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SCALING UP OF HERMETIC BAG TECHNOLOGY (PICS) IN KENYA

REVIEW OF SUCCESSFUL SCALING OF AGRICULTURAL TECHNOLOGIES

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E3 Analytics and Evaluation Project

CONTENTS

ACRONYMS

ACDI-VOCA	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance (original name no longer in use)
ADPP	Animal Draft Power Program
ADS	Anglican Development Service
AGRA	Alliance for a Green Revolution in Africa
ASI	Agribusiness Systems International
BFS	Bureau for Food Security (USAID)
CARD	Community Action for Rural Development
CBO	Community-Based Organization
CDA	County Director of Agriculture
CRS	Catholic Relief Services
CSO	Civil Society Organization
DR	Document Review
E3	Bureau for Economic Growth, Education, and Environment (USAID)
EU	European Union
FGD	Focus Group Discussions
FTF	Feed the Future
GDP	Gross Domestic Product
Ha	Hectare
ICIPE	International Centre of Insect Physiology and Ecology
IFAD	International Fund for Agricultural Development (EU)
IPA	Innovations for Poverty Action
KALRO	Kenya Agricultural and Livestock Research Organization
KAVES	Kenya Agricultural Value Chains Enterprises Project
KCEP	Kenya Cereals Enhancement Project
KES	Kenyan Shilling
KII	Key Informant Interviews
LGB	Larger Grain Borer
lGB	Lesser Grain Borer
MDG	Millennium Development Goals
MoA	Ministry of Agriculture
MSI	Management Systems International
MT	Metric Ton

NCPB	National Cereals and Produce Board
NGO	Non-Governmental Organization
OAF	One Acre Fund
PfI	Partnering for Innovation
PHL	Post-Harvest Loss
PICS	Purdue Improved Crop Storage
PPTL	Pee Pee Tanzania Ltd.
QDSS	Quantitative Data from Secondary Sources
ROPA	Rural Outreach Program Africa
USAID	United States Agency for International Development
USD	United States Dollar
VAT	Value-Added Tax

EXECUTIVE SUMMARY

This report is a case study examining the scaling up of Purdue Improved Crop Storage (PICS) bags through commercial pathways in Kenya from 2013 to early 2016. It is one in a series of studies looking at successful scaling up of agricultural innovations in developing countries. The United States Agency for International Development's (USAID) Bureau for Food Security (BFS) commissioned the E3 Analytics and Evaluation Project to conduct these studies as part of its efforts to scale up the impact of the Feed the Future food security initiative. 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 activities, strategies, and support are necessary to facilitate that successfully.

The purpose of this study is to document the scaling up of PICS bags, identify the current level of penetration, and seek applicable lessons for achieving scale in agricultural innovations through commercial pathways in this and other contexts. It identifies the factors affecting scaling up, as well as the drivers, spaces, and strategies that led to success. It lists the characteristics of the innovation, characteristics of the context and enabling environment, and specific activities to encourage adoption and strengthen the value chain and market system as needed.

Background

Maize is the most important smallholder food crop in Kenya. Yields vary widely across the country, but on average amount to some six 90kg bags of maize per acre (or roughly 540 kg). However, post-harvest losses (PHLs) due to insect infestation can be high, from as low as 5 percent to over 40 percent. Such losses could be costing Kenya as much as USD 45 million per annum in imports, while individual farmers who cannot produce extra bags to compensate for PHLs may have to pay as much as KES 3,000 per bag in high season on the open market. Hermetically sealed post-harvest storage systems, such as the PICS bags developed by Purdue University initially for the storage of cowpeas in West Africa, can contribute dramatically to reducing such losses. In recognition of this, USAID's Kenya Agricultural Value Chains Enterprises (KAVES) project has been a driving force behind the introduction and promotion of PICS bags in Kenya.

Case Study Findings and Conclusions

This study assesses the respective roles played by the public and private sectors, with a special emphasis on the role of the latter (i.e., the commercial pathway) as that is the primary focus of this research.

The review team found that hermetic bag technology is attractive to farmers because of:

- Reduced post-harvest losses;
- The potential to sell stored grain at a higher price later in the year because quality and quantity are preserved;
- The simplicity of transport and utilization of the bags;
- The ease of proper use after basic training;
- The elimination of the need to use post-harvest pesticides that many believe to be dangerous;
- Almost no change to established practices: farmers have been using 90 kg storage bags of porous material, and the only change is the need to tie the bags securely and eliminate air;
- Their adaptability to other uses and for storing other crops, e.g., sorghum; and
- Price, which is within the reach of most farmers relative to their income and cash flow.

Successful scaling of PICS bags has been facilitated by the support of various actors in the agricultural input supply chain. The financial support provided by USAID, including a revolving fund of USD 120,000, is around USD 150,000. The national wholesaler of the bags, its large-scale retailers in the towns, retailers, and individual traders are active in the promotion of the technology and contribute to its popularity through exhibits at county fairs and other community events, as well as through farmer agents who are using the bags already. While individual, farmer-to-farmer contacts are important in popularizing the bags, joint demonstrations at county fairs and community events by local officials, non-governmental organizations (NGOs), and civil society organizations (CSOs), often coordinated by USAID-KAVES, are most effective in reaching large numbers and are especially well received since they imply "non-partisan" support for the technology among farmers who are traditionally suspicious of promoters of "miracle" products. These are also venues where large numbers of smallholders are able to witness the opening of the bags after a period of storage and see for themselves that the technology works.

The popularity of PICS bags among actors along the distribution network can be explained by their being:

- Easily introduced to existing distribution systems; the agro-retail (*agrovets*) supply chain is already adapted to carry such items, and the national producer already has agency relationships with *agrovets*;
- Practical to store pending sale; and
- Able to provide a reasonable profit margin.

The Kenyan national wholesale distributor at the summit of the value chain, Bell Industries in Nairobi, has found PICS bags to be profitable, and demand is continually rising. The company is expanding production of PICS bags because:

- Production can be outsourced, while the option of in-house production is being explored;
- Existing distribution chains can be used;
- Profit margins for the company are high in a context of high and rising volumes;
- Demand is increasing rapidly in response to promotional activities;
- The three-year life of the PICS bags offers potential for sales of 4 million units per annum through repurchases; and
- PICS bags do not conflict with the company's existing product lines, which are in the domain of pre-harvest crop protection.

However, PICS bags are no longer the only hermetic storage product on the Kenyan market. Competitors, such as the U.S.-based multinational GrainPro, have entered the market with similar products, and metal silos are also available. Hence, the success of PICS bags in demonstrating the effectiveness of hermetic storage has resulted in competition that should produce benefits for end-user farmers. From this point of view, PICS bags have made a substantial contribution to the scaling up of hermetic technology as a whole.

The scaling up of PICS bags in Kenya has been the result of concerted action initiated by Purdue University and carried forward by USAID-KAVES, which supported the Kenyan producer with advice and some modest funding. USAID-KAVES undertook its own promotional and distributional activities for PICS bags and coordinated those of local and international NGOs, local community-based organizations (CBOs), farmers' groups, and local officials in the 16 major maize-producing counties of the country. These activities were designed to explain the advantages the bags presented and the training necessary to their successful implementation. These promotional campaigns led to early

adoption by farmers who then not only increased their own orders but also spread the information to their communities, which led to more interest and higher demand. Hence:

- PICS bags are widely known throughout the maize-growing areas of Kenya;
- Farmers are eager to obtain them;
- The distribution system is well adapted to meet demand;
- Scale is currently supply constrained, as there is excess demand – supply is expected to reach 1 million units in 2016, from under 52,000 in 2014 – and
- Copycat versions, of both comparable and low quality, have entered the market.

Several contextual factors supported scaling up. These factors included solid transportation and manufacturing capacity, widespread awareness and use of modern agricultural inputs, a dense presence of competent civil society actors in the agricultural space, and especially having an established, well-functioning agricultural distribution system. The country's infrastructure could be improved, but is basically sound and lends itself to the efficient transport of a compact product, such as PICS bags.

There were multiple drivers of scaling up of PICS bags in Kenya. Purdue University was the driver for the initial introduction and establishing a foundation for scaling, identifying a manufacturer/wholesale distributor, and supporting initial awareness building. Perhaps the key driver for scaling was the USAID-KAVES project, whose leadership decided to help promote the technology as part of its overall efforts to increase productivity and incomes of small maize farmers. Local and international NGOs played a vital role in supporting the innovation by supplying the bags at preferential rates and providing training; without this support, awareness would likely have been lower and access much reduced.

Outstanding challenges to scaling of PICS bags include:

- The need to increase the production and distribution capacity of the current supplier;
- Competition from other manufacturers/distributors that may draw market away from PICS;
- High value-added taxes that limit the potential for price reductions for end users;
- Lack of sufficient active engagement from some local public authorities that could hasten moving to scale;
- Possible emergence of lower-quality copycat/counterfeit products that could damage the reputation of hermetic storage solutions;
- Dependence on imported raw materials and currency fluctuations that could affect prices;
- Possible future environmental concerns from the need to dispose of millions of used bags at the end of their three-year life cycle; and
- The absence of tax incentives to the supplier and end-user farmers to recycle the bags.

Lessons Learned

There are a number of lessons for donors from the scaling up of PICS bags in Kenya. First, the technology has a greater potential for success if it addresses a felt need of agricultural producers and does so in a way that is easily understood by them. Second, working with a research and innovation partner that is prepared to carry an innovation out of the laboratory and into the field produces a better marketing strategy. Third, the innovation needs to be affordable and low-risk, and should not require a significant financial commitment leading to borrowing. Fourth, if donors can partner with a private sector actor directly and establish a business case, the use of a commercial pathway becomes viable, and the long-term success of implementation more likely. Fifth, the experience with PICS bags—very rapid enthusiasm and take-up of the product, accompanied by the early entry into the market of competitors—demonstrated the need for donors to prepare for the unexpected, which may imply

additional costs and adaptive program management. Finally, when donors can coordinate and leverage a combination of government actors, CSOs, NGOs, the private sector, and farmers' groups to support the introduction of an innovation, scaling up is more likely.

I. INTRODUCTION

Background and Context of This Report

The United States Agency for International Development's (USAID) Bureau for Food Security (BFS) and the Agency's country Missions have been implementing the Feed the Future (FTF) food security initiative since 2010. In many cases, innovations developed and introduced at small scale have since gone to scale, or are in the process of scaling. At the same time, some innovations that potentially could scale have not done so, have not reached their full scale potential, or are not fully sustainable at scale.

There are many challenges to scaling, such as a common focus on achieving the immediate outcomes and objectives defined in an activity award or agreement. In addition, there is substantial anecdotal evidence that the use of commercial pathways for scaling is often not well understood or is not integrated into activity designs, procurements, and implementation plans. In other words, there is a great deal to learn about both scaling and sustainability when using commercial pathways.

In this context, USAID/BFS has commissioned the E3 Analytics and Evaluation Project[1] to conduct and synthesize five case studies to understand better 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 a scaling up approach into activity designs, procurements, and implementation. Another important goal is to help develop a methodology that will allow USAID and its implementing partners: (a) to estimate the speed and level of adoption by farmers; (b) to 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) to identify critical levels of initial adoption that would allow for such a transition; and (d) to 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?

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

Purpose of This Report

This report examines the successful scaling up through commercial pathways of Purdue Improved Crop Storage (PICS) bags in Kenya since their introduction in the last quarter of 2013. PICS bags were chosen because their distribution has been largely through the commercial sector, and significant scale has been reached throughout the national territory. Demand for PICS bags (or close substitutes with similar technology) is high, and the commercial market is sustainable. Large-scale sales and utilization can be expected to continue for the foreseeable future, based on the efficiency of the product and the need to repurchase the bags every three years or so.

During the course of field work, the review team observed that the potential adopters' knowledge and awareness of PICS bags and their utility far preceded the availability of the bags themselves. This led to an examination of the reasons behind the popularity of the bags, the actors involved in promoting the bags, the production and distribution capacity, and the efficiency of the value chain. The team carried out field work in the major maize-growing (and maize-dependent) regions of the country, including Western, Eastern, and part of North Rift. However, since maize is grown as a staple throughout the national territory, and there appear to be no important differences affecting either the supply or demand for bags in other locations, the conclusions here can also be applied to the rest of Kenya.

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 adoption through spontaneous diffusion. Unfortunately, this case study was not able to collect enough complete data for the period in question to complete a full S-curve figure, since adoption is still underway and the construction of a significantly long time series was not possible. However, a sense of the probable shape of the S-curve can be seen in Figure 1.

Methodology Used

The approach developed by the review team (see the Team Composition section below) for conducting these case studies is grounded in the spaces, drivers, and pathways analytical framework developed by Hartmann and Linn[2] and the scaling up framework authored by Cooley and Kohl of Management Systems International (MSI).[3] The term "space" is multidimensional and encompasses the fiscal/financial, political, policy (legal and regulatory), organizational, socio-cultural, agro-ecological, partnership,[4] 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.

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[2] "Scaling up: A framework and lessons for development effectiveness from literature and practice," Arntraud Hartmann and Johannes Linn. 2008. See Scaling up: A framework and lessons for development effectiveness from literature and practice (https://www.brookings.edu/wp-content/uploads/2016/06/10_scaling_up_aid_linn.pdf).

[3] "Scaling Up – from vision to large scale change," Larry Cooley and Ricard Kohl, MSI. 2006. More information can be found at the following link to the report: See Scaling Up – from vision to large scale change (Scaling Up – from vision to large scale change).

[4] 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.

The review team developed key components based on the analytical framework used to examine the scaling up of the innovation. The components were:

- **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.
- **Business case for the innovation:** the costs, risks, and returns of 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.
- **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.
- **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 external context or spaces:** In the case of PICS bags in Kenya, a review of the 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 were at best marginally relevant to scaling up in this case, and therefore this case study does not discuss these issues.[5]
- **Scaling up strategy, activities, and drivers:** PICS bags were introduced to Kenya by Purdue University supported by Partnering for Innovation (PfI).[6] The overall strategy for scaling up was led and managed by a USAID program—the Kenya Agricultural Value Chains Enterprises project (KAVES)—in partnership with the local producer, Bell Industries Ltd. Scaling was also supported by community-based organizations (CBOs), international non-governmental organizations (NGOs), farmers' groups, religious-based organizations, and, to some extent, the public sector. The review team narrowed its focus to activities intended to introduce farmers to the innovation and persuade them to adopt it; to address gaps or otherwise strengthen the market system and external context; and to persuade various actors and stakeholders to support the scaling up process.
- **Potential scale of adoption:** what scale was achieved and the patterns over demographics, time, and space. The factors that explain these patterns, and what they tell us about achieving critical mass or a tipping point where spontaneous adoption by indirect adopters becomes self-sustaining.

The methodology for this case study involved four data collection techniques: document review (DR), key informant interviews (KIIs), focus group discussions (FGDs), and analysis of quantitative data from

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

[6] PfI is a specialized project supported by USAID that aims to make agricultural technologies available to smallholder farmers in order to raise productivity and increase the marketing of agricultural output. The project facilitated the entry of PICS bags to Kenya and established the relationship between Purdue, Bell Industries, and USAID-KAVES in 2013.

secondary sources (QDSS). Annex B contains some sample questions used in the fieldwork. The review team used these approaches to collect qualitative and quantitative data from a diverse and large number of stakeholders associated with the maize value chain and the distribution and use of PICS bags in Kenya. Table 1 summarizes the sources, key spaces, and drivers for the data collected. Each cell notes whether relevant data was provided for a particular topic, with the importance and utility of the information gathered ranked on a scale of 1 (X – least important) to 4 (XXXX – most important).

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	KII, FGD	XXXX	XXXX	XXX	XXX	XXX	X
Bag manufacturers	KII	XXXX	XXXX	XXXX	XXX	XXXX	XX
Agrovets	KII	X	XXX	XXXX	XX	X	XX
Innovators – Purdue University	KII, DR	XXXX	X	XXX	X	XXXX	XXX
Ministry of Agriculture	KII, DR, QDSS	X	X		XXXX	X	X
Kenya Central Statistical Office	QDSS, DR				XX		XXXX
Field extension officers at county level	KII	XX	XXXX	XX	XXX	XXX	XX
Agriculture NGOs	KII, FGD	XXXX	XXX	XXX	XXX	XX	XXXX
USAID and other donors	KII, DR	X	X	X	XXX	X	XX
USAID implementing partners	KII	XXX	XXX	XXX	XXX	XXXX	XX
National Farmers Associations	KII, DR	X	XX	XXXX	XXXX	XXX	XXX
National Maize and Produce Board and other buyers	KII			XX	XXXX		XX

Data collection took place over a three-week period in April 2016. Information was gathered in Nairobi; in the counties of Machakos and Makueni, in the Eastern region; in the counties of Uasin Ngishu (Eldoret) and Trans Nzoia, which produce a large surplus; and in Bungoma, Kisumu, Homa Bay, and Kisii in the Western Region and North Rift. These areas constitute the major maize-growing regions of Kenya, with a wide variation in climate and productivity between the semi-arid Eastern counties and the Western and North Rift regions. In addition, they were the target regions of USAID-KAVES and those areas where Bell Industries began its own promotional PICS activities.

Other counties in Kenya are either self-sufficient in maize or carry a deficit. Interviews with promoters, distributors, and sponsors[7] of the technology took place in the main towns and county seats, while

[7] Promoters include USAID-KAVES, local county directors of agriculture (CDAs), and representatives of the manufacturer, Bell Industries. Distributors were local agricultural input suppliers, as well as extension officers and farmers' associations. Sponsors were those groups that supplied the bags at a discount to farmers or helped with training or transport to reduce costs.

meetings with individuals and groups of farmers were held on farms in peri-urban and remote areas. The review team spent nine working days conducting KIIs and FGDs with as many actors as possible in the rural areas to obtain as complete a picture as possible of the extent of scaling and the influences, both positive and negative, behind its extent. In addition, meetings with government officials and representatives of Bell Industries most closely associated with PICS bags rounded out the gathering of evidence.

The team interviewed a large number of stakeholders, including 67 maize farmers in 5 different FGDs (including a majority of women included in cooperatives and garners' groups) ; 11 distributor agro-dealers (located throughout the review area); 3 agricultural research organizations involved in maize breeding or research; 6 NGOs; and 1 public purchasing agency.[8] There were also multiple meetings at the county level with county directors of agriculture (CDAs) and their staffs (who are also farmers), as well as with Ministry officials in Nairobi and the PICS team at Bell Industries. The review team met with USAID-KAVES officials in Nairobi and in the field on multiple occasions, as well as with members of the USAID Mission in the capital.

The review team complemented its field research with a review of documentation from Purdue University and interviews with the university's PICS researchers. The team gathered extensive quantitative data on maize production, storage techniques, post-harvest loss (PHL) estimates, and other data on food security in Kenya from the Central Statistical Office, the Ministry of Agriculture, research papers, and other publicly available data sources. Local county offices provided data on local production, targets, and consumption. The wholesale distributor that contracts out production, Bell Industries, provided detailed production reports and forecasts, and local agricultural goods suppliers provided sales figures for PICS bags.

Team Composition

The MSI in-country review team consisted of an established expert in international development, Colm Foy, and Martin Wafula, a Kenyan national with extensive experience in Kenyan agriculture. The team was supported by Richard Kohl and Gwynne Zodrow of MSI. Dr. Kohl is an internationally recognized primary expert in scaling up of agricultural technologies, while Ms. Zodrow is a technical manager and monitoring and evaluation expert.

Structure of the Report

Section II of this report provides some background information on maize production and the place of agriculture in the Kenyan economy. It reveals the importance of maize in the Kenyan diet and the need to reduce post-harvest losses caused by insect infestation. Section III describes the characteristics of PICS bags and their relevance to maize storage in Kenya. Section IV outlines the business case for the innovation for the national wholesaler, agro-retailers (*agrovets*), small-scale retailers, and end-user farmers. Section V explains what led to its adoption throughout the country on the basis of a commercialization strategy that included private, public, and NGO actors promoting the product in a context of profitability along the full length of the value chain. Section VI analyses the future scale of adoption. Section VII presents key findings conclusions, and Section VIII offers some lessons for donors and policy makers. Section IX presents a summary of conclusions from the study.

[8] See list of interviews in Annex 1.

II. BACKGROUND TO AGRICULTURE IN KENYA

The Republic of Kenya is the fourth largest economy in sub-Saharan Africa. According to the 2014 MDG report, some 47 percent of Kenyans live below the poverty line. The agricultural sector contributes over 30 percent of GDP and dominates the economy. On average, 75 percent of working Kenyans make their living from farming. About half of Kenya's total agricultural output is non-marketed subsistence production.[9]

Although Kenya's population is growing, agricultural productivity is stagnating. This poses critical challenges to food security and the 2 to 4 million people who receive food aid annually.[10] However, there is considerable potential for increases in productivity. Maize productivity increased between 2000 and 2010 from about 1.6 mt/ha to around 2 mt/ha, about the same levels as found in Malawi and Zambia, but half of those found in South Africa[11] (see Table 2 for world maize production). Most farmers work without basic agricultural inputs or updated technology and lack adequate financial or extension services.

TABLE 2: MAIZE PRODUCTION (TONS) – AFRICA, EASTERN AFRICA, KENYA, AND WORLD, 2008-2014

Year	Africa	Eastern Africa*	Kenya	World
2008	58,953,002	20,755,732	2,367,237	830,611,273
2009	59,888,140	20,793,469	2,439,000	820,202,618
2010	66,270,962	26,195,794	3,464,541	851,273,710
2011	66,239,695	27,878,009	3,376,862	887,127,312
2012	69,819,430	27,847,501	3,749,880	875,490,653
2013	70,861,471	27,943,639	3,592,688	1,017,750,854
2014	77,616,037	31,720,698	3,513,171	1,038,281,035
% change	**31.7**	**52.8**	**48.41**	**25.0**

Source: FAO
* Burundi, Comoros, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Seychelles, Somalia, South Sudan, United Republic of Tanzania, and Uganda.

Maize is the main staple cereal in Kenya, as well as in East and Southern Africa. Maize accounts for about 65 percent of Kenyans' total staple food caloric intake and 36 percent of their total food caloric intake. It accounts for about 56 percent of cultivated land.[12] Most Kenyans prefer white maize flour to produce *ugali* which forms part of their daily food intake. Small farmers have traditionally grown white maize (*Zea mays amylacea*) for the past two centuries, both for family consumption and, whenever possible, a small surplus for the market. The range of conditions, agricultural techniques, and growing seasons in Kenya is wide. The Western region from North Rift to the Ugandan border is generally fertile and suitable for rain-fed agriculture. The Eastern region, on the opposite side of the capital Nairobi, is generally semi-arid, with unpredictable rains and frequent harvest shortfalls resulting in severe food insecurity, though there are pockets of more fertile land with better rainfall.

[9] Information in this paragraph is taken from Republic of Kenya (2015), *Economic Survey 2015*, Kenya National Bureau of Statistics, Nairobi and African Development Bank et al (2016), *African Economic Outlook 2016*, Organisation for Economic Co-operation and Development, Paris.
[10] Ibid.
[11] John Olwande, "Smallholder Maize Production Efficiency in Kenya" PowerPoint presentation, slides 7-9. See Smallholder Maize Production Efficiency in Kenya (http://www.fao.org/fileadmin/templates/esa/Workshop_reports/Smallholders_2012/Presentations_1/Olwande_Smallholder_Maize_Efficiency_Kenya.pdf). Yields in Western Europe are around 9-10 kg/ha and 16.5 in the USA. See USDA crop production 2015 Summary.
[12] Ibid.

The vast majority of maize in Kenya is grown by small farmers, defined as 2.5 hectares or less for this study. Cultivation is largely manual. Seeding, weeding, hoeing, harvesting, and initial processing are generally done by hand, although the use of itinerant husking machines is becoming more widespread. Individual smallholder farmers generally plant a mix of hybrid, certified varieties and self-pollinating strains on a single plot. The actual mix varies considerably from region to region and from smallholding to smallholding, but with most differentiation in the Eastern region, where farmers hesitate to "put all their eggs in one basket."

Almost all maize in Kenya is rain-fed, and farmers grow maize even where the weather conditions and the soils are not ideal.[13] Because almost all maize farmers remain vulnerable to the vagaries of the weather, the result in many areas of the country is a "hungry time," when last season's crop is exhausted and the next season's harvest is yet to begin.[14] When this occurs, families, including farming families, are forced to seek maize on the market and to use what savings, if any, they have to buy food.

Kenya is infested by two insect types that infest maize after harvest, in addition to other endemic but less devastating insects. These are the larger grain borer (LGB) (*Prostephanus truncatus*) and the lesser grain borer (lGB) (*Rhyzopertha dominica*), and infestations of one or the other are equally devastating. Major infestations have become increasingly frequent over the past four decades and can have a dramatic impact on PHLs. The stored grain is also targeted by weevils (a type of small beetle) that can consume up to 18 percent of the crop over a 3-month storage period.[15]

This PHL is of major concern to individual farmers and to national policy makers (see Table 3). Kenya is already a net maize importer, importing over 20 percent of total consumption (10 million bags on average between 2010 and 2014 out of total national consumption of 45 million bags); the Ministry of Agriculture (MoA) estimates the increased maize import needs of the country due to PHLs to be around 5 million bags, worth around KES 4.5 billion (USD 45 million). The year 2015 was the hottest on record as a result of changes in climate. The impact in Kenya has been accentuated unpredictability in rainfall and lower harvests. If this trend continues, the country will become even more reliant on maize imports unless yields can be increased and PHLs reduced (see Table 3).

TABLE 3: POST-HARVEST MAIZE LOSSES IN KENYA, 2007-2013 (% OF TOTAL CROP)

Province	2007	2008	2009	2010	2011	2012	2013
Central	22.6	17.6	17.6	26.3	17.5	17.6	26.3
Coast	22.6	17.7	17.5	26.1	18	17.8	18
Eastern	22.6	17.6	17.5	26.3	17.5	17.4	17.5
Nairobi	22.6	22.3	22.3	30.2	22.3	22.3	30.2
North-Eastern	17.2	15.4	15.4	15.4	15.4	15.4	15.4
Nyanza	21.3	17.3	26	17.3	17.3	17.3	26
Rift Valley	22.6	18.5	18.6	27.3	18.5	18.8	27.2
Western	20.9	19.2	17.9	26.4	17.7	17.7	26.4

Source: http://www.aphlis.net/?form=losses_estimates&co_id=25&c_id=324

[13] Interview with Assistant Director of Agriculture, MoA, Nairobi, April 5, 2016.
[14] This is particularly true in Machakos and Makueni counties, as well as in much of Eastern Kenya.
[15] Interview with Assistant Director of Agriculture, MoA, Nairobi, April 5 2016, and confirmed in interviews with farmers.

The shortfall is most severely felt in those regions outside Western and North Rift that are either deficient in maize production or barely self-sufficient. They are also regions of high poverty and high prices for imported maize because of transport costs. Increasing maize production and productivity—including lowering PHLs—to improve food security and decrease imports are goals of the MoA, county authorities, and a variety of civil society organizations (CSOs). The introduction of hermetic storage that can cut such losses from insect damage almost to nil is, therefore, a valuable weapon towards achieving that objective.

TABLE 4: KENYAN MAIZE PRODUCTION, 2010 - 2014

Kenya Maize	2010	2011	2012	2013	2014
Area	2,008,316	2,131,887	2,159,321	2,123,138	2,116,141
Production (90 kg bags)	38,494,899	37,520,694	41,665,332	39,918,751	39,035,228
Production (tons)	3,464,541	3,376,862	3,749,880	3,592,688	3,513,171
Yield (bags/ha)	19.2	17.6	19.3	18.8	18.4
Yield (tons/ha)	1.73	1.58	1.74	1.69	1.66

Source: Kenya Economic Review of Agriculture 2015-16, Table 3.1, p.10. http://www.kilimo.go.ke/wp-content/uploads/2015/10/Economic-Review-of-Agriculture_2015-6.pdf

FTF is helping Kenyan agriculture meet the country's food security and nutrition challenges. The FTF target regions cover 27 of Kenya's 47 counties, categorized below by agro-climatic zones. The target counties comprise more than 50 percent of the maize-growing areas of the country.

Counties in the USAID Feed the Future Zone

Western region counties, high-rainfall zone: Trans Nzoia, Elgeyo-Marakwet, UasinGishu, Nandi, Kisumu, Kericho, Nyamira, Bomet, Kisii, Homabay, Migori, Siaya, Vihiga, Kakamega, Busia, Bungoma
Eastern region counties, semi-arid zone: Meru, Tharaka-Nithi, Kitui, Machakos, Makueni, Taita-Taveta
Northern Kenya counties, arid and semi-arid zone: Turkana, Marsabit, Isiolo, Wajir, Garissa

III. CHARACTERISTICS OF THE INNOVATION

The PICS technology consists of two 80-micron thick high-density polyethylene bags supported by an outer woven polypropylene bag[16]. The bags sell for approximately USD 2.50 and can be reused several times before they are damaged beyond the point of repair. The sealed triple-layer crop storage bags were developed by Professor Larry Murdock and his team at Purdue University in West Africa in the 1980s to assist in combatting insect infestations, specifically from bruchids (a kind of beetle). Though the technology was introduced primarily for the storage of cowpeas, Purdue researchers observed that farmers were increasingly using the bags to store other crops. Since the technology's initial testing, the intended use of the bags has been for pulses and grain storage, and in that role the bags have multiple benefits. Foremost among them is their ability to prevent insect damage to the stored crops. When properly sealed, the PICS bag inhibits respiration, leading to the desiccation of insect pests (causing their death) and prevention of mold. Work by ACDI/VOCA, among others, has shown that the bags also inhibit the spread of the aflatoxin-producing fungus, which is a serious health risk in all regions of Kenya and is particularly prevalent in smallholder maize[17]. Hermetic grain storage is highly applicable to household storage and makes the use of insecticides in stored grain redundant.

[16] See Purdue Improved Cowpea Storage project (https://ag.purdue.edu/ipia/pics/Pages/home.aspx) for details of research, history and manufacture.
[17] See "Drying and Storage for Aflatoxin Prevention" project Annual Report (http://www.acdivoca.org/wp-content/uploads/2016/05/PA00KFQ4.pdf) for more details.

Using PICS Bags

PICS bags (and other hermetic bag solutions) are easily used by farmers with very basic training. The grain needs to be dried to a maximum moisture content of 13.5 percent, which is normally done in the sun. In order to get to this level of accuracy, moisture meters are necessary and the government is currently distributing them.[18] Itinerant grain-drying machines are also being developed – notably by Sophie Walker.[19] The farmer then places the grain in the bag and squeezes out as much air as possible. To seal the bag, the farmer ties each of the two interior bags in turn, finishing with the outer layer. The dryness level is extremely important; if the grain is too damp it will rot and/or germinate.

Impacts on Current Practices

Because PICS bags are a post-harvest storage technology, they require little or no change in farmers' cultivation practices. Instead of bagging up their grain in hessian or similar bags, farmers use the triple-layered plastic solution. Moisture control is very important, and farmers need to recognize that they will not get the intended results if they do not adhere to the drying protocol. This was less important when they used non-hermetic containers, as further drying could take place after bagging, which is not the case with PICS bags. However, the freedom from having to use chemical pesticides on the grain more than offsets the changes in behavior that PICS bags require, including meticulously expelling the air and tying each layer separately to ensure the bag is fully sealed. Pesticides, when used, need to be re-applied within two months, which necessitates the emptying and re-bagging of the crop. The only major change in farmers' storage practices is that grain stored in PICS bags needs to be stored separately from anything that could attract rodents which could chew through the bag. However, none of the end users interviewed indicated that this was a problem (most stored their grain inside the family dwelling).

PICS Bags in Kenya

Prior to the arrival of PICS bags in Kenya, grain was stored in polypropylene or burlap bags. Storage periods varied: up to 10 months in areas of a single, annual harvest, and for 3 months in those areas with 2 growing seasons (though with generally lower yields). However, this system of storage is highly inefficient. According to the World Bank, 45 percent of all PHLs in Kenya in 2009 were due to poor storage, and the rest depended on spillage and weather conditions.[20]

In 2013, PfI, a USAID/BFS project, assisted the Purdue University team in introducing PICS bags to Kenya. This decision was based on reports of high levels of PHLs in the white maize crop. These losses can amount to as much as 50 percent in areas affected by the LGB, known locally as "Osama" because of its potentially destructive effects and the difficulty in eliminating it. Further extensive damage can be caused by the lGB, maize weevils, and bruchids in pulse crops.[21]

Smallholders (on land of less than 2.5 ha or 6 acres) typically attempt to produce a minimum of 6 bags of 90 or 100 kilograms each (equal to a family's consumption over a year). Since many plots are much smaller than 2.5 ha (the average smallholder plot in Kenya is 0.86 ha[22]) and not all the land is available

[18] Government policy attested to by Wamunyu Grain Aggregation Centre Board members, interviewed 08 April 2016.
[19] Interview with Ms. Walker, 19 April 2016; she noted that such a valuable innovation was encountering difficulties in obtaining donor funding, so their use is not yet widespread, despite a relatively modest cost to the operator/owner.
[20] World Bank (2011), *Missing Food: the Case of Post-Harvest Grain Losses in Sub-Saharan Africa*, World Bank, Washington
[21] Interview with Assistant Director of Agriculture, MoA, Nairobi, 05 April 2016 and with the PICS team at Purdue University.
[22] FAO (2005) *Smallholders dataportrait*, accessed on-line at http://www.fao.org/economic/esa/esa-activities/esa-smallholders/dataportrait/farm-size/en/

for maize—it is used for accommodation, livestock, or other crops—even growing enough for six or eight bags can present a challenge. Farmers reported that they plant up to 30 percent more maize than they theoretically need to compensate for the expected post-harvest losses.[23] This results in the planting of more land under maize than would otherwise be the case, limiting the amount of a small farmer's land available to grow high-value cash crops.

Ancillary Benefits

A major objective of the government of Kenya and USAID-KAVES is to increase farm incomes by encouraging farmers to grow high-value cash crops on land liberated through higher productivity and reduced PHLs. USAID-KAVES works with smallholder farmers, businesses, and national and county government partners to address constraints up and down the value chain (such as agro-processors, input suppliers, transporters, exporters, retailers, financiers) and develop fully-functioning, competitive value chains. KAVES aims to increase the productivity and incomes of smallholder farmers, and other actors along the value chain, who are working in the dairy, maize (and other staples) and horticulture sectors[24]. Hermetic storage solutions thus increase food security and decrease poverty in three ways: (1) ensuring that virtually all the harvest is conserved; (2) freeing up land to grow cash crops; and (3) delay the selling of surplus maize (or other grains or pulses) until prices become more attractive, increasing incomes. These benefits potentially apply to other crops, such as hibiscus grain and sorghum. There is, therefore, potential to extend the use of the bags to other crops grown in Kenya, both for cash and for food.

According to interviewees, the condition of the maize stored in PICS bags is superior to that kept in non-hermetic containers, and the grain is more nutritious,[25] which contributes to better health for the consumer. The stored maize retains its ability to germinate. Hence, self-pollinating (non-F1 hybrid) varieties can be stored in PICS bags ready for planting in the following season with no loss. This is a significant benefit for poorer farmers who cannot afford to purchase fresh seed every season, or those who choose to mix improved and local varieties, which is often the case, especially in the Eastern region.

IV. BUSINESS CASE FOR THE INNOVATION

In 2013, the manufacture and distribution of PICS bags was a completely new business activity in Kenya. The Purdue University team, led by Doctor Dieudonné Baributsa, wanted to find a local manufacturer and a local firm to commercialize the product, in line with the objective of local sustainability and contribution to the local economy. However, the first distributor selected for the bags, Jotham Katana,[26] ended up not being a good match for the task, and the license was transferred to Bell Industries, an established company based in Nairobi with a network of local agents, distributors, and *agrovets* employed to sell the pre-harvest chemical agricultural additives that constituted its core business.[27]

[23] Based on interviews with farmers who consistently reported the need to produce excess grain to compensate for anticipated losses from insect spoilage.
[24] See Kenya Agricultural Value Chain Enterprises (KAVES) (https://www.usaid.gov/documents/1860/kenya-agricultural-value-chain-enterprises-kaves), accessed 30 September 2016.
[25] Chairman, Wamunyu Aggregation Centre Board, interviewed 08 April 2016. Others repeated this claim.
[26] There is no real or implied criticism of any of the parties here; further examination of the market and its potential and an assessment of production/distribution capacity eliminated the initial licensee from the contract.
[27] Interview with Purdue PICS team.

The three-layer bags are produced by Pee Pee Tanzania Ltd. (PPTL), a plastics manufacturer in Tanzania, while the outer layers for Bell's own inner-layer production are made by Wonderpack Industries in Nairobi; they are marketed by Bell Industries. Bell's wide sales and marketing network is used to promote and sell the product. The estimated current cost of production is KES 140 (USD 1.40) per bag, which translates into a KES 190 (USD 1.90) wholesale price, including value-added tax (VAT). VAT is 16 percent. The price before VAT is KES 163.80. Actors further down the value chain also have to add 16 percent VAT and incorporate it into the final selling price. The *agrovets* sell directly to farmers at KES 250 USD 2.50) or a 31 percent pre-tax profit on costs. *Agrovets* sell to intermediary retailers at KES 200 to 220 (USD 2.00 to 2.20) for a 5 to 15 percent pre-tax profit margin. These intermediaries sell to farmers at KES 250.[28] Several thousand units were distributed for free during 2013, but at no stage was it ever suggested that the bags would be supplied free of cost or at a subsidized price subsequently. The bags were used for demonstration purposes only.[29]

Bell received a great deal of support from USAID-KAVES initially, both in advice and in the purchase of the company's first run of 2,500 units. Bell hired a dedicated sales and marketing manager in 2014 to promote the product and investigate the size of the market. Serious commercialization began with the hiring of the sales manager, and Bell, with substantial assistance from USAID-KAVES regional offices and staff, started to promote the product directly in rural areas.[30]

The period of commercialization is short, but Table 5 demonstrates the rate of increase in annual terms.[31]

TABLE 5: PRODUCTION LEVELS OF PICS BAGS IN KENYA – 2013 – 2016 (JANUARY TO JULY)

Year	Distributors (Commercial)	ODA (USAID)	Religious Organization/ Promoter	One Acre[32]	Farmer Groups	Total
2013	255	2,500	350 (CARITAS)	0	0	**3,105**
2014	51,792	0	3090 (ROPA, ADPP) 8850 (CARITAS)	937	1,400	**66,069**
2015	156,134	0	4,112 (CARITAS) 4,372 (ROPA, ADPP, IPA)	48,030	2,650	**215,248**
2016 (first five months)	193,092	0	1,319 (AGRA, ICIPE, Purdue, ASI)	35,000	8,000	**237,411**

Source: Bell Industries

With production at some 100,000 units per month and 7 months to run, expected production is 1 million PICS bags in 2016. This would be equivalent to an approximate profit of KES 36 million (USD 360,000) in the course of a year on the sales of PICS bags alone. Profits could rise even further if current negotiations with the Finance Ministry to zero-rate PICS bags (and similar hermetic bag solutions) for VAT are successful. The 16 percent VAT the company currently pays on the final sales

[28] Communication from Bell Industries, 21 September 2016.
[29] Interview, USAID-KAVES, Nairobi, 04 April 2016.
[30] Interviews with project staff, USAID-KAVES, Nairobi, April 4, 2016, and Bell Industries, April 5, 2016.
[31] Source: Bell Industries, 26 April 2016. The company further reports that, with sub-contractors supplying the inner and outer bags, and use of a newly acquired machine in 2015, production is expected to reach or exceed 120,000 units per month in the course of 2016.
[32] One Acre Fund discounts sales to its members but acts, as far as Bell is concerned, just like any other retailer.

price is incorporated into the KES 190 wholesale unit price. Hence, PICS bags produce a very good profit level in Kenyan terms.[33] For this reason, Bell is considering establishing a subsidiary to produce and market PICS bags; though this is only a proposal at this stage,[34] it is a likely development. "Our target this year is [to] reach 1 million bags and in the next year will be [at] 1.5 million bags."[35] Meanwhile, the market continues to grow. There are new competitors for PICS bags, and a new influencer, AgResults, has entered the field.

The international consortium AgResults—a partnership between Australia, Canada, the United Kingdom, the United States, the World Bank, and the Bill and Melinda Gates Foundation—is attempting to drive commercialization of hermetic storage technologies by encouraging competition between producer/distributors.[36] As of May 2016, these include, in addition to Bell Industries: Agro-Z (Kenya), GrainPro (U.S. and Philippines), Kenya Promotion and Marketing Company (KPMC) Holdings, EKIMA (metal silos), and Elite Innovations. The first five of those suppliers to reach sales equivalent to 21,000 mt of storage capacity to small farmers in the Rift Valley by the end of March 2017 will qualify for a cash prize of USD 750,000 and a share of a final USD 1 million prize at the end of the program in May 2018, with their share proportionate to their level of sales. In a similar program in the Eastern region, all suppliers of approved LGB-resistant storage solutions that reach 21,000 mt in storage-equivalent sales to small farmers will participate in a USD 3 million prize, also proportionate to their levels of sales.

Increasing demand and the AgResults initiatives have encouraged lively competition in the Kenyan market. However, there has been, as of May 2016, no impact on prices. This is probably because demand continues to grow at a very rapid rate. According to one *agrovet*, demand for the PICS version alone has doubled every six months since January 2014.[37] Other *agrovet*s and both county and NGO extension workers felt that this was an accurate and even conservative figure. In Eldoret, Amos Kipsang, the local Bell agent, said that his supplies of PICS bags were sold "within hours" of his receiving them and claimed that Uasin Ngishu County alone "could absorb 500,000 units, if we could get them."[38]

Bell Industries' network of *agrovets* and agents is not exclusive, and many other operators are involved in commercializing the bags. These range from the giant National Cereals and Produce Board (NCPB)[39] to established agricultural supply companies, such as Mazop Enterprises in Kitale,[40] and individual and small-scale vendors.[41]

What they all have in common is the ability to make a reasonable profit from the sale of PICS bags. Bell's wholesale price is KES 190, including transport to a major town, for a minimum order of 250 units. The transport cost is between KES 5 and 15 per bag using normal transportation means. The consignment could take up to a week to arrive at its destination. Courier services that provide next-day service are available at between KES 20 and 40 per bag, depending on distance, and are charged as a supplement to clients.[42] This means that the *agrovets* and other direct retailers, such as the NCPB, make a gross profit, before taxes, of KES 60 per bag, since the final price to the farmer is fixed at KES 250. Small-scale vendors purchase their stocks from the *agrovets* at KES 220 and make a KES 30 profit, which is still quite reasonable, given that selling PICS bags is not usually their core activity. As demand continues to grow, however, the future of the small-scale sellers may be cast into doubt because, in reality, the *agrovets* do

[33] Interviews with Bell Industries.
[34] Interview with general manager, Bell Industries, April 5, 2016.
[35] Communication from owner, Bell Industries, May 5, 2016.
[36] Interview with team leader, AgResults Kenya On-Farm Storage Pilot, April 20, 2016.
[37] Interview with Miletech Communications, Machakos, April 8, 2016.
[38] Interviewed April 11, 2016.
[39] Interview with director, April 12, 2016.
[40] Owner, interviewed April 13, 2016.
[41] Small-scale vendor, interviewed in Makueni, April 12, 2016.
[42] Information provided by Bell Industries.

not need them and can sell every bag they receive at the full price. This would not be good for users in remote areas with little or no access to transport, unless they group their purchases enough to drive the cost of transport in a *Matatu* minibus into insignificance. *Matatu* prices vary according to distance, but are generally in the range of KES 150 – KES 300, which means a round trip from an outlying village to a supplier in town can cost up to KES 600. This is a considerable premium for a single purchase of 6 bags (KES 1,500), but manageable for 10 times that many. However, the poorest communities tend to be the furthest from the towns and the main transport arteries, so that ordering or purchasing 60 PICS bags at one go would likely be beyond their means.

TABLE 6: PICS BAGS PRICE STRUCTURE, KENYA (KES[43])

Price Point	Location	Buy	Sell	Margin[2]
Bell Industries	Nairobi	140.00	190.00	36.00[1]
Retailer (*agrovet*)	Major and small towns	190.00	250.00	60.00
Retailer (*agrovet*) selling to small traders	Major and small towns	190.00	220.00	30.00
Small trader	Villages and itinerant	220.00	250.00	30.00
Farmer	Localities	250.00		

[1]Gross profit of KES 50.00 is reduced by KES 14.00 due to 16 percent VAT and transport costs of average KES 10.00 per bag.
[2] Margins are pre-tax (VAT).

The actual monetary value to farmers of using PICS bags has been calculated:

> *Farmers using the hermetic bags incurred weight losses of 3.9% after four months of storage, which is significantly lower than their control counterparts who incurred weight losses of 12.4%. The abated loss, or loss avoided through the bags, amount to 8.5% which is equivalent to a gain of 7.7kg of grain per 90kg bag per season. Given an average maize value of KES 40.00 per kg, this gain is valued at KES 307.00 (USD 3.6) per bag per season, assuming farmers store for four months only. The value sums add up to KES 920.00 (USD 10.7) per bag in 3 seasons, the minimum period the hermetic bags can be re-used if well taken care of.*[44]

Farmers can recoup the entire cost of using a bag in one season – just in terms of reduced post-harvest losses – assuming optimal harvest outcomes. In interviews, farmers were less optimistic, but those who had used the bags over two seasons claimed to have recouped their outlays on the bags, despite the years in question (2014 and 2015) producing lower harvests than expected nationally.

The pricing system (see Table 6) that Bell put in place was based on a final purchaser price of KES 250 (USD 2.50), which allows for acceptable profit margins along the chain while keeping the bags within financial reach of the farmer. Bell Industries, however, is an importer and wholesaler of agricultural products that it supplies on contract to *agrovets* and does not have the physical capacity or expertise to manufacture the bags on its own. The layers are produced separately—the two inner layers are the same material, while the outer layer is made of a woven plastic and needs to be assembled by hand. Bell has acquired a new machine that offers some capability to produce the inner liners, but Bell remains dependent on a sub-contractor to produce the woven outer layer. So far, supplier PPTL in Tanzania, which has experience in manufacturing PICS bags for its home market, has been able to keep up with orders for the bags from Bell. However, the entry of competitors into the market, with a consequent risk that they will compete for sub-contractors, may alter this state of affairs, forcing Bell into self-

[43] Conversion rates are approximately KES 100.00 = USD 1.00 in May 2016.
[44] Ndegwa, M., H. De Groote, Z. Gitonga, and A. Bruced (2015), *Effectiveness and Economics of Hermetic Bags for Maize Storage: Results of a Randomized Controlled Trial in Kenya*, International Conference of Agricultural Economists, Milan, August 2015. The dollar equivalent rates quoted in the citation differ from those elsewhere in this report due to exchange-rate fluctuations.

manufacture that would be costly in fixed-capital and human-capital terms, since it would require the acquisition of more machines and the training of operators.

The PICS bags remain in use for three years. For a smallholder who is not aiming for a surplus, a full set would mean six bags (or five, if one assumes that the first bag would be consumed within two months, or one sixth of a year, and would not require long-term storage). A commercial or semi-commercial grower would be looking to acquire more bags more quickly, but would still need to roll over the stock every three to four years.

The *agrovets* are currently operating at a profit as far as the bags are concerned, since demand is undiminished in the context of continuing promotional activities by NGOs and especially the national wholesaler, Bell Industries. *Agrovets* are not required to pay for their supplies up front, but acquire them on sale-or-return, and they do not extend credit, which means their PICS bags business is sound and does not expose them to cash-flow risk. They are, however, constrained by the ability of Bell Industries to supply them with a sufficient number of bags, and there have been some interruptions to supply when demand rose, particularly in the first two months of 2016.

The only link in the chain that suffers some exposure is the itinerant retailer who purchases a few – usually fewer than 10 – bags at a time to transport to remote rural areas. These individuals purchase bags at a discount from the *agrovets* and use personal means or public transport to bring them to outlying areas. The price to farmers remains the same, and profit margins for the retailer are small, but this is usually a side business providing a small amount of extra income.

Agrovets and retailers rarely have exclusive contracts to sell PICS bags; both face competition from other dealers and carry other hermetically sealed storage products. However, at the time of the survey, for this report, demand was so high for PICS bags that there was more than enough business to go around, according to interviewees, whereas competing products from similar bag manufacturers were only making slight inroads into the market. Despite this, the end-user price has remained stable since the introduction of PICS bags, and other manufacturers have aligned their price with that of PICS.

None of the farmers interviewed for this review reported having taken out loans or obtained bank credit to purchase the bags, so the appearance of PICS bags has not led to an increase in farmer debt. The renewal rate observed—roughly two or three bags per year, per farmer—is unlikely to place a strain on farm finances in the foreseeable future. Group buying is also taking place and, according to farmers, is likely to increase, rendering the transportation costs negligible, while the advanced state of Kenya's infrastructure means that only the remotest areas can expect to suffer a substantial increase in the price of the bags due to transport costs. If the season is good, the *agrovets* are able to sell 500 bags or more in a week and remit their invoices to Bell on average between 30 and 60 days after receipt; however, some customers could take longer, up to 120 days or more.[45]

The market price of any surplus stored in hermetic containers is as much as 30 percent higher[46] especially in the high season when maize on the market is scarce. With such a price difference, in addition to the fact that the bags actually open the possibility of having a surplus to trade at all, the relatively low cost of the bags—KES 250 (USD 2.50)—can be recouped relatively easily.

[45] Bell Industries, September 22, 2016.

[46] Interview of a farmer in Bungoma County, April 14, 2016; he claimed he could get KES 3,000.00 per bag, compared to the regular high-season market price of KES 2,200.00.

At first glance, PICS bags appear to be much more expensive than ordinary bags with chemical pesticides. However, as Table 7 demonstrates, when the cost over three years is analyzed, PICS are about one-third cheaper.

TABLE 7: COSTS PER BAG: PICS VS INSECTICIDE-TREATED BAGS KENYAN SHILLINGS (KES)[47]

Line Item	Insecticide-Treated Bag (ITB)	PICS Bag	ITB (3 year cost)	PICS (3 year cost)
Bag	40	250	40	250
Actellic pesticide dust	27	0	81	0
Dust application labor	96*	0	288	0
Bagging labor	50 *	50	150	150
Total cost	**213**	**300**	**559**	**400**
Annual cost			**186.33**	**133.33**

*If the grain is kept for more than 2.5 months, however, it needs to be re-treated, so these costs are incurred again, bringing the insecticide-treated bag's cost to KES 359. KES 100 = USD 1.00.

The initial cost is only part of the story. Farmers could easily see that, even if they stored their maize for a short enough period that, using the old bags, they could avoid re-applying chemical pesticide, the final cost of PICS bags was still significantly lower, since PICS bags could be used over three years. But there was more: by being able to keep stored grain longer and in excellent condition, they could fetch higher prices in the marketplace if they waited for the price to rise. Table 8 demonstrates this advantage.

TABLE 8: NET BENEFITS PER BAG PICS VS INSECTICIDE-TREATED BAGS[48]

Period	Market Price	Insecticide Treatment (KES)		PICS Bags (KES)	
		Cost	Net Benefit	Cost	Net Benefit
Harvest	2,600				
+3 Months	+100	213	-113	300	-200
+6 Months	+166	386	-220	300	-134
+9 Months	+325	559	-234	300	+25
+ 12 Months	+593	732	-139	300	+293

These advantages had not been immediately obvious to the farmers interviewed, who were used to having to operate in extremely risky environments with no safety net and little experience of cost-benefit analysis, especially over the longer term. Hence, USAID-KAVES built this educational aspect into its training and extension sessions, transferring the knowledge and expertise to other extension workers who subsequently included it in their farmer training activities. This enabled farmers to see that the initial price of the PICS bags was not as high as it appeared. Subsequent farmer experience served further to convince the market that PICS bags were a viable and profitable alternative to traditional bags, the use of chemicals, and the remaining persistence of post-harvest losses.[49] Indeed, some prominent

[47] Following USAID-KAVES (unpublished).
[48] Following UDAID-KAVES (unpublished data).
[49] According to reports from local officials, local USAID-KAVES operatives and Bell Industries, as well as reports from the Catholic Diocese of Eldoret.

farmers were able to demonstrate from their own experience the potential for making substantial profits.[50]

V. ADOPTION DRIVERS AND RESULTS OVER TIME AND SPACE

While hermetically sealed storage bags may be new to Kenya, storage bags *per se* are not; farmers have been using burlap or polypropylene bags to store their harvests for generations. So the initial effort undertaken by Purdue's PICS team and Partnering for Innovation, and then by USAID-KAVES, Bell Industries, and a number of non-governmental partners, was to educate the potential market about the differences and benefits of PICS bags compared with traditional practices. The next challenge was to produce a sufficient number of units to satisfy the resulting demand.

The effectiveness of existing practices in curbing insect infestations was perceived as inadequate by the farmers interviewed. Farmers were already aware of the impact on their livelihoods and food security of post-harvest insect infestations. They were doing their best to counteract such losses by using chemical pesticides with their traditional bagging practices. However, according to interviewees and local officials, the effectiveness of the chemicals was between 80 and 90 percent, and this was only for the first month. The effectiveness of the pesticides declined sharply thereafter, and farmers had to empty the bags and re-treat the grain with pesticides every two or three months before re-bagging.

Farmers interviewed reported that they found the explanation of the use of the PICS bags easy to understand. Faced with high costs of chemicals for treating grain in non-hermetic conditions, and believing that the chemicals are harming their children's health, farmers are easily persuaded to adopt the new technology. In addition, the technology is promoted by public or NGO extension workers and non-governmental contacts with whom farmers are already familiar and with whom they have already established relationships of trust. The disastrous impact of severe insect infestation in recent memory has also played a role in farmers' seeking effective methods of control.

Initial demonstrations by USAID-KAVES, CSOs, and NGOs, as well as the supplier, Bell Industries, had an immediate effect. Whereas Bell had supplied a mere 3,105 units in 2013, almost all of which went to promoters, the following year 88 percent of over 66,000 units went to the commercial sector, and by 2015 almost all the production was sold through the commercial distribution network. At the beginning of 2016, demand had risen so sharply that Bell was unable to keep up with it, and the network of suppliers was reporting empty shelves throughout the country.[51]

The External Context or Spaces

Policy Space

Kenya's MoA has made reducing post-harvest losses a policy priority. Kenya engaged in a process of political devolution to the counties through the new constitution in 2010 and elections in 2013, which placed most policy and programmatic implementation at the county level.[52] Devolution effectively meant

[50] Several CDAs and their staffs who were early adopters are themselves farmers and began using the PICS bags to store grain for sale two or three seasons ago to great effect. This is also the case with some personnel in the CSOs.
[51] As reported by numerous *agrovets* to the survey team and confirmed by Bell Industries.
[52] The 2010 new constitution and subsequent March 2013 general elections provided for the creation of 47 counties. Each county has its own executive and legislative branches and is responsible for agriculture, transportation, trade licenses,

that both the decision as to how to implement agricultural policy and the means to do so, including policies to combat post-harvest losses, would be the responsibility of the CDAs. The reaction of the CDAs in practical terms, however, varied considerably. While all CDAs interviewed expressed support for the use of hermetically sealed technology, the levels of active support—through, for example, demonstrations and distribution of the bags—are not uniform and depend on the importance of maize in the local economy, the resources available in each county, the priorities of CDAs, and the overall agricultural policies of the counties. In the areas where CDAs were active in promoting the bags, uptake by farmers appeared to be more significant. The review team was unable to interview CDAs outside the areas visited, but it would be reasonable to assume that the same differences in approach and attitude obtain in the other areas of the country.

Value Chain

The supply chain for agricultural inputs in Kenya is fairly well developed, and one of the better ones in sub-Saharan Africa. There are local manufacturers of agricultural tools and chemicals, a very well developed private seed production and distribution sector, over 20 fertilizer companies, and a well-established and efficient cellular phone network that can be used for everything from price checks to market information to cash transfers. The commercial distribution network operates efficiently throughout the country from the wholesale level to the *agrovets* and down to individual retailers serving isolated communities.

The supply of PICS bags requires up to four components: (1) manufacturer, (2) national wholesale distributor, (3) retail distributors, and (4) in some areas, individual retailers who help sell and distribute to poor and/or rural small farmers (i.e., "the last mile"). Bell Industries was brought into the role of national wholesale distributor by the original Purdue University implementation team, with the idea that Bell would outsource production. This selection was based on Bell's experience of outsourcing agricultural supplies, its existing distribution chain, and its ability to reach the target population of small farmers through its associations with local farmers' groups. Once Bell was engaged, the company established a dedicated internal team to commercialize PICS bags through engaging with their *agrovet* colleagues on sale-or-return terms. As the product becomes more widespread and popular, this business model may change, but the suggestion from Bell is that the *agrovets* are used to this sale-or-return system. At the same time, the Purdue team contacted a number of NGOs and CSOs to do both awareness raising and some distribution. This was on the basis that Purdue saw PICS bags as a contribution to poverty reduction and higher nutrition levels and sought out allies with similar objectives.

Scaling Strategy and Activities

An essential component of scaling is the identification of a market for the innovation and the establishment of a supply chain to serve that market. This entails an estimation of market size and the recruitment of a supplier or suppliers capable of satisfying the demand generated by initial promotional efforts. Purdue, Bell Industries, and USAID-KAVES knew the importance of having a good product that responded to a real need acknowledged by farmers, but failed to appreciate how quickly demand could

sanitation, pre-primary education, village polytechnics, and most health facilities. While overall policy in these areas may still be drawn up by the national government, counties will be in charge of implementation and service delivery. Much of this effort was intended to divest the highly centralized presidency of power and temptations for corruption, and reverse the centralization of power, authority, and opportunity in Nairobi. It was also intended to diminish inter-tribal and inter-regional conflicts by promoting accountability, transparency, participation, and decision-making at the lowest level of government, and formally granting rights to communities to manage their own resources.

be generated. It would have been useful to have employed demand forecasting[53] to overcome this critical knowledge gap that would have some serious consequences for distribution as sales got underway.

The initial foray into the Kenyan market by Purdue University's PICS team and PfI in mid-2013 was to test the market and reach out to NGOs and CBOs to see if PICS could contribute to lowering poverty rates and improving nutrition. In fact, the potential far exceeded expectations and was revealed to be beyond the capacity of the initial commercial partner.[54] The Purdue team was eager to transfer the technology and establish the innovation in Kenya, generating interest in some local Kenyan partners,[55] especially in the voluntary sector. Purdue had worked with Catholic Relief Services (CRS) and Caritas Internationalis in other countries, notably Tanzania and Ethiopia, and continued this cooperation in Kenya. In addition, One Acre Fund (OAF) expressed interest and decided to include PICS in its catalogue of funded inputs to farmers. The Purdue team was also aided in its Kenyan initiative by the fact that PICS had already appeared and been studied in neighboring Tanzania and Rwanda.[56]

Partnerships

USAID-KAVES adopted and pursued the project in the last quarter of 2013 because it identified reducing PHLs through effective hermetic storage as a means of liberating land and resources to enable farmers to expand into cash crops (which is the main objective of the USAID-KAVES project). USAID-KAVES adopted an advisory role, helping Bell to establish a credible business plan and using the USAID-KAVES network in 16 counties to promote the bags, thereby developing the market in advance of Bell's effective introduction of the bags to the *agrovets*. In addition, USAID-KAVES secured the cooperation of local NGOs and CSOs, as well as local CDAs and farmers' organizations, in preparing demonstrations of PICS bags at local events. Of Bell's first run of 3,105 units in the last three months of 2013, only 255 went to commercial distributors, while 2,500 were purchased by USAID-KAVES, and 350 were bought by Caritas.[57]

The idea of reaching out to the non-governmental sector was based on the experience Purdue had in other countries and was in line with the approach adopted in Kenya by USAID-KAVES. PICS bags were a totally new product in the country and used the hermetic seal technology that, until their arrival, was only available using sealed steel silos that were too large and too expensive for most smallholders to use. USAID-KAVES saw its mission as creating a market alongside Bell industries and reasoned that this could only be done through the non-governmental sector, including farmers' groups in the rural areas. Their purchase of almost all the initial production run was in support of this approach and was intended to help Bell establish a market of initial adopters that would then take the product further to a position of market take-off.[58]

The strategy adopted by USAID-KAVES and Caritas to promote PICS bags in the countryside was to perform demonstrations of the bags in contexts where farmers gathered in some numbers. Such events and circumstances included meetings of self-help groups or regional and village events where farmers expected to meet agricultural and veterinary supply distributors (*agrovets*), as well as local agricultural extension officers and CSOs. Initial contact was made with community leaders who were offered free

[53] See, for example, Demand Forcasting Toolkit (http://www.smetoolkit.org/smetoolkit/en/content/en/416/Demand-Forecasting) , accessed September 22, 2016.
[54] According to information from the Purdue PICS team.
[55] Interview with technical director – maize and food crops, USAID-KAVES, Nairobi, April 4, 2016.
[56] As reported by CRS, which had used PICS in Tanzania and Sierra Leone, and by OAF, which had used them in Ethiopia and Rwanda.
[57] See Table 4.
[58] Interviews with USAID-KAVES and Bell Industries, Nairobi, May 2016.

bags in return for using their maize for the demonstrations. *Agrovets* were specifically invited to attend the demonstrations in the villages and were, in any case, present at the county fairs and other community activities, as well as being visited by extension workers who had already been informed of the national policy of supporting the introduction of hermetic seal technology.

The impact of using the bags can only be seen over time, so the demonstrations for farmers were essentially teaching sessions on how to use the product and "teasers," where a local farmer trusted by the community would be asked to keep the sealed, grain-filled bag for three months. These, then, were the "closing ceremonies" designed to pique the interest of the farmers and encourage them to come back for the corresponding "opening ceremonies" three months later. In this way, some 20,000 farming communities corresponding to some 2 million individuals were reached by the efforts of USAID-KAVES, civil society partners, and Bell Industries.[59]

The real test of the bags came at the "opening ceremonies," where larger numbers of farmers congregated, eager to see the results and, according to one farmer,[60] somewhat skeptical about the likely outcome. The undeniable quality of the grain emerging from the PICS bags and the absence of insects encouraged many farmers to seek to buy the bags.[61] Bell Industries increased production in 2014 to over 65,000 bags, more than 52,000 of which went to commercial distributors (including OAF) and the rest to NGO promoters to be used for demonstration purposes.[62]

Bell Industries also took to promoting the bags using its own network and field visits by the sales manager in charge of the PICS account.[63] Its initial business was in distributing pre-harvest chemicals to farmers, so it already had a wide and regular system of distributors and *agrovets* throughout the country. In addition, Bell's core activity did not conflict with post-harvest conservation but instead complemented it, because Bell did not sell the pesticide dust used to conserve bagged grain. This was in marked contrast to other agricultural suppliers who commercialized the chemicals for conservation of bagged grain (e.g., Actellic Super, Sumicombi, Skana Super grain dust, Spintor Dust, and Super Malper dust) recommended by the Kenyan National Farmers' Information Service.[64]

Caritas initial role was the first of what became an important role in promotion and distribution by NGOs and CSOs. These organizations saw promoting PICS as one element in an overall poverty-reduction strategy and, thus, aimed to help poorer communities obtain the bags with some form of initial subsidy to cover potential risk perceptions. Interviews with the review team validated this approach, and members of poorer communities who had acquired PICS bags (and intended to continue to do so) testified that they had been persuaded to do so by the intervention of CSOs and NGOs. The donor, USAID-KAVES, did not subsidize the activities of NGOs or CSOs, but made a small revolving fund available to Bell to cover cash-flow gaps. Retailers who carried the bags the "extra mile," both in terms of distance and income group, did so on the basis of a discount accorded by the *agrovets* and also received no subsidy. This was also in accordance with an established and quite efficient practice where individuals carry discounted goods at their own risk to remote communities that cannot afford to pay for transport in a minibus or other public vehicle to the nearest town with an *agrovet*.

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[59] USAID-KAVES, Nairobi.
[60] A farmer from Makueni, who now runs a small business distributing small quantities of PICS bags in Makueni County, interviewed April 9, 2016.
[61] Two Farmers in Eldoret, interviewed April 11, 2016; farmer in Sergoit, Ngishu County, interviewed April 12, 2016; and many others.
[62] Bell Industries interviews, April 5 and April 18, 2016.
[63] Interview with Bell Industries, sales manager, April 5, 2016.
[64] See Pest Control (http://www.nafis.go.ke/agriculture/maize/pest-and-disease-control/), accessed May 12, 2016.

In addition to Caritas, one of the most important players is OAF. OAF has integrated PICS bags into its catalogues since 2014, and by 2016 was offering the product to over 200,000 smallholders who will all receive training in its use. OAF operates on a "membership" basis, whereby groups of members are able to obtain credit in order to buy productivity-enhancing or labor-saving items from a catalogue. The credit is repayable after harvest, and OAF claims a 100 percent repayment rate. For 2016, the organization has had a 9.9 percent take-up rate for PICS bags through its catalogue.[65]

TABLE 9: ONE ACRE FUND AND PICS BAGS

	2015	2016
Farmers offered	34,620	209,067
Farmers bought one or more bags	2,735	20,710
Adoption	7.9%	9.9%
Total PICS bags sold	6,658	52,303
Average bags per farmer	2.4	2.5

Source: One Acre Fund (OAF).

Although OAF may be the largest CSO client of Bell, it is not the only one. Other allies in promoting PICS bags include the Anglican Development Service (ADS), CRS (especially the Archdiocese of Kisumu, Diocese of Eldoret), Caritas, Community Action for Rural Development (CARD), the Animal Draft Power Program (ADPP), and several smaller local initiatives. Bell also employs some local agents to encourage the sale and distribution of PICS bags in the rural areas who get involved in demonstrations and promotional events.[66]

Bell and others who were promoting PICS bags specifically mentioned the fact that using the bags obviates the need to use chemical insecticide dust. Many farmers interviewed for this report claimed that the dust "made their children ill,"[67] and not having to use it became a big selling point that was exploited by Bell to great effect. Bell promoted the PICS bags—and continues to do so—through radio broadcasts in the local vernacular, thus reaching an even wider audience than it does through markets and local community gatherings.[68] In addition, local volunteers connected to farmers' organizations act as unpaid "agents" for the bags; in return for fuel for their vehicles, they demonstrate the use of PICS bags within their own communities and in neighboring areas or fellow farmers' groups.[69]

[65] Interview with deputy country director, OAF Kenya, April 19, 2016.
[66] Interview with Bell agent on commission, Kitale, April 12, 2016; interview with Bell agent on salary, Eldoret/North Rift, April 11, 2016.
[67] Kanyapir Farmers' Group, Homa Bay, interviewed April 15, 2016. This attitude was also reported by several CDAs and NGOs including CARD, ADPP, and OAF, as well as by farmers themselves in all locations. The actual cause of such illnesses, however, may, according to ACDI/VOCA, be aflatoxin, a highly toxic secretion of a fungus present in maize fields all over Kenya.
[68] Interview with Bell sales and marketing manager, April 5, 2016; and Bell agent, Kitale, April 12, 2016.
[69] Interview with itinerant PICS bags promoter and farmer, member of the Kenyan Federation of Agricultural Producers, April 13, 2016.

A member of Musalava Women Farmers' Group, Kaani, near Machakos (left) shows her grain stored in PICS bags in her bedroom. April 08, 2016. On the right, a farmer from Eldoret is storing the bags incorrectly next to grain kept in permeable bags likely to attract rodents against which PICS bags are no defense. April 11, 2016. *Credit: Colm Foy, MSI.*

Once the market began to become established, local *agrovets* also participated in promotional activities for the bags[70] through attendance at local events and agricultural fairs, and through demonstrations of the bags during visits to or from farmers in their respective regions. Since the *agrovets* are also distributors of the insecticide dust used in the absence of hermetic storage, one way of estimating take-up is by referring to the drop in sales of the dust, which, at least in Kisii and Eldoret, was "significant," according to the local supplier. Since the income from sales of the dust seems to be dropping in any case,[71] distributors are turning their attention to winning the market for PICS bags and so are more actively promoting them.

The local CDAs are involved in promoting PICS bags, but are constrained by the obligation to avoid favoritism and support the distribution of other hermetic storage solutions as well. Individual CDAs have taken a varied approach to promoting hermetically sealed storage bags. For example, in Machakos County, east of Nairobi, and in Eldoret (Uasin Ngishu) in North Rift, the local CDAs and their staffs are knowledgeable about and active in promoting PICS bags,[72] whereas in Bungoma, the local CDA's office was knowledgeable about PICS bags but was hardly engaged at all in their promotion.[73] Elsewhere, the CDA offices' involvement in promoting PICS bags fell somewhere between these two extremes, although all of them were aware of the benefits of hermetic storage. The involvement of the local offices was also influenced by two factors: resources and the level of involvement of the extension officers. In Machakos, Mona Bay, Kisii, and Uasin Ngishu counties, despite heavy workloads, extension workers were deeply involved in disseminating information about the PICS solution and wholly committed to distributing it throughout their areas. In all these cases, extension workers took PICS bags with them on their regular rounds, both to demonstrate and to sell. As a result, farmers reported that extension workers had influenced them in obtaining PICS bags.[74]

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[70] Interviews throughout April with distributors in Machakos, Makueni, Eldoret, Kitale, Homa Bay, and Kisii.
[71] See FAO Statistics Division (http://faostat3.fao.org/home/E) . The use of pesticides in Kenya is declining sharply and has dropped by two thirds since 1990. All of the *agrovets* interviewed reported declining pesticide sales, though the reasons in addition to the use of PICS bags are not clear.
[72] Interview with CDA, Machakos County, April 9, 2016; and interview with CDA, Ngishu County (Eldoret), April 12, 2016.
[73] Interview with acting CDA, Bungoma, Dr. Stella Wobobwa, April 14, 2016.
[74] The members of Musalava Women's Group in Kaani, Machakos County, for example, reported that they had first heard of the bags through the local extension worker and were then approached by USAID-KAVES who helped them understand and learn how to use the bags (interview, April 8, 2016). In some cases, the activities of the county extension workers and those from projects, such as USAID-KAVES or CARD, are blurred in the minds of farmers.

VI. POTENTIAL SCALE OF ADOPTION

According to the MoA, there are some 10 million small-scale farmers in Kenya, 98 percent of whom are growing maize to a greater or lesser extent. In the Eastern region, North Rift, and Western region, maize is grown as the staple, both as subsistence food and as a cash crop. In 2014, 39 million 90-kilogram bags of maize were harvested, slightly down from the 40.7 million bags the previous year.[75] Of this, 66 percent is either immediately sent for milling or consumed in other ways, leaving some 13 million bags to be stored. This, then, is the absolute potential market size for maize storage, but it may be extended further when storage of other grains, including sorghum, are taken into account.

A reasonable estimate for scaling, however, on the assumption that scaling is part of a *process*, rather than an *end*, in this case, would be about a third of that, or 4 million bags. Since Bell's entire production so far amounts to only 452,659 units, PICS bags have clearly not gone to full scale in Kenya yet. Even if the ambition of producing about 760,000 more units this year were to be achieved, there would still only be 1.3 million bags in circulation, 66,000 of which are nearing the end of their programmed existence. However, were Bell able to reach its desired output of 1.5 million units per year henceforth, scale could be achieved in under six years (see Table 10), assuming a standard product "retirement" rate of three years.[76]

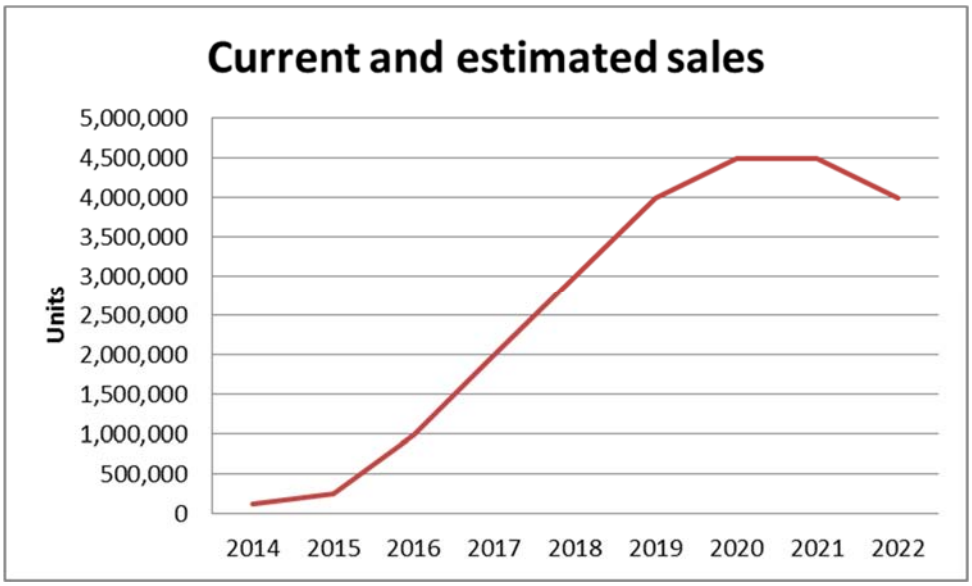
TABLE 10: SCALING TIMELINE

Factor	2014	2015	2016	2017	2018	2019	2020	2021	2022
Current sales	125,000	250,000	1,000,000	2,000,000	3,000,000	4,000,000	4,500,000	4,500,000	4,000,000
Cumulative stock			1,375,000	3,375,000	6,250,000	10,000,000	13,500,000	16,000,000	17,000,000
Less bags that need to be replaced				125,000	250,000	1,000,000	2,000,000	3,000,000	4,000,000
Net stock			1,375,000	3,250,000	6,000,000	9,000,000	11,500,000	13,000,000	13,000,000

Source: Authors' estimates and calculations.

[75] Republic of Kenya (2015), *Economic Survey 2015*, Kenya National Bureau of Statistics, Nairobi.
[76] During interviews with farmers, however, they confessed the intention to use the bags beyond three years before ordering anew.

FIGURE 1: CURRENT AND ESTIMATED SALES CURVE



There is increasing demand for hermetically sealed crop storage bags, as farmers both hear about the system and witness the results of its use on their neighbors' plots. This is good news for all the manufacturers and importers, but especially for Bell. Bell's order books are full, and the *agrovets* report not being able to keep up with the demand. Villagers return home disappointed (and the cost of a bus or *matatu* ride poorer) because there were no PICS bags available in town. In January 2016, the supply of bags ran out entirely, a situation that continued into the following month.[77] The reasons for the enthusiasm are not hard to find. Kenyan farmers are subject to both real and rumored PHLs. Estimates of losses of 18 percent by weight are common,[78] and even the MoA advances a figure of "… up to 40%"[79] of PHLs in maize. Rumors in the countryside include reports of individual farmers losing 100 percent of their crops to insects, especially the main enemy, "Osama," the LGB. Everyone in the farming community knows of someone who suffered catastrophic losses, and even if these claims are dismissed as nonsense by some, including ACDI/VOCA,[80] they are widely believed.[81]

Challenges in Scaling Up

Ensuring adequate production to keep up with accelerating demand has been the major challenge of scaling up PICS Bags. Bell Industries outsourced production from the start, currently to PPTL in Tanga, Tanzania. As the business grew, it quickly became obvious that the company could not absorb the cash flow crunch it was experiencing between paying its supplier and awaiting receipts from the *agrovets*. Seeking a bank loan was not really an option, since the rate of interest would have exceeded 22 percent, and it was not certain that such a loan would be forthcoming. To address this issue and facilitate scaling, USAID-KAVES provided a revolving credit of USD 120,000 (KES 12 million). This resolved the short-term problem. However, as production increases and orders to the manufacturers also increase, so does the extent of the cash-flow problem. If in the long-run steady state Bell or others are selling 4

[77] According to interview with Bell's sales and marketing manager on April 18, 2016, this served as a wake-up call and encouraged the company to take steps to increase production and ensure that it did not happen again.
[78] See, for example, the African Post-Harvest Losses Information System (APHLIS) at www.aphlis.net.
[79] Interview with assistant director of agriculture, MoA, April 5, 2016.
[80] Interview with ACDI-VOCA, April 20, 2016.
[81] This type of report was common in interviews with farmers and their associations, though nobody was able to produce someone to whom it had actually happened.

million bags annually, this is 333,333 bags per month, worth KS 46.6 million or about USD 466,000. For Bell to be able to meet a cash flow with a three-month lag in payment would require KES 140 million, or USD 1.4 million. However, by September2016, Bell had developed a relationship with its suppliers that grants the company 7 to 30 days of credit for a maximum of KES 10 million, which relieves part of the cash-flow pressure, although the long delay of up to 120 days in receiving payment from the *agrovets* is still a problem.

Bell has purchased its own machine to manufacture the bags, but this is not really a "solution," since it requires substantial maintenance, staff training, and a constant and reliable power supply that at present is not available in the premises where the machine is located. In addition, the capacity of a single machine is about 30,000 bags per month, assuming full and uninterrupted production, which is far below needs; to produce 333,333 bags per month would require at least 14 machines taking into account down time for maintenance or other issues. Moreover, the exterior layer is still produced by a sub-contractor. These issues will need to be resolved if Bell is to meet the rising demand and not lose market share to emerging competitors.

The newly acquired extruded plastic PICS bag manufacturing machine operating in Nairobi. The day this photo was taken, the machine was out of commission for half a day. April 7, 2016.

Entrance into the market by sub-quality counterfeit products is a serious and real threat, and has already been seen in Nigeria, according to the Purdue PICS team. There is no reason to assume the same will not occur in Kenya. PICS bags are largely promoted by early adopters and farmers themselves, as well as the *agrovets* who find them profitable, so much of their success is based upon reputation. If inferior products become available, the faith of the farmers will be shaken, especially if they open their "PICS" lookalike bags to find their grain (and their livelihoods) ruined. In such a case there is a danger that many farmers will abandon the technology as being too unreliable and return to the "devil they know."

It is nonetheless important to distinguish between "competition" and "counterfeit." Competitors have entered the market with a branded product that conforms to certain standards specified by the Government of Kenya, while counterfeit products merely mimic the genuine article, with conformity to quality rather variable or non-existent. It would be advisable and important for Bell to develop a label resistant to counterfeit or for the nascent industry to establish a standard identifying mark that distinguishes tested hermetic solutions from unregulated ones. This is something that donors need to

take into account when they support the introduction of a new technology the impact of which can be evaluated only after purchase and use.

As demand continues to rise, the *agrovets* may cease offering the discounts to small traders who supply remote rural areas and farmers' groups, since there will be ample business without the discounted units. This would effectively limit the extension of supply and resupply to those farmers who live close enough to the distribution points in the towns or are able to reach them on economical transport. This is a problem already recognized by, for example, OAF, which carries the products bought by members to distribution points within 2 km of their farms.[82] As the product becomes more and more profitable, Bell may wish to consider extending its own networks to ensure access in more remote areas, perhaps in cooperation with local *agrovets*. However, since this would clearly be unprofitable for a commercial enterprise, it could be an issue that donors and local authorities might consider funding in order to take PICS bags "the last mile" to the neediest and poorest sections of the rural community.

One final consideration is what to do with the millions of PICS and other plastic storage solutions when their useful life is over. There is some evidence from Nigeria that the bags are recycled, used for other forms of storage, or transformed into tarpaulins at the end of their lives as hermetic storage,[83] but full-scale research into the question may need to take place before a clear answer emerges. In Rwanda, for example, where PICS are already in use and where, in general, the use of plastic bags is prohibited on environmental grounds, the distributor is also a recycling company and will buy back the bags at the end of their lives. Though this is unlikely to be a serious challenge for Kenya in the short term, it may be worth taking pre-emptive action to ensure that the Kenyan countryside does not become littered with retired PICS bags.

VII. KEY FINDINGS AND CONCLUSIONS

Characteristics of the Innovation

Relevance of the Innovation

PICS bags are easy to use, inhibit the spread of insect infestations present in the grain at harvest time, prevent new infestations, maintain the quality of the grain for consumption and sale, enhance food security and nutrition levels, free up land for high-value cash crops, and are cost effective. They are, *prima facie*, the right product for several needs of the market.

PICS bags found a ready market amongst Kenya's maize farmers. The benefits to farmers were very clear and addressed a strongly felt need: increasing food security and reducing PHLs. Farmers could clearly and easily see the impact of PICS bags on insect infestations, and that is why they adopted them. Although the PICS bags actually have a measurable impact on the transmission of aflatoxin, and potentially other health benefits, that aspect of the bags' use was never once cited by farmers to the review team.

Minimal Changes to Current Practices

The science behind PICS bags is quite complex, but the implementation is simple. In under an hour, a group of farmers can learn the techniques required hermetically to seal PICS bags and benefit from their

[82] Interview with OAF, Bungoma, April 14, 2016.
[83] Baributsa, D., K. Djibo, J. Lowenberg-DeBoer, B. Moussa and I. Baoua (2014), "The fate of triple-layer plastic bags used for cowpea storage", *Journal of Stored Products Research* 58 (2014) 97-102.

full effectiveness. End-user farmers are not required to learn any complex sequencing—as they would be, for example, in applying a new type of fertilizer or pesticide. All they have to do is learn how to dry the grain, which entails merely drying it in the sun, fill the bags while expelling the air, and tie them correctly.

A farmer using PICS bags for post-harvest storage is not required to change any established practices prior to preparing her grain for storage. At that point, the crucial dryness level must be reached, which, until grain dryers become widely available, can still be a challenge. Instead of using porous bags with string ties, farmers use the triple-sealed, tight-tied plastic variety. The only other change is the requirement that the bags should be stored separately from other food products to avoid contamination and rodent attacks. With just these few slight changes, the farmer can reap the full benefits of the PICS bags innovation.

Minimal Risk

Even for poor farmers in Kenya, the risk is minimal, since the PICS bags are cheap, though they are slightly more expensive than the traditional gunny bags. When farmers look at initial outlay, they take into account the cost of the bags, but also factor in the cost of pesticides and the inevitable PHLs that occur in any case, as well as the decline in the quality of the stored grain. In most cases, and even without producing a surplus to sell, farmers recover the cost of the PICS bags in one season and can use the bags for two or three years after that. Hence the initial risk to the farmer is very low, which makes the product inexpensive to try, and farmers can experience its effectiveness for themselves.

Business Case for Farmers, Distributors, and Others

The value chain for PICS bags provides an affordable product for farmers, while providing reasonable profits for each link in the chain. The essential element is the large potential number of units sold. While 30, 50, or 60 cent profit margins may seem small, the relative percent profit is large and results in considerable income when multiplied by hundreds of thousands or millions of units. Even small traders, who are able to shift two or three hundred units in a month, can make a useful supplementary income alongside their core activities. There are no cases of PICS bags languishing unsold on commercial premises. On the contrary, everyone associated with their sale reports rising demand and even impatience on the market. In these conditions, the sustainability of the value chain is ensured for the foreseeable future.

Despite their low cost to the end user, PICS bags are highly profitable to the national wholesaler. This means that Bell Industries is prepared to invest in promoting and supporting the product, driving up sales and distribution and carrying the innovation to scale. Based on projected profits, the company is expanding its production and foresees becoming independent of the minimal financial assistance and technical support it has been receiving up to this point.

Adoption Drivers

PHLs of maize have been a fact of life in Kenya, and the struggle to reduce them has been arduous and ongoing. The introduction of PICS bags, and the demonstration after three months' storage that they are almost 100 percent effective, has led to a groundswell of enthusiasm for their use. In fact, the more the bags are distributed, the higher the demand. Initial adopters have become advocates for the bags in their communities, alongside the suppliers, CSOs, and local CDAs.

The support for hermetic technology as a means of reducing PHLs operates at the national, county, and non-governmental levels. The Kenyan government is actively seeking both to increase maize production

and to reduce PHLs. At the same time, the private sector is aware of the market importance of hermetic storage. Hence, there is a coalition of farmers, those who work with them, and the public authorities that is available to support the introduction of PICS into the country.

External Context or Spaces

Conducive Public Environment

The Kenyan authorities see hermetic storage solutions, such as PICS bags, as a valuable part of their struggle to reduce PHLs. Hence, county officials—particularly the CDAs and their staffs—and parastatals, such as the NCPB, support the introduction of PICS bags, both in principle and in many cases in active promotion. While the use of hermetically sealed post-harvest solutions is in line with government policy, the amount of active support from CDAs for the innovation varies.

Established Private Sector

The agricultural supply industry in Kenya is developed and used to distributing inputs throughout the country using private and public transportation networks. The *agrovets* are established in towns in every county and are used to carrying on their business with indigenous and foreign suppliers. It was, therefore, relatively easy to find a wholesaler with a national distribution network. Each link in the value chain functioned according to established custom, which allowed for long-term credit, payment systems, and personal relationships that made business smoother and adapted to accepting new products. The private sector, supported by NGOs and CBOs, in a context of affordability of the product and well-developed infrastructures, is able to promote and distribute the bags successfully to a wide market.

Scaling Strategy

An Appropriate and Effective Commercial Partner

Bell Industries had a system of distribution capable of handling PICS bags already in place, was able to benefit from Kenya's good quality infrastructure, and found a manufacturer that could supply its needs efficiently. Assistance from a donor agency in the form of revolving credit was essential in the initial phase, but amounted to a very small investment indeed. Hence, donors and the public authorities, where they perceive an innovation to be a priority, need to be ready to provide such seed money, on the understanding that it will be a temporary measure.

Coalition of Partners

Purdue, PfI, USAID, and Bell Industries were fortunate in having the support and cooperation of actors in the non-governmental sector right from the beginning. This impacted the credibility of the innovation in the eyes of end users who were used to working with non-governmental and public partners and had already established relationships with them. The exploitation of a wide range of partners also allowed for a wider reach than may have been possible with USAID-KAVES and Bell Industries on their own.

The involvement of USAID-KAVES was pivotal in introducing PICS bags to Kenya. The commercial partner did not have the experience or the means to establish a country-wide promotional strategy in the short term and depended on the USAID-KAVES network and relationships with other civil society actors. Moreover, USAID-KAVES was able to offer management, commercial, and technical advice to Bell Industries and set up meetings with the company and advisors from the commercial sector. Its role in promoting the bags themselves, encouraging and advising Bell Industries, and supporting the promotional activities of CSOs and church groups was vital and probably crucial to the successful

penetration of the market. However, the subsequent assumption of a marketing role by the private sector also represented a major element in introducing the innovation to end users and ensured the continuation of promotional and marketing activities.

The public sector, by generally supporting the use of PICS bags and, in many cases, actually promoting them, gave both credibility and long-term confidence in the product. As a result, PICS bags now occupy a position of trust in Kenyan farming communities, which explains the continually rising levels of demand for the innovation.

Potential Scale

Imaginative promotional activities and the willingness of early adopters to promote PICS bags have created a demand level throughout the country, according to Bell, that could be described as already being "at scale." However, in the short, almost three-year period leading up to September 2016, the distributor has not been able to match supply to the increased demand. At the same time, as efforts to advertise the bags continue, and as peer-to-peer information continues to flow, demand is continuing to increase. However, Bell Industries is making serious efforts to meet the challenge, and should they be successful, the innovation will have gone to scale in under seven years from its introduction.

In order to meet demand, the distributor is changing tactics and investing in its own production of PICS bags. This can be only a partial solution in the short term. Meanwhile, the market for hermetic solutions is rapidly increasing, which may encourage sub-quality products that may end up in the most remote areas as *agrovets* remove the subsidies they offer on PICS bags to small traders.

Reaching the limits of potential scale within Kenya, which would entail bringing the innovation to the entirety of the market, is problematic using commercial pathways, even in the case of a simple, inexpensive, easily transportable product like PICS bags. This is because the poorest of the rural poor tend to be located in the most remote areas, and this imposes a price premium linked to transport costs, unless a discount is applied at some stage along the value chain. At present this discount is offered at the *agrovet* level, although the *agrovet* is compensated by neither increased sales nor subsidies. Should circumstances change—through lower prices from increased competition, for example—this rural discount practice could come to an end, leaving the most vulnerable smallholders unable to have access to the technology. This situation is not unique to PICS bags or Kenya and needs to be taken into account when supporting the scaling of agricultural innovations in developing countries, especially as an element in a strategy of poverty alleviation and enhancing food security.

VIII. LESSONS FOR DONORS

Identify the Right Product at the Right Price

Smallholder farmers cannot afford to experiment with innovations that may or may not respond to a need they have identified. These farmers are much more likely to adopt a product, such as hermetically sealed bags, that they can see demonstrated as effective in attacking one of their problems at a price they can afford, than a more expensive technology, such as steel silos, that they cannot afford without increasing debt. They tend to be risk-averse, and the experience of PICS bags in Kenya reflects the findings in other case studies in this series that the higher the up-front risk, notwithstanding demonstrably positive expected outcomes, the lower the take-up.

Identify the Right Research and Innovation Partner(s)

Purdue University proposed PICS bags as a product designed to increase farm incomes and food security, which are objectives identified by donors as development-enhancing, while being frequently elusive. Purdue also proclaimed itself prepared to participate in introducing and marketing the product, and indeed had done so elsewhere previously, so was a credible partner. Within Kenya, the selection of CSOs already active in working with smallholder farmers meant that both Purdue and USAID via USAID-KAVES were able to draw on their expertise and benefit from their established channels of communication. This saved time and effort, increasing the efficiency of the introduction of PICS bags to the smallholder farming community.

Identify the Right Commercial Partner

If the intention is to use commercial pathways to introduce and distribute the innovation, donors need to align their objectives with a private-sector partner's business plan and capacity. In the case of PICS, the eventual chosen partner successfully climbed a steep learning curve, as far as the nature of the product was concerned, but failed adequately to address the issue of evaluating potential market size. As a result, production capacity fell behind rising demand, leading to the adoption of emergency measures, such as opting for in-house production capacity, that carry with them additional risks in terms of capital and human investment. USAID-KAVES recognized this problem and attempted to work with Bell Industries to find solutions, but it would have been preferable to have identified the problem in advance through demand forecasting. In addition, the original choice of national wholesaler by Purdue was unsuited to the task, which revealed the need for donors to be particularly careful in making the choice.

Identify Hidden Costs and Anticipate the Unexpected

In the case of PICS bags, the reaction of local civil society partners and of end-user farmers seems to have taken donors and commercial producer alike by surprise. The result was a hasty effort to provide sufficient supplies to the market and a cash-flow problem that was resolved by the provision of a revolving fund by the donor. On its own initiative, the commercial partner purchased a machine to manufacture PICS bags at some expense from India. Raising in-house production capacity beyond this first machine would involve considerable capital and human outlay, requiring resources that the company does not have at its disposal. Donors need to anticipate as far as possible such eventualities and prepare a response before the problem manifests itself. In particular, donors need to decide in advance whether they are prepared to finance downstream expenditures of this type.

PICS bags effectively opened the market for small-scale hermetic bag technology in Kenya. Once Purdue University, PfI, and Bell Industries demonstrated the effectiveness of the product and the potential of the market, other commercial actors marketing similar products arrived on the scene. AgResults, a multi-donor organization, entered the funding structure without discriminating for or against the competing products, while USAID remained committed to Bell Industries and PICS bags. The development of competition should be seen as a positive result, but donors will need to decide how they will react to such a transformation of the market.

Donors cannot ignore the question of quality control. While the entry of competitors into the market is positive and desirable, the arrival of counterfeits is not. Where an innovation is successful—and has, therefore, gone to scale—the temptation for counterfeiters is substantial. An innovation, by definition, is an unfamiliar product, and farmers can easily be fooled into thinking they have bought the genuine article, particularly in a context of shortage. Donors may wish to consider financing or co-financing quality control mechanisms when they support the introduction of an innovation.

IX. SUMMARY OF CONCLUSIONS

PICS bags have been shown to be effective in lowering PHLs due to insect infestation, including in circumstances where pests are already present in the grain. They are also effective in limiting the spread of the fungus carrying the aflatoxin infection. The bags are easy to use, easy to store, and—as end users can see once the economics are explained—cost-effective. Their use requires virtually no change in farmers' practices, although farmers must ensure that the moisture content in their grain is at most 13.5 percent. In fact, PICS bags obviate the need to re-treat sealed bags with pesticide every three months. In a context where farmers, the national authorities, and the international community are very concerned about PHLs in staple grains, they constitute the right product, at the right place, and at the right time.

The proof of this observation is the acceleration in demand for the product over the short time—just under three years—that it has been available in Kenya. Indeed, that demand has been largely fueled by the actions of farmers themselves who have actively promoted the bags through their groups and geographical areas. Local traders and *agrovets* have also promoted the innovation, as have the suppliers and their agents in local areas. It can be shown that the market for the product exists and is likely to remain in existence as long as small farmers need to protect their grains from post-harvest insect attacks and the country needs to struggle against aflatoxin. That means that, until something better comes along, PICS bags are likely to be in demand for a very long time, so the market is commercially viable and sustainable.

The reason PICS bags have not yet gone to scale in Kenya has nothing to do with the bags themselves. They are relatively simple to produce, their use is easy to understand, and their impact is obvious. The challenge lies in the commercial strategy of the manufacturer who, it is fair to recognize, was taken by surprise by the success of the bags. It has taken a relatively short space of time—about 18 months—for a new strategy to be adopted to resolve the problems of production. An additional impetus is the entry to the market of competitors who are actively seeking market share. While this is a sign of a healthy product and a healthy market, it also represents a challenge for Bell Industries and one they will have to confront if they are to remain market leaders in hermetic storage technology in Kenya.

The role played by PICS bags in popularizing hermetic storage technology in Kenya can no longer be in any doubt. The donor—in this case, USAID through USAID-KAVES—has played a central role in introducing hermetic storage to Kenya and in helping to resolve problems faced by the national wholesaler, as well as difficulties encountered by partners in popularizing the technology. One important lesson is that supporting an innovation of this kind also renders necessary as realistic a forecasting of demand as is possible. At the same time, the difficulties of going "the final mile" to the poorest of the rural poor must be recognized, and ways of overcoming them explored in a timely fashion.

ANNEX A: LIST OF MAJOR INTERVIEWEES

TABLE 11: DETAILS OF FIELD MISSION, APRIL 4 – 20, 2016

Date (April 2016)	No. of People	Name(s) of Individuals/Groups	Meeting Highlights/Notes
4th	2	1. Mr. Steven New – Chief of Party 2. George Odingo – Technical Director – Maize and Food Crops USAID-KAVES	Outline of strategy to introduce and promote PICS in Kenya
5th	2	1. Lunah Njeri, Sales and Marketing Manager 2. Leah Muriuki, General Manager	Description of business plan, marketing strategy, outline of current level of business
5th	1	Mrs Jacinta Ngwiri, Assistant Director of Agriculture	Outline of government policy, some details of production levels and import needs + PHLs
7th	1	Mr. Mugambi Ibui, Project Leader	Demonstration of plastic extrusion machine
8th	2	1. Japheth Katumo – ADS Machakos 2. Steven Muli	Local representatives in Machakos of USAID-KAVES, provided briefing and transport
8th	2	1. JM Kariuki – CDA Machakos County 2. Caroline Kimweli – Crops Officer	Briefing on local farming situation and grain-storage practices
8th		Partrick Mutua Mutisya – PICS Bags Distributor Machakos	Explained business model and praised quality of bags, cited high demand and good profits
8th	1	Susan Muia – Agent Wote Makueni	Itinerant retailer
8th	9	Musalava Women Group – Kaani, Machakos	100+ members of women's cooperative using PICS bags to store maize. Supplied by USAID-KAVES
8th	4	Wamunyu Grain Aggregation Centre Board 1. Gorge Mutu Auziu – Chairman 2. Festus Muthoka – Secretary 3. Sammy Ngati – Agriculture Officer 4. Peter Muindi – Store Clerk	As part of a drive towards "aggregation," the County provides support and a chairperson to groups of farmers wishing to come together for purposes of marketing, packaging, and sales.
9th		Travel to Nairobi	
10th		Travel to Eldoret	
11th	1	David Kimtai – Maize Specialist, KAVES Eldoret	Described USAID-KAVES operations in Western Region, accompanied field visits
11th	1	Amos Kipsang – Sales Agent, Bell Industries – Eldoret/Northrift	Outlined his activities in support of Bell's sales and distribution strategies in the area.
	1	David Cheruyiot – Farmer	Demonstrated use of PICS for preserving maize on multi-crop, mixed farm outside Eldoret.

Date (April 2016)	No. of People	Name(s) of Individuals/Groups	Meeting Highlights/Notes
	1	Susan Chemueno – Distributor	*Agrovet* distributing PICS bags: demand is "variable," but always high; ran out in January/February.
12th	2	1. Scolasticah Odhiambo 2. Mr. Joseph Cheboi – CDA	Demand for PICS rising, but supply concerns. Farmers need advice on rodent control.
12th	2	1. Samuel Yego, Director 2. Vivian Saina	Description of activities of NCPB, pricing policy, promotion of PICS, tour of facility
12th	1	Samson Chepkonga – Farmer	Application of PICS to a small family farm setting; ability to free up land for cash crops via PICS use
12th	1	Shirley Kibor – Sales Agent	Works on commission and finds that PICS afford a good opportunity for income – high demand
13th	3	1. Edward Osanya – CDA 2. Simon Mwombe – Agribusiness Officer 3. Keneth Kagai – Crops Officer	Three hermetic bag suppliers, but PICS most popular, especially supported by OAF. CDA promotes at farm meets, groups, and fairs. Coordinates with others.
13th	1	Musa Naibei – Farmer and PICS Bags Promoter	The Kenya National Farmers' Federation (KENAFF) is a non-political, non-profit making and democratic member-based umbrella organization of all farmers in Kenya. It represents the interests of about 2 million farm families.
13th	1	Joseph Nzomo, Mazop Enterprises – Distributor Kitale	Very large *agrovet* sells "thousands" of PICS every month. Demand is rising, competition not as good.
13th	1	Mr. Sigei – Kenya Farmers Association-KFA – PICS Bags Distributor Kitale	Travels the area offering advice on the use of PICS bags, arranges for transport of large orders.
13th	9	Tumaini Self-Help Group – Saboti Users of PICS Bags	Farmers' group with 70 families growing maize in remote rural area; use PICS but need more and cannot afford transport. Bulk order with others?
14th	12	Lukhuna Jitahidi Group – One Acre Fund	Farmers' group with 80 members. Obtained PICS via OAF scheme. Highly satisfied, want lower price.
14th	1	Karen Underwood	Outlined OAF objectives, procedures, and promotion/supply of PICS.
14th	1	Dr. MaryStella Wabobwa- MoA, Acting CDA Bungoma County	CDA works with OAF, ADS, and extension workers to promote PICS; reach about 35,000 farmers/year
14th	2	1. Scolastica Baraza-PICS Bags User 2. Mildrade Malala- PICS Bags User	Ms. Baraza is a smallholder and uses PICS for family. Ms. Malala buys grain for selling to schools and uses PICS to store it while awaiting sale and in school storerooms.
14th	1	Rev. Johnstone Nyongesa – ADS Coordinator	Protestant aid agency coordinator for the Western region. Promotes PICS via churches of all denominations and does demonstrations in villages. Arranges transport to remote areas.
15th	2	1. Sylvester Oketch – CDA Nyanza 2. Dominic Otieno – Crops Officer	Outlined support for PICS, which is good in principle, but reported resistance because of price.
15th	1	Phillip Kajwang – Project Director, CARD	Also a medium-scale farmer so uses and promotes PICS. Highly appreciated

Date (April 2016)	No. of People	Name(s) of Individuals/Groups	Meeting Highlights/Notes
15th	1	Mr. Jacob Otieno Ongow – Project Director, ADPP	Promotes PICS in conjunction with local *agrovets*
15th	1	Noah Juma Odundo, Project Field Officer – Homabay, CARD	Brings PICS to villages on his motorbike for demos and sales
15th	1	Joseph Okello, Awendo General Stores – Homabay	Sells directly to public and via CARD or ADPP. "Very profitable, less work than chemicals."
	3	Triza Achieng Owino, Kanyapir Farmers Group – Homabay	Farm supports 14 people, grows 11 bags, down from 16 because of PICS, so cash crops.
16th	1	Yobes Onyanja, Project Field Officer-Kisii, CARD	Promotes and demonstrates bags in remote areas, offers transport for free.
16th	1	Rabecca Mora, Farmer and PICS Bags User-Kisii	Been using PICS for 2 years, plans to increase stock from 3 to 6 or more.
16th	1	Norah Mageto, Distributor PICS Bags-Kisii	Stocking PICS for 6 months and selling 300/month.
18th	2	1. Ephrahim Chabayanzara – Catholic Relief Services 2. Gregory Makabila – Catholic Relief Services	Gregory managed the CRS/PICS program in Tanzania; praised the bags for their effectiveness and ease of use.
18th		1. Lunah Njeri 2. Leah Muriuki 3. Mugambi Ibui	Report back
18th	1	Maryann Njogu, Programme Coordinator	KCEP is funded by EU/IFAD/equity bank. Selected farmers receive an e-voucher for fertilizer, seed, a tarpaulin plus 10 hermetic bags. Farmers contribute 10% initially. This graduates to 40% and 60% in the 2nd and 3rd years.
18th	2	1. Phinias Nyaga – Director, Plant Protection Section of the MoA 2. Francis Musavi – Plant Protection Section of the MoA	Non-devolved section of the Ministry of Agriculture for (i) management of trans-boundary pests, (ii) storage pests, and (iii) aflatoxin/micro toxins. Hermetic bags need good training. (KALRO has been promoting dryness meters, recently acquired 2,000 units.)
19th	1	John Clark	Elaborated on OAF's structures and activities, provided data for final report.
19th	1	Sophie Walker	PICS inhibit aflatoxin-carrying fungus, so good, but skeptical about claims of PHL reduction, especially from LGB and IGB.
20th	1	Andrew Gathecha	Outlined AgResults projects, suggested that it was one of the main factors behind entry of competitors to PICS.
21st	2	Samson Okumu, Enock Kanyanya	Final debriefing at U.S. Embassy with preliminary conclusions. S.O. emphasized importance of dealing with the waste plastics issue upstream.

ANNEX B: SAMPLE QUESTIONS

Field interviews were purposely left fluid to account for the very wide range of roles and impacts that various actors had on scaling. These examples, however, present an outline of the interviews according to category.

Group I: Farmers and Farmers' Groups

How did you first hear of PICS bags?
Why were you interested?
Was it easy to obtain the bags?
Where did you get them from?
What do you think of the price?
How many bags did you purchase?
Did the seller or anyone else offer training?
Have you found them easy to use?
If you have already emptied bags, what has been the result in terms of the preservation of the grain?
Is the result better than with traditional bags?
Have you had any problems or disappointments with the bags?
Are you still using them?
Have you all the bags that you need and, if not, will you buy more?
Have you any other comments?

Group II: Vendors

How did you first hear of PICS bags?
Why were you interested?
Was it easy to obtain the bags?
Where did you get them from?
What do you think of the price?
Do you pay cash for your supplies?
Do you actually promote PICS bags yourself?
Have you been able to keep up with demand?
Who are your principal customers?
Are there many repeat customers?
Do you offer training?
What do you think of the competition?
Do you intend to continue selling PICS bags?

Group III: Public Officials and NGOs

Have you heard about PICS bags?
How did you hear about them?
How does your ministry/county/local office see them contributing (or not) to local farmers' livelihoods?
Are you supporting promotion of PICS bags?
How?
What results of your efforts can you describe?
Are you using the bags yourself(ves)?

What has been (is) the result?
Are you planning to continue using them?
Have they contributed to the wellbeing of local households?
In what way?
Are people in your areas continuing to acquire the bags?
How do you see the future of PICS bags in Kenya?

Group IV: Miscellaneous (manufacturers, researchers, local associations and journalists)

What is your role in the manufacture, distribution or promotion of PICS bags?
How did you become involved?
What contribution to the introduction of PICS bags did you make?
What solutions do PICS offer to which problems?
How do your activities contribute to the scaling of PICS bags?
Are there any negative impacts?
Have you been surprised by the commercial success or challenges?
Do you think PICS have made positive and a lasting impact?
What was done well overall?
What was done badly or sub-optimally?