufficient. The market was not sufficient to guarantee market access at a remunerative price and these conditions were met by FRA.

25. **Ensuring affordable access to inputs and markets, especially for small remote farmers, appears to require either public sector or donor intervention**. In Zambia, FRA and FISP were supported mostly by the public sector, although at a substantial cost to the GRZ. Despite the fiscal impact, the GRZ was willing to scale up FISP and FRA as demand grew, although this may prove politically difficult to unwind or phase out in the future.

26. **Public sector support for scaling, or for supporting institutions and programs, must have political benefits**. Improving maize production and food security was politically important to the GRZ because it benefitted two key constituencies: rural maize producers and urban maize consumers.

27. **Failure to strengthen access to markets, credit, and other inputs can limit scaling.** In Zambia, the lack of credit and financial resources, market access, and labor/mechanization did not inhibit scaling, which probably explains why this ceiling is not closer to 100 percent.

E. General Lessons

28. **Scaling up through commercial pathways can expand production and food security, but it does not necessarily lead to reductions in poverty or malnutrition**. This is especially the case if there are no donor or public sector projects to address issues such as credit, resources, and access. In Zambia, the shift to hybrid seeds and production for commercial surpluses mostly affected farmers with more than two hectares, and therefore had little impact on the poorest of the poor – a plurality of maize farmers. To some extent this was a function of the fact that the GRZ programs targeted those farmers with potential to be emerging farmers.

29. In cases where there is a simple intervention and a strong private sector that can drive the scaling up process, donors can play a role in the following areas:

    a) **Provide new innovations to the private sector and let them take care of marketing and distribution when these costs are not excessive and unprofitable.** In Zambia, investments (through CIMMYT) in developing new varieties and providing germplasm to the private sector contributed to the profitability of that sector and the ability of the sector to innovate, and permitted smaller companies to compete effectively with multinational corporations in the market. One caveat is that with some seeds, marketing and distribution costs can be excessive and unprofitable. This is true of many pulses (e.g. cowpeas, pigeon peas, groundnuts) or very small seeds like millet or sorghum.
    b) **Focus on innovations with broad appeal and demand first** (e.g. hybrid seeds and then target specific niches such as DTM).
    c) **Help offset the initial costs of risk mitigation and adoption** (e.g. subsidized inputs and guaranteed market access). This can have advantages over public sector support for these efforts, as the latter may be more difficult to phase out. The key is to ensure that all actors know ahead of time that these are temporary and to encourage initial adoption only.
    d) **Extend the benefits of scaling up to the bottom of the pyramid and those in more remote areas where lack of resources and transactions costs make private solutions difficult**. In Zambia, support for animal traction or machinery services would have been helpful, as well as building road infrastructure to make remote communities more accessible.
    e) **Strengthen value chain institutions as needed**. In the case of Zambia, SIDA and others invested in building the capacity in key institutions in seed certification.
    f) **Help ensure sufficient market demand to avoid adverse effects on prices.** In Zambia, support for the poultry industry and poultry feed would help support prices and pull supply.

ANNEX A: STAKEHOLDERS TARGETED FOR INTERVIEWS/FOCUS GROUPS

Stakeholder	Innovation Characteristics	Market System and Enabling Environment	Scaling Up and Market System Strengthening-Strategies	Drivers and Pathways of Diffusion
Farmers: broad demographic representation	3	3	2	3
Local Farmer Associations	2	2	2	2
Other Grassroots Organizations (Coops)	2	2	2	2
Retail Distributors	1	2	2	2
Wholesale Distributors	2	2	2	2
Field Sales Agents	2	0	2	3
Government Extension Agents	2	0	1	2
Local Level Agricultural Research Stations	2	0	0	0
Donor Project Field Staff	2	2	2	2
Donor Project Field Managers	2	2	2	1
Rural Development relevant local NGOs	2	0	2	2
Local VIPs	0	0	0	0
Local Government Officials	0	0	1	0
Local Ministry of Agriculture Officials	2	0	1	0
Local Media	0	0	0	0
Producing Company Local Agents	2	1	3	2
Downstream Buyers and Processors	1	2	2	1
Local Agricultural Financial institutions	0	1	1	0
National or Regional Farmer Associations	0	2	2	1
National Level Producing Co. Management and Sales Staff	3	2	3	2
National Ministry of Agriculture Officials	1	2	2	1
*Other relevant National Ministry officials	0	0	0	0
National or Regional Agricultural research stations	3	0	1	0
National or Regional Media	0	0	1	1
National level Donor project management	1	1	1	2
Other Donors working in Agri/Relevant projects	0	1	0	0
National Distributors Associations	0	1	1	2
National Agriculture relevant NGOs	0	1	0	1
National Agricultural Financial institution management	0	1	0	0

ANNEX B: ADDITIONAL TABLES USED IN PREPARATION OF THIS REPORT

TABLE 16: DTM VARIETIES RELEASED IN ZAMBIA FROM 2007-2014

Release	Year of Release	Hybrid/OPV	Maturity Range[67]	Suitable Agroecologies	On-Farm Yield Range	Resistance
PGS53	2007	Hybrid	Intermediate	Drier mid-altitudes	3.0-6.0	MSV resistant
PGS71*	2007	Hybrid	Intermediate	Drier mid-altitudes	3.0-6.0	MSV resistant
KAM601*	2008	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	GLS & MSV resistant
KAM602*	2008	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	GLS & MSV resistant
SC721	2008	Hybrid	Very late	Drier mid-altitudes	6.0-8.0	GLS & MSV resistant
CAP9001	2010	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	GLS & MSV resistant
SC727	2010	Hybrid	Late	Drier mid-altitudes	4.0-6.0	GLS & MSV resistant
ZMS606	2010	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	GLS & MSV resistant
ZMS623	2012	Hybrid	Intermediate	Drier mid-altitudes	3.0-5.0	GLS & MSV resistant
GV 635*	2013	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
GV 638*	2013	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
GV 628*	2013	Hybrid	Early	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
GV613*	2014	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
GV637*	2014	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
GV655*	2014	Hybrid	Intermediate	Drier mid-altitudes	4.0-6.0	Semi-flint, MSV & GLS resistant
ZM423	2007	OPV	Early	Drier mid-altitudes	3.0-4.0	MSV resistant
ZM523	2008	OPV	Early	Drier mid-altitudes	3.0-4.0	MSV resistant
ZM625	2008	OPV	Intermediate	Drier mid-altitudes	3.0-5.0	MSV resistant
ZM721	2008	OPV	Late	Drier mid-altitudes	3.0-5.0	Flint, MSV & GLS resistant
Nelson's	2010	OPV	Intermediate	Drier mid-altitudes	3.0-4.0	GLS, MSV & rust resistant
MMV409	2011	OPV	Very early	Drier mid-altitudes	2.0-3.0	Flint, MSV resistant

Release	Year of Release	Hybrid/OPV	Maturity Range[67]	Suitable Agroecologies	On-Farm Yield Range	Resistance
MMV607	2014	OPV	Intermediate	Transition & drier mid-altitudes	3.0-4.0	Semi-flint, MSV & GLS resistant

Source: IITA. 2015. DT Maize Quarterly Bulletin, Volume 4, No. 2 June 2015

TABLE 17: PRODUCTION VS. DOMESTIC CONSUMPTION, TOTAL AND RURAL POPULATION

	Population	Rural Population	Expected Production (MT)	Implied food Security Needs (MT)	Total Pop Production Less Food security needs (MT)	Implied food Security Needs Rural (MT)	Rural Production Less Food security needs (MT)
2000	1,212,124	968,709	251,946	192,728	59,218	155,962	95,984
2001	1,246,063	989,489	117,379	198,124	-80,746	159,308	-41,929
2002	1,280,953	1,010,714	--	203,672	--	162,725	--
2003	1,316,820	1,032,394	127,277	209,374	-82,097	166,215	-38,938
2004	1,353,691	1,054,539	211,976	215,237	-3,261	169,781	42,195
2005	1,391,594	1,077,159	120,518	221,263	-100,745	173,423	-52,905
2006	1,430,559	1,100,265	230,105	227,459	2,646	177,143	52,962
2007	1,470,615	1,123,866	238,570	233,828	4,742	180,942	57,627
2008	1,511,792	1,147,974	115,421	240,375	-124,954	184,824	-69,403
2009	1,554,122	1,172,598	365,226	247,105	118,121	188,788	176,438
2010	1,606,793	1,197,751	582,984	255,480	327,504	192,838	390,146
2011	1,642,757	1,235,270	639,541	261,198	378,343	198,878	440,662
2012	1,694,370	1,269,472	573,176	269,405	303,771	204,385	368,791
2013	1,746,791	1,304,043	453,532	277,740	175,792	209,951	243,581
2014	1,799,885	1,338,977	597,999	286,182	311,818	215,575	382,424
2015	1,853,464	1,374,255	372,450	294,701	77,749	221,255	151,195
Average 2000-06	--	--	185,396	212,711	-28,606	168,187	16.428
Average 2007-2015		--	462,541	266,523	196,018	202,062	260,479

Source: GRZ CSO and authors' calculations

TABLE 18: PRODUCTION VS. DOMESTIC CONSUMPTION, NATIONAL

	Population	Rural Population	Implied food Security Needs National (MT)	Implied food Security Needs Rural (MT)	Expected Production (MT)	National Production Less Food security needs (MT)	National Production Less Rural Food Security needs (MT)
2000	9,885,591	6,458,729	1,314,784	800,882	850,465	-464,319	49,583
2001	10,162,388	6,594,362	1,351,598	817,701	445,487	-906,110	-372,214
2002	10,446,934	6,732,844	1,389,442	834,873	--	--	--
2003	10,739,449	6,874,234	1,428,347	852,405	1,157,861	-270,486	305,456
2004	11,040,153	7,018,593	1,468,340	870,305	1,213,601	-254,740	343,295
2005	11,349,277	7,165,983	1,509,454	888,582	866,187	-643,267	-22,395
2006	11,667,057	7,316,469	1,551,719	907,242	1,424,439	-127,280	517,197
2007	11,993,735	7,470,114	1,595,167	926,294	1,366,158	-229,009	439,863
2008	12,329,559	7,626,987	1,639,831	945,746	1,211,566	-428,265	265,820
2009	12,674,787	7,787,154	1,685,747	965,607	1,887,010	201,263	921,403
2010	13,092,666	7,919,216	1,741,325	981,983	2,795,483	1,054,158	1,813,500
2011	13,459,261	8,155,510	1,790,082	1,011,283	3,020,380	1,230,298	2,009,097
2012	13,836,120	8,364,391	1,840,204	1,037,184	2,852,687	1,012,483	1,815,503
2013	14,223,531	8,575,072	1,891,730	1,063,309	2,532,800	641,070	1,469,491
2014	14,621,790	8,787,529	1,944,698	1,089,654	3,350,671	1,405,973	2,261,017
2015	15,031,200	9,001,647	1,999,150	1,116,204	2,618,221	619,071	1,502,017
Average 2000-06	--	--	1,451,106	862,286	1,046,314	-413,601	180,112
Average 2007-2015	--	--	1,816,596	1,026,371	2,533,602	717,007	1,507,231

Source: GRZ CSO and author's calculations