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SYNTHESIS REPORT

REVIEW OF SUCCESSFUL SCALING OF AGRICULTURAL TECHNOLOGIES

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COVER PHOTO

Caption: PICS Bags for Sale in Kenya.

Credit: Colm Foy, MSI.

SYNTHESIS REPORT

REVIEW OF SUCCESSFUL SCALING OF AGRICULTURAL TECHNOLOGIES

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E3 Analytics and Evaluation Project

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I. ACRONYMS

AFP	Axial Flow Pump
ASU	Arizona State University
BADC	Bangladesh Agricultural Development Corporation
BMGF	Bill and Melinda Gates Foundation
BFS	Bureau for Food Security (USAID)
CIMMYT	International Maize and Wheat Improvement Center
CNCAS	*Caisse Nationale de Crédit Agricole du Sénégal*
CSISA-MI	Cereals Systems Initiative for South Asia – Mechanization and Irrigation
CBO	Community-based Organization
DTM	Drought Tolerant Maize
DTMA	Drought Tolerant Maize for Africa
E3	Bureau for Economic Growth, Education, and Environment (USAID)
FISP	Farmer Input Support Programme (Zambia)
FRA	Food Reserve Agency (Zambia)
FTF	Feed the Future
GAPs	Good Agricultural Practices
GOK	Government of Kenya
GOS	Government of Senegal
GOZ	Government of Zambia
Ha	Hectares
iDE	International Development Enterprises
IP	Implementing Partner
KAVES	Kenya Agricultural Value Chain Enterprises
KII	Key Informant Interview
LSPs	Local Service Providers
M&E	Monitoring and Evaluation
MFI	Micro-Finance Institution
MOA	Ministry of Agriculture
MT	Metric Ton
MSI	Management Systems International
NAGRC & DB	National Agricultural Genetic Research Centre and Databank (Uganda)
NGO	Non-governmental Organization
PCE	*Projet Croissance Economique*
PICS	Purdue Improved Crop Storage
PSP	Private-Sector Partner
PT	Power Tiller
PTOS	Power Tiller Operated Seeder/Fertilizer
SAED	*Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé*
SOW	Scope of Work
SRV	Senegal River Valley
USAID	United States Agency for International Development
ZOI	Zone of Influence (Feed the Future)

II. EXECUTIVE SUMMARY

This report provides summary findings and conclusions from a set of five case studies examining the scaling up of pro-poor agricultural innovations through commercial pathways in developing countries. The E3 Analytics and Evaluation Project conducted the studies and prepared this synthesis report on behalf of the United States Agency for International Development's Bureau for Food Security (USAID/BFS), as part of the Bureau's efforts to scale up the impact of the Feed the Future (FTF) initiative. The study's findings also draw on the results of a one-day workshop at which the Project team presented the case studies and preliminary findings to a group of agriculture and scaling experts.

USAID/BFS commissioned this study to produce lessons and, ultimately, guidance for the Agency including its country Missions about what types of innovations and which country contexts are best suited for scaling up through commercial pathways, and to identify the activities, strategies, and support necessary to facilitate successful scaling. The findings are timely as the U.S. Congress recently passed the Global Food Security Act, which will continue support for global food security, resilience, and nutrition. Findings on scaling are very relevant for informing the development of the Global Food Security strategy and implementation guidance moving forward.

The Project team worked in collaboration with USAID/BFS to select the five case studies based on criteria designed to give significant variance in terms of types of innovations, country contexts, and scaling strategies used. Each case had to (1) have achieved significant scale, (2) have used a commercial pathway to reach scale, (3) be commercially sustainable, (4) offer clear opportunities for learning about innovations, context, and strategies, and (5) involve a USAID-supported activity in which the Agency had a pivotal role. Some of the cases turned out to be different than what had been expected based on information gathered through desk review and remote interviews. This was particularly true of the case of Kuroiler chickens in Uganda, which nevertheless provided important lessons as a counterpoint to the other cases.

The case studies examined the scaling up of innovations in Bangladesh, Kenya, Senegal, Uganda, and Zambia. The Bangladesh case examined scaling up access to agricultural machinery services in southwest Bangladesh, and was driven by the USAID-funded Cereals Systems Initiative for South Asia – Mechanization and Irrigation project. The case study in Kenya concerned the scaling up of Purdue Improved Crop Storage (PICS) hermetic storage bags, which were developed with USAID funding. In Senegal, the Project team reviewed the scaling of a complex package of innovations designed to improve productivity and strengthen the value chain in irrigated rice production in the Senegal River Valley. The USAID-funded *Project Croissance Economique* led that scaling effort, working in close partnership with the government and several other donors. The Uganda case concerned the scaling up of Kuroiler chickens, a high productivity breed that was developed in India for use by rural farmers. The scaling effort was funded by the Bill and Melinda Gates Foundation and implemented through a partnership between Arizona State University and the Government of Kenya. The Zambia case examined the scaling up of hybrid maize seed between 2005 and 2015 (there had been a first wave of scaling there in the 1980s). While the development of hybrid maize seed in Zambia was supported by the International Maize and Wheat Improvement Center with funding from USAID and other donors, scaling was driven by private seed companies.

A. Characteristics of the Innovation that Facilitate Scaling

The case studies reveal several innovation characteristics that facilitate successful scaling. The most important characteristic is that the innovation be easy to adopt. This has several dimensions, beginning with the fact that in general, the fewer the components of the innovation package, the better. The

innovation should not require a huge departure from existing agricultural practices or need extensive, ongoing training. Technology adoption is often facilitated when the innovation is either a replacement or an upgrade for an older technology, or makes use of existing technology or infrastructure. By contrast, technologies that require technical sophistication on the part of the adopter, or greater management, surveillance, and oversight, can often be more challenging.

Perhaps equally important, the innovation must have strong and obvious financial benefits and address a perceived need. Benefits should be immediate and tangible. These characteristics are especially pertinent for farmers who are not fully commercial and have limited cash flow or financial assets. Savings on production costs, labor, and time can be equally as important as increased productivity and profit.

In that regard, affordability (price point) relative to cash income or assets is important. Farmers were more likely to adopt the innovation when they could foresee the possibility of cash profits, not just increases for consumption. Innovations applied to cash crops (or breeds), versus staple crops, were adopted more quickly, creating an initial mass of adopters as the basis for wider adoption.

Risk is often more important than return. Farmers prefer to adopt innovation packages that require minimal financial investments, have short repayment periods, and will cover their costs even when yields are below average, and they prefer innovations that allow them to diversify risk over time and space.

B. Characteristics of the Country Context that Facilitate Scaling

Several characteristics of the country context facilitated adoption in the cases examined. In all five countries, though to a lesser extent with Kuroilers in Uganda, the innovation could be used to supply a preexisting demand. In three of the countries, this involved the potential for import substitution.

For commercial scaling to be successful, all parts of the value chain need to be working and their capacity must grow at parallel rates to avoid constraints. The case studies demonstrate the need for private-sector producers or importers who can increase their capacity to keep pace with demand, even if they require some assistance to do so. The importance of quality (or fidelity to the original design) varied across the cases. For innovations involving new seeds or breed varieties, it was essential to have a functioning certification system in place and be able to limit counterfeiting. In cases where agricultural inputs or equipment where involved (i.e., PICS bags and machinery services), there was more room for quality variation and certification proved less necessary. In fact, having a variety of price/quality points facilitated adoption.

In several cases, the presence of complementary services proved essential to scaling (e.g., vaccines and veterinary services for chickens, spare parts and after-sales service for machinery). Perhaps the most important complementary services or inputs are financing and machinery services.[1] Financing is relevant in cases where the cost of the package – and not just the technology – is beyond the cash resources of the potential adopter. It was possible in the Senegal and Bangladesh cases to address this constraint, in significant part because appropriate financial institutions already existed. Even when there is unmet potential demand, downstream market linkages need to exist already (i.e., Bangladesh and Kenya), or be created or strengthened (as was done in Senegal and Zambia, but not in Uganda).

Across the cases examined, organizational capacity for scaling was vital – either contained in one actor or mobilized through multiple partnerships. The most important need was for commercialization

[1] Access to sufficient labor has been shown to be important in some innovations as well, but was not apparent in the five studies under review.

expertise. This could be met by working with an implementing partner (IP) that has existing commercial experience and private-sector actors, as in Senegal or Bangladesh, or where the private sector acts alone, as was the case in Zambia. Agricultural research organizations, the public sector, and partnerships between the two tend not have this capacity. However, partnerships that involve the public sector remain important, less for any implementation role the public sector performs than for the creation of a supportive policy environment or for sanctioning the scaling activities of others.

One of the major unexpected findings from the case studies was the important role that government subsidies played in facilitating adoption, even though in some cases subsidies created distortions. Public-sector extension services generally had neither the resources nor the capacity to play a significant role in supporting scaling. Where they existed and functioned well, farmer's associations were able to help leverage resources such as in training, but they were not critical.

C. Drivers and Strategies that Facilitate Scaling

Commercialization is aided by the presence of one or more large, private-sector actors as early as possible. In all five case studies, these were upstream rather than downstream actors. When the innovation package has multiple components, as it did in Senegal, then a donor-funded IP makes more sense to drive the process, as it can engage with the respective private-sector actors relevant to each component. A third scaling driver was a supportive public-policy environment, both generally (e.g., a policy supporting food security) and specifically for the actual program or innovation (e.g., subsidies for farmers in that sector).

Commercially focused farmers adopted innovations more easily than smaller, less commercial ones. This correlated with population density and proximity to input and output markets. The business case for adopters, input suppliers, and downstream buyers was often sensitive to transaction costs, usually transport. Even if the eventual goal is to reach small, less commercial farmers in more remote areas, initially focusing on emerging, commercial farmers to drive adoption often makes strategic sense.

Based on the findings and conclusions from these studies, the team provides the following guidance for donors and other organizations that are designing and implementing scaling-up strategies:

- Build in scaling-up strategies from the beginning. Do studies of the market for the innovation, output, and of the whole value chain.
- Ensure that there is a solid business case for all actors in the value chain.
- Use an adaptive approach based on a commercially-oriented monitoring system.
- Use a phased approach that includes testing the design and the market; identifying a marketing strategy; addressing weakness and gaps in the value chain and complementary services; creating a critical mass of adopters; and going to scale.
- Use a targeted marketing strategy that identifies the demographic and geographic characteristics of early adopters as well as direct and indirect adopters. Use modern marketing techniques that go beyond simple demonstration and information dissemination. Start with early adopters who have cash and commercial experience and are close to markets, even if they are not the ultimate target beneficiaries.
- Identify a private-sector partner as early as possible, with a solid and attractive business case. Ensure that they have direct financial involvement (have "skin in the game"). Ensure buy-in at all levels of the private sector organization, especially middle management and on-the-ground personnel.
- Use subsidies and incentives judiciously early in the process to mitigate risk for both private sector partners and adopters. Have an explicit strategy for phasing subsidies out.

- Address gaps and weaknesses in the value chain so that demand and supply for both inputs and outputs grow in parallel, and complementary services like financing and machinery are available.
- Ensure public-sector support and buy-in, even if the government has little value to contribute in actual implementation.

D. Recommendations for Donors

Based on the conclusions that emerged from the case studies and the workshop, the team provides the following recommendations for USAID and other donor organizations:

- Integrate scaling up into the design and procurement phases of a project. This is best done by mainstreaming and integrating scaling into the flow of activities.
- Allow for as much flexibility as possible in the initial design and scope of work for a project, focusing on outcomes rather than activities. Do not mandate partnerships with specific actors, or specify adopters or other actors to work with initially to reach ultimate demographic targets.
- Recognize that usually what needs to be scaled is not only a technology, but a bundle of components that may have a new technology at its center. Often, teaching good agricultural practices is essential.
- Restrict scaling-up efforts to those country contexts where the policy environment is already largely favorable. This implies that a precondition for good project design is an assessment of the policy environment relevant for scaling a particular innovation or set of innovations.
- Use a phased approach and ensure that both the donor and the implementing partners (IPs) apply a scalability assessment tool after the initial product design and market-testing phase to confirm scalability. As contractors and IPs have strong incentives to scale up something to indicate progress, having them initially introduce several innovations and then narrow to those that show market validation will minimize incentives to scale those with little potential.
- Make addressing gaps and weaknesses in the value chain and market system a central part of the scaling strategy, and ensure that these areas receive sufficient resources.
- Use procurement mechanisms that allow for flexibility and an adaptive management approach. While contracts, cooperative agreements, and grants can all be used to support scaling, more flexible instruments that allow for adaptation and interim targets are preferable. This may require innovation and trial of new procurement approaches.
- Ensure continuous interaction between donor representatives and IPs, and between IPs and private sector partners, to foster successful scaling and use of associated adaptive management approaches. Work plans need to be negotiated annually based on events to date, and often should be revisited during the course of the year.
- Require monitoring and evaluation systems to include market information that can be used for adaptive management purposes. This may require simplifying some existing reporting requirements.
- Recognize that scaling, especially through commercial pathways, requires a tolerance of risk and a timeframe that often conflict with USAID's organizational culture.
- Take into account when selecting IPs that commercialization experience and existing relationships with the private sector in country and in relevant sectors is vital. These may take time to build, favoring IPs with pre-existing relationships. Technical knowledge, while important, may be secondary.
- Support scaling strategies that include risk mitigation for early adopters and first movers in the value chain, but do not "buy" large numbers of adopters. Ensure that subsidies or other incentives are phased out in a timely way, unless there is certainty that the public or private sector is willing to assume them from the beginning or upon withdrawal of the donor.

- Build in intermediate targets such as number of early adopters, value chain gaps addressed, or achieving critical mass. Recognize that these will need to be adapted. As current knowledge and methodologies to identify these milestones are limited, invest in applied research on S-curves in technology scaling in developing countries.
- Provide guidelines and training to donor staff so they understand the need for flexibility, adaptability, different monitoring systems, and how to use existing mechanisms and regulations in cases of scaling up. Particularly essential is (re)training of contracting officers.

III. INTRODUCTION

A. Purpose of this Study

The United States Agency for International Development's Bureau for Food Security (USAID/BFS), through the E3 Analytics and Evaluation Project,[2] commissioned a study on successful cases of scaling up pro-poor agricultural technologies through commercial pathways in developing countries. Through analysis of five case studies, USAID/BFS sought to understand the strategies and actions that organizations driving the scaling process have taken to facilitate the successful widespread adoption and diffusion of innovations by farmers. The study is part of USAID/BFS' efforts to increase the successful, sustainable scaling of innovations developed under the Feed the Future (FTF) initiative and to produce lessons and guidance that the Bureau and the Agency's country Missions can apply to the design, procurement, implementation, and monitoring and evaluation of food security projects.

This study was 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?

B. Conceptual Framework

The approach developed by the review team for conducting these case studies was based on two existing scaling up frameworks: (1) the spaces, drivers, and pathways analytical framework developed by Hartmann and Linn[3], and (2) the Management Systems International (MSI) scaling up framework authored by Cooley and Kohl.[4] These frameworks detail the roles in which spaces, drivers, and pathways contribute to successful scaling.

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[2] The E3 Analytics and Evaluation Project is implemented by team lead Management Systems International, in partnership with Development and Training Services (dTS).

[3] "Scaling up: A framework and Lessons for development Effectiveness from Literature and practice," Arntraud Hartmann and Johannes Linn. 2008. https://www.brookings.edu/wp-content/uploads/2016/06/10_scaling_up_aid_linn.pdf

[4] "Scaling Up – from vision to large scale change," Larry Cooley and Ricard Kohl, MSI. 2006. http://www.msiworldwide.com/files/scalingup-framework.pdf

DEFINING "SCALING UP"

"The process of sustainably increasing the reach and potentially scope or impact of a proven package of technology innovations with fidelity and quality, thereby, retaining its demonstrated positive impact."

- Review Team

Scaling requires that there be adequate "space" for its development and that growth not be constrained. In this context, the term "space" is multidimensional and encompasses the fiscal/financial, political, policy (legal and regulatory), organizational, socio-cultural, agro-ecological, partnership,[5] and learning components that could affect scaling.

The case studies also identified the "drivers" that moved an innovation from pilot towards scale, focusing particularly on the leadership, motivation, and incentives of various critical stakeholders and adopters. Each case study assessed the respective roles played by the private sector, public sector, donors, and other third parties.

The important "pathways" for these case studies are commercial pathways. A key emphasis was put on the role of the private sector – versus donor-supported projects – in driving activities over the timeframe of the scaling-up process. The role of the private sector includes: initial introduction and dissemination; marketing and promotion; initial supply of inputs; extension and advisory services (ongoing if necessary); establishing a viable and widely available source of sustainable production, supply, and distribution of the innovation, filling other gaps in the supply chain as needed; and facilitation of spontaneous adoption and diffusion. However, the case studies looked at the role of all actors in facilitating successful scaling through commercial pathways, especially the role of the public sector, parastatals, or state-supported research organizations. In most of the case studies, the public sector played a critical role in scaling, ensuring commercial sustainability, or both.

C. Case Study Components

The review team worked in collaboration with USAID/BFS and an advisory committee to select the five case studies based on criteria designed to give significant variance in terms of types of innovations, country contexts, and scaling strategies used. Each case had to (1) have achieved significant scale, (2) have used a commercial pathway to reach scale, (3) be commercially sustainable, (4) offer clear opportunities for learning about innovations, context, and strategies, and (5) involve a USAID-supported activity in which the Agency had a pivotal role.

Based on the conceptual framework for scaling described above, each case study conducted for this review collected data to examine six components of an innovation that are relevant to answer the research questions. These components are: (1) the innovation's key characteristics, (2) the quantity of scaling actually achieved over time, space, and by demographic characteristics, (3) the "business case" for adopters and suppliers, (4) the external context for scaling, (5) the scaling strategies and activities employed, and (6) the innovation's potential demand and market size. These components explore different concepts in and are closely aligned with the research questions. The review team used these components to guide and structure the case study data collection and analysis.

[5] 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.

D. Methodology

The review team conducted research for the five case studies between the fall of 2015 and summer of 2016. The team's two lead scaling-up experts, Dr. Richard Kohl and Colm Foy, worked with local researchers in each country with support from MSI Technical Manager Gwynne Zodrow, to collect both secondary and primary data (including in-country research) for all cases. Data collection methods that the team used include document analysis, semi-structured key informant interviews (KIIs), group discussions, and direct observations. The cross-case synthesis on which this report is based involved a comparative review of all individual case studies to reveal common elements that contributed to the widespread adoption of the different innovations examined, as well as differences arising from the varied circumstances under which scaling occurred in each case.

Although each case study examined innovations, the cross-case analysis considered the six components mentioned above to determine the key elements required for an innovation to be adopted at scale. These six components served as the units of analysis that the review team compared across all cases. This report also draws on the results of a one-day workshop that the review team and USAID/BFS facilitated in Washington, DC in July 2016 which the case studies and preliminary findings were presented to a group of agriculture and scaling experts who provided feedback and further discussion on key elements of scaling up agricultural innovations.

IV. CASE STUDY OVERVIEWS

This section provides brief summaries of the individual case studies completed for this review. The review team also prepared detailed summary reports for each case study, the links for which are provided as a footnote in each case study sub-heading below.

A. Hybrid (Drought-Tolerant) Maize in Southern Zambia[6]

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

Hybrid maize went to scale between 2006 and 2015, peaking at around 60 percent of national adoption rates. It appears that most of the scaling occurred in the first half of that period; national adoption rates rebounded from a low of around 20 percent in the mid-1990s to around 60 percent by late 2015. Adoption rates of DTM appear to be around 10 percent of hybrid maize seed, although the available data are not consistent on this issue. Current adoption rates for both hybrids and DTM are likely higher in the Southern province, which is the largest producer of maize in Zambia and the most prone to adverse rainfall patterns. Overall, scaling of hybrid maize has resulted in more extensive cultivation of maize relative to intensification of production. Average yields in Southern province increased from

[6] Scaling Up of Drought Tolerant Maize in Zambia: Review of Successful Scaling of Agricultural Technologies. Available at: https://agrilinks.org/sites/default/files/resource/files/BFS%20Scaling%20Review%20-%20Zambia%20Report%20REVISED%202-8-16.pdf

around 1.2 metric tons (mt) per hectare (ha) in the early 2000s to around 1.75 mt/ha in 2015, while the area cultivated in maize has more than doubled. All of this increase in production appears to have come from the addition of previously uncultivated land.[7]

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

Public support for seed certification, access to seeds and fertilizer from the Farmer Input Support Programme (FISP), and a guaranteed market for outputs from the Zambian Food Reserve Agency (FRA) made adoption of the new technology affordable and available for most farmers, at least at some scale, and lowered risks significantly. It is likely true that FISP and, to a lesser extent, FRA have been characterized by corruption, inefficiency, and poor targeting and that they are fiscally unsustainable, at least in their current scale. Nonetheless, it is undeniable that they played critical roles in promoting the scaling of hybrid maize from 2006 to date. The private sector was willing and able to drive and especially accelerate scaling with little additional support from donors, the public sector, or non-governmental organizations (NGOs), given the public support for inputs and an output market. Scaling probably would have occurred without the FISP or FRA, but would not have reached anywhere near the current scale. The combination of the intrinsic ease of adoption and affordability of the intervention meant that scaling could occur with relatively little effort, apart from that of FISP and FRA, to address constraints on affordability/resources and credit, mechanization, and market access.

B. Irrigated Rice Production in Northern Senegal[8]

The scaling up of a package of innovations in the irrigated-rice seed sector was effected through commercial pathways in Senegal from 2005 to 2015. This package of innovations included: new varieties of Sahel rice, certification of rice seed, good agricultural practices (GAPs), financial innovations, and the capacity of the value chain in areas such as the supply of mechanization services, processing, and processing quality. This case study focused only on the irrigated rice value chain in the Senegal River Valley (SRV) region and did not examine the scaling up of Nerica rice varieties in rain-fed areas of Senegal. The SRV is by the far the largest area of irrigated rice production in Senegal, currently with 60,000 ha, nearly double the area cultivated a decade ago, and with the potential to go to at least 120,000 ha. However, not all parts of this package have reached the same scale in terms of number of adopters or surface area. For example, while most farmers use Sahel varieties, the majority actually used were introduced in the mid-1990s. Similarly, many farmers continue to plan saved seed and do not use quality processing.

The story of scaling up of irrigated rice production in the SRV is atypical in many ways. First, maximum potential scale was and remains constrained by the extent of irrigation infrastructure. Second, from the beginning the SRV produced a marketable surplus of rice, and thus the producers who were the target

[7] Maize area under cultivation went from around 575,000 ha in the early 2000s to around 1,350,000 ha in 2012-2014. Area under cultivation of the next 9 largest crops also increased slightly, from around 700,000 to 750,000 ha over the same period. Total area cultivated went from around 1.3 million ha to 2.2 million ha.

[8] Scaling Up of Sahel Rice Varieties in Senegal: Review of Successful Scaling of Agricultural Technologies. Available at: https://agrilinks.org/library/scaling-sahel-rice-varieties-senegal-review-successful-scaling-agircultural-technologies

of scaling up always had something of a commercial orientation, even if many consumed most of their own production. Third, Senegal has been and remains a huge rice importer, so there has always been a substantial potential market for domestic rice, assuming it could compete with imported rice. Fourth, almost all the institutions needed for a viable commercial rice value chain already existed in the SRV as of 2010, even if many were weak or barely functioning. Fifth, all rice is irrigated in the SRV, substantially mitigating the impact of adverse weather events, which are the primary source of risk to farmers and buyers. Finally, while government subsidies have proved to be important in other cases of agricultural scaling up, they were particularly comprehensive in this case, which included the USAID-funded *Project Croissance Economique* (PCE).

Context played a key role in scaling up for this case, including: higher market prices for rice, government subsidies, and existing irrigation infrastructure. Almost all rice farmers had a commercial orientation and were accustomed to using improved seeds, fertilizer, and other inputs, employing machinery services and selling on commercial markets. The majority of rice farmers were already in farmers' organizations.

Several key aspects underlay the success of PCE's scaling up of the package of innovations. A push-pull approach helped producers to increase yields, production, and quality, while increasing market demand by facilitating linkages to processors and distributors and strengthening those downstream institutions. This was in addition to kick starting private upstream and downstream investment through subsidies, risk mitigation, and market facilitation. PCE's support for agricultural machinery leasing through *Locafrique* and innovating crop insurance with the government are examples of aligning the incentives for farmers, banks, processors, machinery services, and wholesalers, so that everyone makes money. In some cases in Senegal, such interventions have been complicated by government-induced distortions of prices and margins at various stages in the value chain. This was particularly true for banks and the Caisse Nationale de Crédit Agricole du Sénégal (CNCAS). PCE addressed risk for key actors through the innovations of contractualization, crop insurance, and the use of a warehouse receipts system.

C. Purdue Improved Crop Storage Bags in Kenya[9]

Maize is the most important smallholder food crop in Kenya, but frequently suffers from high post-harvest losses due to insect infestation. Hermetically sealed post-harvest storage systems, such as the Purdue Improved Crop Storage (PICS) bags developed by Purdue University, can contribute dramatically to reducing such losses. In addition, PICS bags appeal to farmers because they are easy to transport, eliminate post-harvest pesticides, are affordable, and require minimal changes in behavior to use them.[10]

Various actors in the agricultural input supply chain supported the successful scaling of PICS bags. The national wholesaler of the bags, 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. However, 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 viewpoint, PICS bags have made a substantial contribution to the scaling up of hermetic technology as a whole. However, copycat versions of both comparable and lower quality have entered the market, which adds another challenge.

[9] Scaling Up of Hermetic Bag Technology (PICS) in Kenya: Review of Successful Scaling of Agricultural Technologies. Available at: https://agrilinks.org/library/scaling-hermetic-bag-technology-pics-kenya-review-successful-scaling-agricultural

[10] This includes changing the way bags are tied and where they are stored (away from other items that might attract rodents).

A member of Musalava Women Farmers' Group, Kaani, near Machakos in Kenya, shows her grain stored in PICS bags in her bedroom. *Credit: Colm Foy, MSI.*

Supply of the bags is expected to reach 1 million units in 2016, from under 52,000 in 2014. Several contextual factors supported the scaling of PICS bags in Kenya, including 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.

This case study provides important lessons for donors. First, innovations have a greater potential for success if they address a perceived need of agricultural producers and do 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 by end users. Fourth, if donors can support 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 – rapid enthusiasm and take-up of the product accompanied by the early entry of competitors into the market – demonstrated the need for donors to prepare for the unexpected, which may imply additional costs. Finally, scaling up is more likely when donors can coordinate and leverage a combination of government actors, community service organizations, NGOs, the private sector, and farmers' groups to support the introduction of an innovation.

D. Agricultural Machinery Services in Bangladesh[11]

This case examined the scaling of agricultural machinery services in southwest Bangladesh from 2012 to early 2016. The investment was made possible through the USAID-funded Cereal Systems Initiative for South Asia - Mechanization and Irrigation (CSISA-MI), which introduced and promoted the adoption of new agricultural machinery to smallholder farmers with the goal of increasing farm productivity and incomes.

CSISA-MI is a partnership of two partners in CSISA, the International Maize and Wheat Improvement Center (CIMMYT) and International Development Enterprises Bangladesh (iDE-B). CIMMYT's role was to provide technical expertise in cereals cultivation, especially in selecting appropriate machinery. iDE-B was primarily responsible for market facilitation, getting farmers and private supply-chain actors to adopt the new machinery. CSISA-MI began implementation in summer 2013 and has only been operating for three years. As such, scale has not yet been reached although there have been significant numbers of early adopters. CSISA-MI has been operating only in the FTF Zone of Influence (ZOI) in southwest Bangladesh, Khulna Division, Barisal Division, and a portion of Dhaka Division.

[11] Scaling up of Agricultural Machinery in Bangladesh: Review of Successful Agricultural Technologies. Available at: https://agrilinks.org/library/scaling-agricultural-machinery-bangladesh-review-successful-agricultural-technologies

Agricultural machinery being examined under the scaling case study in Bangladesh. *Credit: Richard Kohl, MSI*

The package of innovations currently being scaled up concerns three agricultural machines that are relatively new to Bangladesh: (1) axial flow pumps (AFPs), which are used for irrigation from surface water sources and operated by separate diesel engines; (2) power-tiller operated seeders (PTOS), which provide tilling, seeding, and – in principle – fertilizing services; and (3) self-propelled reapers, which cut field crops like rice, wheat, and possibly other crops like jute. In all three cases, the introduction of new machinery was combined with a business model of using local service providers (LSPs) to provide services to smallholder farmers on the assumption that it was neither economic nor affordable for smallholder farmers to buy their own machines. LSPs already existed in the FTF ZOI, providing services with power tillers.

As new technologies, AFPs and PTOS represented an upgrade of existing mechanization rather than a replacement for hand labor. AFPs serve as a replacement for low-lift pumps, which can use the same diesel engines while reducing fuel costs and increasing water volume pumped per hour. They are also easier to service and maintain, especially in colder weather. PTOS are attachments to power tillers, which have gone to scale in Bangladesh since the 1990s, so that there was a large installed base of power tillers to leverage. They represent an upgrade on power tiller technology because they provide a much finer till – particularly useful for root vegetables – as well as the ability to do seeding and fertilizing, allowing for the easier introduction of much more productive line sowing. By contrast, reapers did replace hand labor. As there were multiple technologies with multiple applications, the natural experiment showed that those with minimal behavior change were more readily adopted, e.g., the tilling functions of PTOS versus the line sowing.

While the investment is recent, early successes can be attributed to the characteristics of the technologies, the scaling strategy, and the market context. The technologies were largely upgrades on existing technology and, depending on the application, required minimal additional training to use. The business case was (or was tweaked to become) strong for all actors, from producers/importers to distributors, LSPs, and farmers. Innovations that could be used by farmers growing cash crops were particularly appealing, as these tended to be taken up by early adopters since they had more of a commercial orientation and the cash flow to finance purchase and repayment. These earlier adopters were large fish farmers and horticulture producers – particularly onions and garlic – which had the highest returns (and costs) of any crop widely produced in southwest (SW) Bangladesh. For farmers and LSPs, the more successful technologies allowed for not just greater production but also cost savings, short repayment periods, application to cash crops, and risk diversification. Farmers and LSPs were particularly attracted to machinery or uses that could be applied to cash crops and to multiple types of cultivation over multiple seasons.

While public policy and the enabling environment probably played less of role than in Senegal or Zambia, public support for mechanization and some subsidies did facilitate scaling in Bangladesh. By contrast, like Zambia, the presence of several large- and medium-sized agricultural machinery companies with capital, experience, and a tolerance for risk was critical to the close partnership between the private sector and a USAID project; that partnership drove the scaling process.

Critical factors for scaling strategies were a flexible, adaptive management approach; willingness to change strategy in terms of crops, technology, and locations based on market feedback; and a successful partnership with private-sector actors from inception. Because of these innovative approaches, CSISA-MI is expected to achieve a high degree of sustainability for its outcomes, especially as they relate to machinery producers, service providers (i.e., purchasers of the machinery), and farmers utilizing commercial machinery services.

E. Kuroiler Chickens in Uganda[12]

Kuroiler chickens are a hybrid, dual-purpose (meat and eggs) breed developed by Kegg Farms in India and introduced into Uganda in 2009. Their advantages, as recorded in rural India and several studies in Uganda, are their speedy growth to marketable size for meat and the prodigiousness of their egg production. In addition, they have been developed as scavenger birds that should require little supplementary feeding. They physically resemble local Ugandan birds. However, the Kuroiler is an F1 hybrid bred from two independent lines, and cannot reproduce itself through breeding. Kuroiler in-breeding through subsequent generations (e.g., F2, F3) will eventually lose all the breed's advantageous characteristics, while cross-breeding will provide unpredictable results. Hence, the Kuroiler flock requires replacement every 18 to 24 months. In addition, although Kuroilers are hardy, they require strict adherence to a vaccination and phytosanitary protocol, or else they fall prey to local diseases, especially Newcastle disease and infectious bronchitis.

Adult Kuroiler chickens in Uganda.
Credit: Colm Foy, MSI

However, there has been greater interest in poultry products in Uganda. The thought was that if smallholders and rural households could adopt a more productive breed of chicken, they could improve their incomes and living standards, and increase nutrition levels by consuming excess eggs and meat. The Ugandan government supported such a process and identified poultry husbandry as a means of raising rural living standards. The authorities backed up the policy approach with facilities to produce and distribute Kuroiler chicks, as well as launching an advertising and promotional campaign in partnership with the promoters, Arizona State University. The Bill and Melinda Gates Foundation supported the project with a grant and some training.

The Kuroiler chicken has the potential to be more productive in both meat and egg production in a context where poultry husbandry is a traditional activity. Therefore, the level of adaptation should have been relatively high and there was an assumption that marketing structures, habits, and facilities were already established. In reality, raising Kuroilers proved to be much more training-intensive than expected and failures resulted from inadequate knowledge of the specific requirements of the birds. Far from being a "tweak" to existing poultry, the Kuroilers are much more complex, requiring specific vaccination protocols, additional feed to thrive, and a wider scavenging range. Other birds in the flock were unable

[12] Scaling up of Improved Poultry Breeds in Uganda: Review of Successful Agricultural Technologies. Available at: https://agrilinks.org/library/scaling-improved-poultry-breeds-uganda-review-successful-scaling-agricultural-technologies

to compete with the larger and more aggressive Kuroiler, potentially damaging cross-breeding occurred frequently, and Kuroiler males were found to be capable of inflicting serious harm on local females they mounted. Furthermore, the Kuroiler required fresh stock to be purchased on a regular basis, something to which rural householders were not accustomed.

Kuroilers also were over-productive in an environment where basic infrastructure such as transport, veterinary supplies and services. and extension services were inadequate. Farmers did not have the means to market them for meat beyond the traditional practice of occasional roadside sales, and in many cases were unable to supply the egg market because of distance and lack of adequate transport. In addition, alongside the "official" two sources of supply of genuine Kuroilers, an entire industry in fake and counterfeit birds (most "Kuroilers" in Uganda may in fact be fakes) developed that could not be controlled by the enforcement structures in place. As a result, the context was woefully inadequate to support the successful scaling up of the innovation.

The scaling strategy was based on the premise that producing and marketing the breed would guarantee its widespread acceptance and distribution through mother units and distribution channels, as in India. It was thought that advertising and promotional activities would support the introduction of Kuroilers and farmers would be encouraged to purchase three-week-old chicks that had already been vaccinated and the weakest individuals would be removed from the stock. Income from sales of chicks would finance the acquisition of more parent stock from the Indian patent holder. In reality, the official distributor created a demand that it could not meet, did not carry out educational campaigns beyond advertising the superior quality of the birds, and was prepared to sell vulnerable day-old chicks that risked falling prey to disease and poor nutrition. Distribution infrastructure was not commensurate with the needs of the market, and the market itself was unprepared for the arrival of Kuroiler products as meat or eggs. The official supplier, the promoters of the breed, and the donor foundation failed to take into account the aspects of upstream (inputs and supplies) and downstream (outputs of meat and eggs) markets, veterinary supplies, extension services, corruption (both official and non-official), farmer education and training, infrastructure development, or the regulatory environment. Due to government procedures, the official supplier was unable to recycle profits from sales to the purchase of more stock. The late-stage partnership with a private operator failed to remedy these problems.

Overall, public-sector support for the introduction of Kuroilers was extensive yet insufficient, and local officials who were supposed to dispense training were often inadequately trained themselves. The limited capacity of the current official (and only) hatcheries is insufficient to take Kuroilers to scale in Uganda, despite rising demand that is currently being met by counterfeit birds. There are an estimated 40 million chickens in Uganda, of which 90 percent are indigenous. The combined output of surviving birds from the National Agricultural Genetic Research Centre and Databank (NAGRC & DB) and the private partner, Chick Masters, is around 2 million Kuroilers annually, which is below the 10 percent threshold that could be used as a rule-of-thumb scaling baseline. Furthermore, that production is shifting from Uganda; Chick Masters sees as one of its main objectives the expansion of its export market without a significant increase in capacity, because profits are higher.

The review team found that Kuroilers in Uganda would have been most appropriate for adoption by better-off smallholders and households, rather than the rural very poor to whom the scaling strategy was directed. This finding highlights the importance of donors identifying the target group for scaling and recognizing that an innovation with good potential for widespread adoption may not actually be appropriate for the group on which they are concentrating. Donors should pay particular attention to the nature of the product. "Miracle" solutions to developmental problems are generally illusions and enthusiasm needs at all times to be tempered with rational analysis both before the introduction of an innovation and in constant monitoring once the innovation is in place.

V. CROSS-CUTTING FINDINGS AND CONCLUSIONS

A. Characteristics of the Innovation

The starting point for analyzing the scaling up of an agricultural innovation is identifying the technology or innovation package that is to be scaled. Based on the findings from the cases examined for this review, four key components need to be considered to understand the potential scale for an innovation: (1) how many components or how complex the innovation package is; (2) the extent to which the innovation builds on previous experience with a similar technology, or upgrades/leverages an existing technology; (3) whether the innovation addresses a perceived need and has immediate and tangible benefits to adopters; and (4) if the innovation offers strong financial benefits in terms of risk, return, and affordability.

1. Is the innovation simple and practical to adopt?

One key aspect contributing to ease of use is that the innovation package should have relatively few components, which are preferably technologically uncomplicated. The cases of PICS bags and hybrid maize seeds stand out, as those technologies constituted the entire innovation package; the other three cases examined involved more complex packages. The Kuroiler project in Uganda required that adopters not only acquire the breed, but also adopt more complicated management techniques (e.g., complex phytosanitary practices, chicken enclosures, and supplemental feed). LSPs that adopted the new agricultural machinery in Bangladesh needed to have more sophisticated business skills in marketing and time management. Depending on the machine and its use, farmers had to adopt more sophisticated practices. Not surprisingly, the adoption of those uses was slower than those that were more plug-and-play. The package of innovations introduced in the SRV were perhaps the most complicated in both number and technological sophistication, especially as they covered almost the entire value chain. For farmers, the package required them to change their behavior in many significant ways, including the time of planting and harvesting, how rice is milled and by whom, and quality standards for both seeds and paddy. The high levels of adoption that were achieved in that case would probably not have been possible without the substantial, and resource-intensive, technical assistance and training that PCE provided for several years.

Scaling up is thus much more challenging if farmers have to receive intensive training and extension support – which may be necessary over several seasons – to achieve successful adoption. Such requirements limit spontaneous adoption and reduce the benefits of the innovation because indirect adopters are unlikely to take up the entire package. If quality and fidelity are important, the innovation may be less profitable – or even unprofitable – for indirect adopters, who are unlikely to adopt the technology and practices exactly as recommended. These considerations may limit potential scale to those who have access to training, and underscore the issue of who pays for necessary training at scale.

While donor projects may be able to cover the costs of often expensive and time-consuming training for early adopters, they usually cannot afford to do so in the drive for large-scale diffusion of an innovation. In many countries, the public sector has neither the financial nor the human resources to provide specialized training and extension support, because of weaknesses in the capacity and capabilities of the public-extension system. Private commercial actors are often reluctant to provide training if they do not have field agents already in place and cannot justify it in terms of a positive cost-benefit, particularly in the absence of a monopoly or oligopoly situation where they would in effect be providing a public good at private expense.

2. Does the innovation build on previous experience with a similar technology, or upgrade or leverage an existing technology?

Having previous experience with a similar technology decreases the degree of change that adopters face when taking up an innovation. The introduction of hybrid maize varieties in Zambia illustrates the importance of this consideration. Maize hybrids had already been scaled in Zambia during the 1980s and utilization dropped after the shocks of structural adjustment and the retreat of state support. Older farmers and the fathers and uncles of younger ones clearly remembered this experience. When new hybrids appeared 20 years later, there was nothing new or different for farmers other than to decide which of the many varieties were best for them. In contrast, women in Uganda were already raising chickens, so Kuroilers appeared to be just another, better variety of poultry, rather than a totally new farming activity. The problem, however, was that apparent similarities concealed substantial differences in the management and care required.

The introduction of PICS bags to Kenyan farmers represented an upgrade to the existing practice of storing grain and legumes in bags, facilitating the scaling of that innovation. Similarly, in Bangladesh, rice and fish farmers were already using mechanical (low-lift) pumps, so when CSISA-MI introduced axial flow pumps, most users saw this as an upgrade of an existing technology that was not only more efficient but also easier to use. Mechanical reapers, by contrast, have been a harder sell since they replace hand labor, not older reapers.

Lastly, innovations that leverage or complement existing technology or infrastructure facilitate scaling up, as in the case of the introduction of PTOS to Bangladesh. PTOS are attachments to power tillers (PTs), and use PTs as their source of power and mobility. Bangladeshi farmers were already accustomed to using PTs as a power source for other attachments and PTs are widely owned. The need to have access to complementary infrastructure or technology can constrain scaling. For example, in Senegal, the package of innovations introduced by PCE has only proven to be scalable where farmers have irrigation infrastructure, which includes just a small fraction of the country. Efforts were underway in late 2016 to scale a modified package to rain-fed rice elsewhere in the country.

3. Does the innovation address a perceived need and have immediate, tangible and visible benefits to adopters, especially in time and labor savings?

Innovations that were seen to address a clear need and have tangible benefits were more likely to be successfully scaled. For example, SW Bangladesh suffers from acute shortages of agricultural labor, particularly around planting and harvesting time. This lack of labor supported the adoption of PTOS, which allows farmers to plant more quickly and enjoy a longer growing season. This is particularly true for garlic and onion farmers, for whom planting is quite expensive and time consuming. These farmers were among the earliest and most rapid adopters of PTOS, and they were spared waiting for a labor crew to come to their fields and spending several days planting. These labor, time, and cost savings were more important for the adoption of that innovation than any promised increased yield or income (and, in any case, time and cost savings lead to higher incomes). Kuroilers present a counter example because their adoption may lead to increased time and labor expenses. While local chickens run free, Kuroilers should be fenced to avoid cross-breeding and abuse of smaller local chickens as well as allow for supplemental feeding, all of which require additional time and labor. This extra burden is borne in particular by Ugandan women, who are primarily responsible for the chickens on top of their existing responsibilities for cooking, cleaning, childcare, and fetching fuel and water. For rural women, the determining factor regarding adoption may be whether the innovation requires more or less time, rather than profit considerations.

For Kenyan maize farmers, post-harvest losses from pest infestations of stored grain can account for a significant percentage of their harvest and the difference between self-sufficiency and having to buy maize in the off season. PICS bags largely eliminated these losses and allowed grain to be stored for longer. Farmers could avoid having to sell immediately after harvest at low prices and buy later. The benefits of PICS bags as compared to non-hermetic storage were quite evident within just a few months of storage.

In SRV, contractualization[13] and crop insurance allowed rice farmers to have greater and timelier access to finance, which translated into well-timed land preparation, planting, and harvesting. The same was true with improved access to machinery services in Bangladesh, where farmers tended to cite the time savings that allowed them to have a longer growing season and harvest at the right time, more than the cost savings of using less manual labor.

4. Does the innovation offer strong financial benefits in terms of risk, return, and affordability?

Historically, there have been many attempts to scale innovations where the business case was not solid or made explicit. One of the common characteristics across all of the cases that the review team examined was that crop budgets, internal rates of return, and economic tools generally are being used more frequently than in the past to assess the profitability of a technology. This is a development that should be encouraged and built upon. Adopters are interested in 'returns' in areas like cost, time, and labor savings, as well as concerned about mitigating or diversifying risk, rather than just being focused on greater output or potential profits.

End-user affordability is critical to unlocking the scaling-up process, since potential adopters often face cash and credit constraints, especially small farmers. They cannot borrow, or are obliged to borrow on unattractive terms (e.g., interest rates, repayment periods, repayment frequency, types of security required), which limit their potential to borrow for the investment or associated working capital. PICS bags were among the cheapest of all the innovations reviewed, and many farmers interviewed who adopted them emphasized this as a major advantage. Of the three types of machinery scaled up in SW Bangladesh, the two that were most successful were also the cheapest: AFPs and PTOS. By contrast, a significant obstacle to the adoption of mechanical reapers was their much higher price point (nearly $2,000 versus $250 for an AFP). While Kuroilers appeared to be affordable if one only considered the cost of the chicks, affordability decreased when the up-front cost of vaccinations, fencing, and feed were taken into account – even though absolute and relative returns were high.

Closely related to affordability is adopters' preference for a short timeframe for recovery/repayment of the investment. This was most relevant in the case of large investments like agricultural machinery in Bangladesh, where LSPs had to borrow money from financial institutions or relatives. Since the cost of a PTOS could be recouped in two seasons or less (in a three-season context), they were very attractive to farmers, whereas the repayment period for a reaper was at least a couple of years. A short repayment period is critical for risk-averse adopters operating in the highly uncertain contexts that characterize much of agriculture in developing economies.

[13] Contractualization was created by PCE in partnership with the state agricultural bank, CNCAS, to minimize rice farmers' cash flow needs and transaction costs. Under contractualization, once farmers receive approval of their bank loan, it is paid directly to input suppliers who provide seed, fertilizer, etc. Farmers do not have to sell their crops to repay their loans, which can take time; instead, they deposit the necessary quantity of rice in a warehouse and sign the rights over to the bank. In more recent versions, the bank also extends credit to the rice miller, who receives a warehouse receipt instead of cash. This cashless system has proven highly effective.

Adoption was facilitated when farmers – especially smallholder farmers – could foresee the possibility of translating additional profits into cash, and not just increased own consumption. Innovations that were applicable to cash crops (e.g., large commercial fish farmers and producers of garlic and onions in Bangladesh) were thus easier to scale. The fact that the package of innovations introduced in the SRV was for rice farmers – most whom were already producing and selling a commercial surplus above their own consumption – was critical to their willingness to borrow the nearly $500 per hectare needed to finance cultivation.

The cases of Kuroilers in Uganda and Zambian maize serve as partial counter examples. In Zambia, many farmers in more remote rural areas do not have access to commercial markets, and have only been willing to adopt hybrid maize (and increase production) thanks to the presence of the FRA's purchasing scheme. In Uganda, farmers expected to be able to sell the substantial increase in production of eggs and birds in local markets, but in some cases those markets quickly became saturated, causing some farmers to withdraw from Kuroilers. This was not the case, however, in those areas where local market surpluses were bought by local traders and resold on larger secondary markets.

Perhaps the most important lesson about profitability was that farmers were at least as concerned about risk as they were about returns. Innovations that helped reduce risk for farmers were hugely attractive and facilitated scaling up. In the SRV, the package of rice innovations reduced risk through crop insurance, contractualization, and the greater availability of machinery services, all of which allowed farmers to plant and harvest on time. Risk mitigation was particularly important in harvesting at the end of the hot dry season, before the rains started and potentially ruined the crop. The introduction of machinery services in SW Bangladesh had identical effects, allowing farmers to improve planting and harvesting times and avoid the onset of rains.

Another important source of risk reduction was diversification across crops, time, and space. The timelier availability of credit and machinery services in the SRV made it easier for farmers to plant two to three crops per year, so that even if there was one bad season they had a chance to make it up in the other ones. One of the reasons that PTOS were the most attractive of the three machines introduced in SW Bangladesh is that they could be used for multiple crops in the same season and across multiple seasons. In Kenya, PICS bags allowed farmers to hold onto their grain for extended periods of time, reducing the risks that they would have to sell maize at low prices and buy it at high prices. In Zambia, the large number of hybrid maize varieties available meant that farmers with sufficient land could plant two or three varieties with different risk-return profiles. Many planted a medium-maturity variety that had high upside if there was good weather, but would produce little with adverse weather. To hedge this, they would plant a short-maturing variety, a drought-tolerant variety, or both. Unfortunately, smallholder farmers did not have sufficient land to diversify this way, which may have been why they were less likely to adopt than farmers with more than one hectare.

Kuroilers may serve as a counter example to the cases in which the innovations helped reduce risk. While Kuroilers were, in principle, both scavengers and very resistant to disease, the reality was slightly more complicated. To get the best yield, Kuroilers needed to be given supplemental feed, and to avoid high mortality rates, adopters need to follow a time-consuming, rigorous, and expensive vaccination protocol. As many farmers did not do this, or were unaware of the requirements, they had poor experiences and found Kuroilers to be riskier in actual practice.

In the cases reviewed, the business case for adopters (usually farmers) could vary widely across potential adopters. In both Zambia and Senegal, yields for farmers who adopted the innovations could vary by 2 mt/ha or more. In Senegal, even when average yields were around 7 mt/ha, there were reports of farmers getting 4-5 mt/ha and 8-10 mt/ha. While there are multiple explanations for this variance, micro-climates, farmers' skills, soil condition, local incidence of pests, and disease all play a role. Partial or

incomplete adoption of the package of innovations may be a key factor. Lower yields in Zambia were partly explained by farmers who used less than the recommended level of fertilizer, although soil quality and local rainfall patterns were also important. While above-average yields are no challenge for farmers' adoption, this is less likely to be the case when there are below-average yields. In Senegal, rice is sufficiently profitable (once government subsidies are included) that even low yields tend to be profitable, but this is not the case in Zambia, where farmers with lower yields were not making money. In sum, many farmers evaluate potential adoption, even if not explicitly, in terms of both their own risk and what might be called a sensitivity analysis and portfolio approach across livelihood activities (i.e., what a formal analysis would call the covariance).

B. Characteristics of the Country Context and Market Demand

Across all five cases, a key characteristic of the country context and market demand was the fact that the final output produced by the innovation was already part of local consumption; there was nothing new about eggs, poultry, rice, maize, or horticulture. For example, Kuroiler chickens were taste-tested and their meat was considered equivalent in taste to local varieties.

In all five countries, there was a pre-existing, large potential (unmet) demand for any increase in final output generated by adoption of the innovation packages. In Kenya, Senegal, and Zambia, the innovations produced an increase in net production of staple cereals, maize, rice, and maize, respectively (in Kenya this was a result of lower post-harvest losses). These three countries were net importers of their staple cereal, so there was great potential for import substitution; potential production increases could be easily absorbed without putting downward pressure on prices.[14] Import substitution was also possible for Kuroiler chickens, as not only were farmers/producers likely to eat more eggs and poultry, but Uganda was also a net importer of live chickens and poultry meat at a cost of $1.5 to $2 million per year. In Uganda and Senegal, demand for poultry meat and rice, respectively, is also increasing with urbanization and rising incomes. However, it appears that in Uganda the potential for import substitution is quite limited relative to current domestic ownership and consumption of chickens, meaning that the additional unmet market 'space' was relatively small. In Senegal, by contrast, the import-substitution potential for locally produced rice is huge, easily allowing for at least a doubling of domestic production. These examples emphasize the importance of doing market studies.

A similar characteristic of the country context was that there were structural factors relevant to production driving greater demand for the innovations. This was most obvious in the case of Bangladesh, where substantial outmigration from rural areas to cities and overseas created chronic labor shortages in rural areas. This deficit created a ready demand for machinery services, and the marketing, distribution, and rest of the value chain needed to be put in place to address this demand.

In most of the cases examined, the sector in which the innovation was located was a cash product, meaning that the majority of potential adopters already had some commercial orientation. This was most clearly the case in Senegal, where the vast majority of rice farmers in the SRV were already producing more than their own consumption needs and selling some of their harvest commercially. They had experience with commercial sales, buying inputs and selling outputs. The same was true for most of the early adopters in Bangladesh; fish farming and horticulture are overwhelmingly cash products.

[14] As of this writing, scaling has only eliminated imports and achieved national food security in Zambia (where scaling is the most advanced and largest in terms of the percentage of potential adoption achieved); imports remain large in both Kenya and Senegal.

Commercial experience was less dominant among maize farmers in Zambia and Kenya, and among poultry producers in Uganda, who, nonetheless, had some experience selling their surplus on local markets. (This is one reason that an essential driver of scaling in Zambia was the government's program to purchase maize, especially in more remote areas.) In Uganda, commercial poultry farmers were the exception and small poultry farmers were only used to selling surplus by the roadside or in small local markets. For successful adoption and scaling, they needed training in marketing as well as improved linkages between local markets and secondary and urban markets. Unfortunately, neither formed part of the project. Scaling up tends to be easier for more commercially-oriented farmers who are potential adopters – as opposed to those producing primarily for their own consumption or consumption plus small and irregular surpluses.

As noted earlier, innovations that leveraged existing infrastructure or installed technology, or upgraded existing technology, were easier to scale. This implies that when the innovation needs to be combined with infrastructure or technology, those requirements need either to pre-exist or be scaled up in parallel. For example, scaling up in the Senegal case would have been impossible without the large irrigation infrastructure. The scaling up of the PCE was accompanied by a substantial investment in the rehabilitation of old irrigation infrastructure and the construction of new irrigation infrastructure (with funding from the World Bank, the Millennium Challenge Corporation, and the French Development Agency). In Bangladesh, adoption of AFPs benefitted from a large installed base of diesel engines, and PTOS benefitted from relatively widespread ownership of PTs. Almost all farmers in Kenya and Zambia had previous experience growing maize, and there was a similarly large base of small poultry farmers in Uganda.

A final contextual factor that facilitated scaling up was that the majority of potential adopters – especially smallholder farmers – lived in close proximity to upstream and downstream value-chain institutions (i.e., suppliers and markets). This was the case in the SRV, where most farmers have their fields within a few miles of the river and therefore close to the irrigation infrastructure. This was particularly true in the Dagana region, which is close to the key Dakar market and farmer density is high. High density facilitated training and providing extension services without incurring high transportation costs. It also facilitated upgrading the seed-supply system and access to quality rice milling. The SRV irrigated rice sector provides an example of the importance of proximity, in that the more distant upstream parts of the SRV are much further from Dakar and the number and density of rice farmers is much lower. In those areas, adoption was much lower in both absolute numbers and in percentage terms, although PCE also put less effort there.

This contrast can be seen in the Zambian maize case as well. Maize farmers close to the towns along the main road and rail line between Lusaka and Livingstone found it relatively easy to access new hybrid maize varieties and, because of low transportation costs and higher population densities, seed companies saw it as profitable to heavily advertise close to the roads, putting in place many demonstration sites. In Zambia, there was an accelerating drop-off in marketing and adoption of hybrid maize with the distance from the road, as transportation costs rose and population density fell.

C. Characteristics of the Value Chain and Market Systems

It is more challenging to draw conclusions from the five cases about the characteristics of the value chain, since the value chain required depends heavily on the innovation package, relevant sector(s), and contextual factors. However, based on the findings from the five cases studies, four main characteristics are discussed in this section: (1) input supply, (2) input quality, (3) complementary services, and (4) output markets and linkages to them.

Input Supply

The pre-existing supply, or the ease of creating supply, of the innovation and complementary inputs greatly facilitated scaling up. The most compelling example of this was with hybrid maize seed in Zambia. Due to political and economic issues in neighboring Zimbabwe, much of the hybrid maize seed production for Southern and Eastern Africa moved to Zambia. This included several of the largest multinational seed producers, which used it primarily for seed production for export. Thus, there was already a supply of hybrid maize available; most of it was being exported. Following the 2007-2008 food crisis and the Government of Zambia' s (GOZ) decision to move towards self-sufficiency in maize, the increased demand for hybrid maize seed was easily met by the existing production base. Even as domestic demand for maize seed increased with scaling up, there was generally no problem in meeting it, as domestic demand was still a fraction of total seed production.[15]

Although a large pre-existing production capacity was absent in Bangladesh, Senegal, and Kenya, the potential or pre-conditions were there and could be mobilized with some effort. In Bangladesh, a key factor was a vibrant and healthy domestic agricultural machinery sector, with a few large players, several medium-sized firms, and some local producers. CSISA-MI was able to negotiate memoranda of understanding with two of the largest firms, which were easily able to import the machines. The same was true with medium and smaller manufacturers in subsequent years, as CSISA-MI chose to widen the production base to increase competition. The one major downside was that most supply was imported and the lags of 60 days between orders and delivery made it very difficult to respond quickly to surges in demand. In Kenya, there were several major agricultural-input distributors, only one of which did not have an existing business in the post-harvest pesticides that PICS bags would displace. The distributor, Bell Industries, was able to contract with several manufacturers in the region to produce the bags.[16]

The counter example is Kuroilers. The existing number and capacity of chick producers in Uganda was quite limited, in large part because of the lack of demand. Most farmers owned local chickens that reproduced themselves, and thus they did not buy commercially bred chicks. The government of Uganda's animal research center, NAGRC & DB, quickly ran out of capacity to meet the surging demand that resulted from the promotion of Kuroiler chickens. While NAGRC & DB, Arizona State University (ASU), and the Bill and Melinda Gates Foundation (BMGF) were able to contract with a commercial producer, Chick Masters, to increase supply, it was already too late and much of the gap had been filled by fakes and counterfeit birds. Moreover, the mother units to take chicks from day-old chicks to three-week-old chicks (the preferred age of sale) did not exist and had to be created, which proved challenging. Finally, distribution has been problematic because of a limited distribution network of veterinary supplies, commercial feed, and chicks, which require special care in transport.

Input Quality

In many cases, quality control of the inputs or of the innovation supplied is critical to the innovation's impact. This was particularly true of Kuroilers, Sahel rice seed, and hybrid maize seed. Although lower-quality machines in Bangladesh and imitation PICS bags performed worse, it was not a substantial difference. A key driver of the successful scaling up of hybrid maize seed was that Zambia already had in place a well-regarded seed certification system, the creation of which was originally heavily supported by the Swedish International Development Cooperation Agency. Strong political and economic support for

[15] The exception was that many seed companies allocated production towards exports first, and so if there was unexpectedly high domestic demand for a particular variety, dealers would sometimes run out

[16] The major obstacle that arose in increasingly supply was that Bell lacked sufficient working capital to cover the gap between accounts receivable and payable; this constrained the ability of supply to increase as demand accelerated.

this system existed because maize seed exporters needed to have a credible reputation for high quality. In Zambia, maize seed that is not sold by the end of the season has to be returned to the producer and recertified. In Senegal, a seed certification system and processing capacity did not exist and its creation was a key part of the package of innovations that was scaled up through a partnership between the Government of Senegal (GOS), the PCE project, and local seed-multiplier collectives.

Kuroilers again serves as a counter example here. Fake and counterfeit agricultural inputs (e.g., seeds, veterinary supplies, animal feed) were a serious problem in Uganda before the introduction of Kuroilers. The lack of effective quality control, branding, or regulatory enforcement of Kuroilers led to an upsurge in fakes, fueled in part by the fact that supply could not keep up with rising demand. Small farmers were used to being able to replenish their flocks by breeding their local chickens. They did not understand (and were not well informed) that Kuroilers were F1 hybrids and could not be replenished by breeding because they would lose their favorable characteristics, especially when interbred with local chickens. Moreover, they did not understand that Kuroilers lack the brooding gene, which means that interbreeding could eventually lead to large number of mixed-breed chickens incapable of reproducing on their own.

Input quality depends on the innovation itself. While PICS bags were very high quality, their introduction spurred a copycat industry that has produced slightly lower quality imitations that retain much of the effectiveness of the PICS bags. In this regard, copycats can be seen as an effective form of scaling up, especially if they lead to widespread acceptance of the technology behind the innovation. On the other hand, counterfeits can seriously undermine and potentially even reverse scaling, especially in cases where there is no regulatory or other enforcement mechanism to ensure quality. In part this depends on the importance of quality or fidelity. In Uganda, fake Kuroilers have few if any of the positive characteristics, and did pose a serious challenge.

A similar aspect of input quality is that commercial pathways allow for the emergence of a range of options in terms of price, quality, and characteristics. A good example of this concerns AFPs in SW Bangladesh, as some adopters prefer larger, heavier-gauge pumps that will last a long time while others are content with cheaper, lighter-gauge pumps with smaller throughput; this often varies with the volume of water being pumped. Many farmers choose to buy rotovators as an alternative to PTOS, which are essentially lower-powered seeders without the ability to distribute fertilizer. PT-attached reapers have emerged as a much cheaper alternative to self-propelled reapers, even if they are slightly more difficult to operate. Perhaps the best example is hybrid maize seeds, as there are dozens of varieties to choose from in terms of maturity, yields, disease and pest resistance, drought tolerance, etc.

Complementary Services

Innovation packages may require complementary inputs or services to be easily available and affordable. For Kuroilers, this included access to veterinary services, certified vaccines, and supplementary poultry feed, all of which were difficult to obtain and complicated by the widespread presence of fraud. For agricultural machinery services in both Senegal and SW Bangladesh, scaling up revealed the need for, and absence of, a sufficiently dense network of after-sales service, repairs, and spare parts. In Kenya, PICS bags lack a viable means of ecological disposal and, while this does not prohibit scaling up, it does create issues of sustainability.

Perhaps the most important complementary services or inputs are financing and machinery services.[17] Financing is only relevant in cases where the cost of the innovation package is beyond the means of the

[17] Access to sufficient labor has been shown to be important in some innovations as well, but none of those contained in the five studies under review.

potential adopter. This was the case for reapers and PTOS in SW Bangladesh, for crop campaign financing in Senegal, and probably for Kuroilers – at least for smaller farmers. Financing poses major challenges for several reasons: (1) few financial institutions operate in rural areas, (2) institutions that do operate in rural areas, such as micro-finance institutions (MFIs), generally have little or no experience with agricultural lending, (3) the repayment period and payment schedule of existing loan products often do not match the time profile of the earnings term generated by the innovation package, and (4) small adopters do not have the means to meet the security and collateral requirements.

In the case of Senegal, there was already a *Crédit Agricole* with a long track record of financing irrigated rice, but this had produced an equally long history of payments arrears. The result was that many farmers were no longer eligible for credit and, at the same time, little lending was available for either rice millers or machinery service providers. Even those farmers who received credit got it with delays that pushed back land preparation and planting dates, which reduced yields. PCE helped to innovate crop insurance to protect banks from non-payment. It developed a cashless payment system for farmers and processors known as "contractualization" (see footnote 11), which increased the feasibility of lending. PCE partnered with a leasing firm, *Locafrique*, to make financing for machinery purchasing accessible.

Access to machinery services was important in Senegal and Zambia, and constituted the innovation in Bangladesh. In SW Bangladesh, CSISA-MI experimented with partnerships with multiple MFIs, was able identify a primary partner that had experience in agricultural lending, and partnered with it to expand activities to cover machinery purchases by LSPs. This partnership included co-investment in marketing, temporary subsidies on interest rates, and covering the cost of additional staff to handle these loans. In Zambia, no machinery services were available, and many farmers had lost their traction animals recently to disease. Interviews with farmers indicated that a lack of traction services was a major constraint on scaling.

Output Markets and Linkages to Them

In all five cases, scaling up of the innovation package was expected to increase farmers' incomes – usually by increasing productivity, sometimes by reducing costs, and occasionally both. Hybrid maize seeds increased yields in Zambia significantly. Access to seeders and reapers reduced Bangladeshi farmers' costs and increased the length of the growing season. In Senegal, the broad package of innovations resulted in significant increases in irrigated rice yields. In Kenya, use of PICS bags reduced post-harvest losses and this effectively increased incomes, which was further augmented by farmers being able to sell any surplus at higher prices.

Even when there is potential demand for the increased output resulting from scaling, there need to be linkages from producers to those markets. This is especially the case where producers traditionally had not produced any commercial surplus, or where the little surplus that was produced was usually sold in local village markets. In SW Bangladesh, there were already solid links for most products (e.g., fresh fish, rice, horticulture) to urban markets, especially in Dhaka. In most of the other countries, downstream linkages had to be created. In the SRV, PCE built market awareness that quality domestic rice was available as the alternative to imported rice, and the project supported networking to link rice mills in the region to urban wholesalers in Dakar and elsewhere. In Zambia, the GOZ developed a maize-purchasing program that included creating depots in remote villages, allowing all farmers to have access to a market. By contrast, in Kenya the Kuroiler scaling effort did not include the creation of market linkages. With the greater productivity of Kuroilers, many farmers found themselves with a surplus of eggs they could not sell, especially in northern Uganda where the important market of South Sudan was constrained when conflict resumed there. The same was true for poultry meat; while Uganda imports live fowl and poultry meat, small rural farmers had limited linkages to growing urban markets.

D. Characteristics of Institutions and Partnerships

Organizational capacity and partnerships proved central to scaling up in four of the five cases, with Zambia as the partial exception. These partnerships were between the donor's implementing partners (IPs) and a variety of actors, including other donors, national and local governments, parastatals, the private sector, NGOs, and community-based organizations (CBOs). The key partnerships are summarized in Table 1.

TABLE 1: DONOR/IP INTERLINKAGES ACROSS THE FIVE CASE STUDIES

Country	Donor	Government	Private Sector	NGO/CBO
Bangladesh	CSISA-MI was funded by USAID and was the primary driver of initial introduction and scaling, along with its private sector partners. CSISA-MI identified the right machines, did market testing, and supported marketing and initial subsidies. USAID played a vital role in being flexible in goals and workplans.	CSISA-MI partnered with agricultural research parastatals to approve and design machinery; with the Ministry of Agriculture (MOA) for extension agents to promote machinery and provide advice; and with MOA to provide subsidies for machinery purchases	CSISA-MI partnered with large agricultural machinery companies to import and sell machines as well as co-investment on marketing and sales	CSISA-MI partnered with a local MFI to provide subsidized financing for machinery purchases. They also supported additional MFI personnel to increase marketing capacity.
Kenya	Major donors, including USAID, came together to stimulate hermetic storage via AgResults	- PfI and KAVES secured government support for promoting PICS via county offices - KAVES partnered with counties to offer training and distribution of PICS	- PfI worked with Purdue and a local contractor to manufacture PICS - KAVES partnered with a new company to promote PICS -KAVES partnered with Bell to provide roll-over financing - KAVES and AflaSTOP partnered with Bell to offer training	- KAVES partnered with local and international NGOs to provide training to purchasers - KAVES partnered with ADPP, CARD, CRS, Diocese of Eldoret to promote and provide PICS
Senegal	PCE/USAID partnered with multiple other donors to fill in gaps in the rice value chain; the Japanese donor provided quality technology to farmers and rice mills; Spanish donors financed warehouses; multiple donors built or rehabilitated irrigation infrastructure. USAID played a vital role in being flexible in goals and workplans.	- PCE partnered with GOS parastatal banks and insurance to develop crop insurance and cashless warehouse receipt system - PCE partnered with GOS parastatal SAED to deliver extension services - PCE partnered with national research institutes to introduce new varieties - PCE partnered with GOS to create seed certification and processing	- PCE partnered with *Locafrique* to develop lease financing - PCE partnered with rice mills to improve quality and link to urban markets	- PCE partnered with farmer's associations and hydraulic unions to improve rice productivity - PCE partnered with seed multipliers association to improve supply of certified seeds

Country	Donor	Government	Private Sector	NGO/CBO
Uganda	No donors apart from BMGF involved	- BMGF worked with MAAIF through NAGRC & DB on pilot - NAGRC & DB selected as initial local partner - MAAIF through NAADS promoted Kuroilers in partnership with BMGF and ASU - BMGF channeled initial funding of parent-stock purchases by NAGRC & DB	- BMGF partnered with ASU to select private supplier CML - BMGF partnered CML to establish mother units -BMGF partnered with ASU to fund initial parent-stock purchases by CML	Not significant – no cooperation between ASU/donor and non-government sector
Zambia	Not a major factor	CIMMYT partnered with GOZ research stations to develop new maize hybrids, especially drought tolerant varieties	CIMMYT partnered with private seed companies to develop new maize hybrids, especially drought tolerant varieties	Not a major factor

Partnerships with the private sector were important in Bangladesh, Kenya, and Senegal, which may be the three most successful cases of scaling up out of the five examined. In all three cases, private partnerships were involved from very early in the scaling process, if not from the beginning (as in Bangladesh and Kenya). These partnerships were negotiated largely on a commercial basis, in that the IP required its private partners to invest their own capital and contribute other resources (e.g., distribution networks) in exchange for donor funding of efforts to build market awareness, demonstrations, and initial price discounts. Both PCE and CSISA-MI were able to work on a commercial basis because they were clear that they were offering commercial actors an attractive deal, and were willing to absorb some of the risk to make it even more appealing to first movers. In Bangladesh, private-sector partners (PSPs) put up all the funding for the purchase and import of new agricultural machinery. In Kenya, Bell Industries saw distribution of PICS bags as an attractive addition to its portfolio of agricultural inputs, and found a manufacturer. In turn, Bell received USAID loans to address its cash flow issues. In Senegal, *Locafrique* put up its own capital to fund purchases of combines and tractors by machinery-services companies. All of these commercial partners had substantial business skills and commercialization experience, even if *ex post* performance varied (e.g., some rice mills that partnered with PCE were more successful than others). A key factor that may explain the poor performance of the Kuroiler scaling effort in Uganda was that a PSP was not involved until fairly late in the scaling effort.

Perhaps a more surprising finding for scaling through commercial pathways is the importance of partnerships between IPs and the public sector.[18] This was especially true in Senegal, where the government had significant involvement in providing financial support for the rice sector. In Bangladesh, partnerships with key government institutions were vital because of their role as gatekeepers and regulatory authorities, rather than the value-added they provided. Without their tacit approval and a good relationship, there was a strong risk that nothing would happen or activities could be blocked. In all five countries, the weakness of public extension services and agents complicated efforts to form partnerships to provide technical support. In Kenya and Uganda, this was further complicated by the greater role of local government — because of devolution — in providing these services.

[18] See Table 1.

Partnerships with farmers' associations played a key role in promoting the adoption and mastering of new technology in Kenya, Senegal, and Uganda. In Senegal, hydraulic associations were the primary conduit for a cascade approach to training; PCE provided training to these associations, and they in turn disseminated it among their members. In Kenya, farmers' associations both promoted PICS bags and arranged bulk purchases for their members. This brought the bags within the reach of very poor rural households that would not otherwise have been able to access them because of the small quantity they could afford and the cost of transport to the supplier. The picture in Uganda was different; while the mother units could have linked with farmers' groups, they do not seem to have done so to any great extent. The reason may be the relative scarcity of poultry-raising rural organizations, since commercial poultry production was a new activity, such organizations had not had time to form, and there was no structured support from the promoters of the Kuroiler project to develop them.

E. Characteristics of the Policy Environment

While the five case studies focused on scaling through commercial pathways, a favorable policy environment proved to be a major factor in successful scaling. First to be considered is the overall policy context, in which the government's agricultural strategy is aligned – or not – with the scaling up of the particular innovation package. In all five countries, the overall policy stance was favorable to the introduction and scaling of the innovation. In Kenya, Senegal, and Zambia, food security in the staple cereal was a major policy priority. This created an environment in which private-sector actors were more willing to make risky investments. This was particularly true in Senegal, where many investors cited the government's support for the sector as almost an implicit guarantee of their investment.

Government subsidies were critical to scaling in Senegal and Zambia, and to a lesser extent in Bangladesh. Both Zambia and Senegal heavily subsidized inputs in maize and rice production. In Senegal, this significantly increased farmers' profitability. In Bangladesh and Zambia, subsidies served to make purchases of the innovation more affordable, and in Zambia also provided for a guaranteed price and market for maize output.

Government intervention in the output market and pricing proved to be a mixed bag, which is not surprising given the political sensitivity of staple cereals. In Senegal, government interventions and facilitation of negotiated prices helped ensure that domestically produced rice could successfully compete with imports (but may have squeezed margins for millers and wholesalers). Zambia's FRA provided a guaranteed market for maize purchasing; for more remote farmers, it was the only market. The dominance of the FRA in the market proved to be fiscally unsustainable and has driven private-sector actors out of the market, while putting pressure on maize processors' margins.

One area where government support seemed to be less important was in the provision of extension services. While in Bangladesh, Kenya, Senegal, and Zambia, they did play a role (in partnership with the private sector), their lack of capacity limited the impact they could have had. However, drawing lessons from this requires caution. In Bangladesh, agricultural machinery was sufficiently profitable that companies were willing to absorb marketing and training costs. In Kenya and Zambia, training costs were minimal, given the fact that there were few and no new components, respectively, in the innovation package of PICS bags and hybrid maize; maize farmers were already accustomed to using fertilizer and herbicides. In Senegal, the scale achieved to date has been limited and thus the PCE could afford to finance training and extension, even though the *Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé* (SAED) had limited capacity. Uganda again serves as a counter example, as the lack of effective government extension made scaling more challenging, although this may have had as much to do with a lack of proper training and information as it did with institutional capacity.

The absence of government interference was also important. In Bangladesh, the government is heavily involved in strategic sectors like rice, supplying most rice seed at subsidized rates, designing agricultural machinery, and providing subsidies for machinery purchases. When government agencies or parastatals play a major role in a sector in producing inputs, this can make it challenging for the private sector to compete effectively. Where this is not the case, commercial scaling is more viable. The best example of this was Zambia, where the state seed producer had been privatized in the 1990s. The result was a level playing field for all private-sector companies, whether foreign-owned or domestic, and a generally free-market regulatory environment helped make Zambia the primary producer of hybrid maize seeds in the region, with positive spinoffs for the domestic market.

Lack of price controls – on hybrid maize seed in Zambia, PICS bags in Kenya, and agricultural machinery and services in Bangladesh – probably played a vital role in the private sector's willingness to be a major driver in all three countries. The heavy government involvement in Senegal produced mixed results. While GOS subsidies for physical inputs and credit were important, government subsidies on agricultural machinery (an input) made it much more difficult for private lenders and machinery services to build market share.

Quality control and enforcement of intellectual property rights and branding can, in principle, be done by both the private and public sectors. This proved to be an important government role in cases where maintaining the quality of the innovation was important for optimal results, or, alternatively, where there was a significant risk of fraud and counterfeits. In Zambia, the strong seed-certification system was invaluable to ensuring quality and minimizing fraud for scaling of hybrid maize seed, creating a reputation effect that helped both domestic scaling and export sales. The same was true in Senegal, once the system was put in place with the help of PCE. Experience in Uganda reinforces this point, as the lack of effective certification and quality control led to an industry of counterfeit Kuroilers and naive cross-breeding by farmers, undermining profitability and farmers' willingness to continue raising Kuroilers because of the inevitable disappointment.

Bangladesh and Kenya were cases where quality control was less important. While the Bangladesh Agricultural Development Corporation did certify machinery, it is not clear that counterfeiting was a major issue; copycat or knockoff designs usually performed well and *de facto* were a form of scaling up. In Kenya, certification of genuine PICS bags was not an issue, and the development of copycats that retained much of the effectiveness of the original facilitated scaling of the idea of hermetic storage bags, even if not the PICS design *per se*. This was facilitated by the low cost of bags, as it was not costly to try an alternative bag.

F. Scaling Drivers and Strategies

In some countries, there was a conscious scaling-up strategy or approach – this was clearly true in Bangladesh and Senegal, where USAID projects and IPs were responsible for scaling up. In Kenya and Uganda, there may not have been an explicit strategy for scaling, as the 'driving' organization was a research institution, but one can infer an implicit strategy from their actions. In Zambia, there was no single actor or partnership driving scaling, but the case still provides lessons about the activities necessary for scaling.

Drivers

One of the factors that seems to most facilitate successful scaling through commercial pathways is the presence of large private-sector actors with a commercial interest in driving the process. In the five cases examined, private companies were all upstream operators involved in production and/or

distribution of goods and services.[19] In some cases, the companies found it profitable to underwrite or share the costs of marketing, training, and extensions services. In Bangladesh, this took the form of two large agricultural machinery companies (actually conglomerates with machinery divisions). In Zambia, the private-sector actors were large and, initially, primarily multinational seed companies. In Senegal, it is more difficult to identify a few drivers because of the large number of innovations that were scaled. However, Vital Industries played a critical role in helping to revive rice-milling operations, the parastatals CNCAS and *Compagnie nationale d'assurance agricole du Sénégal* were critical in banking and insurance, and *Locafrique* was crucial in machinery leasing. In Kenya, Bell Industries was pivotal in driving scaling. In Uganda, there was no commercial driver until very late in the process, and Chick Masters played only a minor role in marketing or training provision.

A donor project and IP with a strong commercial orientation can function as a complementary driver. In Senegal, the fact that the PCE Chief of Party was a former private-sector businessman positively affected the project's entire philosophy and approach. In Bangladesh, one of the two IPs was iDE Bangladesh, an NGO whose specialty is in market facilitation from a private-sector perspective. In both countries, these actors involved the private sector from the very beginning in profitable deals that implied long-term commercial sustainability. To a lesser extent, the USAID-funded KAVES project in Kenya, which helped support the scaling of PICS bags, also had an important commercial orientation. The ownership of production, marketing, and training by private seed companies in Zambia clearly made the scaling of hybrid maize seed sustainable.

A third driver was a supportive public-policy environment, generally and specifically for the actual program or innovation. In Senegal and Zambia, the government's strong support for food security and the scaling up of the rice and maize sectors, respectively, constituted a major driver for scaling up of the specific packages of innovations. This was also true in Bangladesh and Kenya, although it was of lesser importance. In Senegal, Uganda, Zambia, and to a lesser extent Bangladesh, this general policy support was combined with specific program support through subsidies or direct government implementation. In Senegal and Zambia, this general and program support combined with significant potential demand for increased output, which was another important driver.

Scaling-up Strategies

The five cases produced a number of lessons for the design and implementation of scaling strategies, which are summarized in this section. In general, these themes reinforce the conclusion that scaling is complicated and takes more active monitoring and oversight from donor agencies than a standard project.

Building in scaling up from the beginning, using a phased, adaptive approach

Scaling considerations need to be included in the design stage of a project, while recognizing that both the path and the goal will evolve over time. Four of the most important tasks in the initial design phase are: (1) ***understand the whole market system*** and value chain, (2) ***determine the right package*** of innovation(s), (3) ***test the innovation in the market*** (and not just at research stations and plots), and (4) ***adjust the innovation based on market feedback***. A systems-level perspective and engagement

[19] This is not universally the case; the KAVES project has been scaling up horticulture production using a 'pull' approach where it is the downstream buyer that provides training, inputs, quality control, etc. In many countries and sectors, there is not necessarily a choice of push versus pull, because the upstream or downstream actors are small and diffuse, and do not have the either the means or the vested interest (market share) to justify absorbing some of the intangible costs of scaling, especially information provision and awareness building. Nonetheless, further research on the pros and cons of using a push versus pull approach to commercial scaling would be useful.

with all stakeholders – including researchers, funders, government, investors, and implementers – are essential to ensure that system gaps are being addressed. Most of the cases examined involved consultation with all stakeholders to determine the best way for the design to be structured.

An ***iterative approach works best*** in both choosing the right packaging and testing the market. Starting with a portfolio of innovations and seeing what achieves acceptance, as was the case in Bangladesh and Zambia, produces optimal results. In packages that center on single, simple innovations (e.g., Kuroilers and PICS bags), it is critical to understand the package of complementary innovations. That this was not done in Uganda is largely responsible for the failure to reach scale and uncertainty over sustainability.

Determining market readiness should include studying and ***verifying feasibility, usability, and potential market size for both the innovation package and the expected increased output***. In Bangladesh and Uganda, this kind of study was not done, and implementers were taken by surprise. In Bangladesh, initial demand was significantly overestimated. iDE Bangladesh did subsequently do these types of market studies and they proved extremely useful in adjusting the packages of innovations and scaling strategy.

Market studies need to include an ***assessment of the major players in the market***, whether upstream or downstream, and identify which of them would make good PSPs. The evidence from the case studies is that PSPs need to be introduced as early as possible, preferably before actual scaling and implementation begins.

This phased approach to scaling must be accompanied by an understanding that ***it often takes time to see the results and impact of scaling; the numbers may look weak for the first few years***. For example, in the case of irrigated rice in Senegal, it took three to four years to start seeing results. This has been similar to the situation in Bangladesh. In the cases of Kuroilers and PICS bags, where the packages were simpler and much less costly, signs of scaling up were visible more quickly. ***Insisting on quick wins and big early numbers can often incentivize projects to distort market incentives, undermining the long-term commercial sustainability of any scale achieved***. If big early numbers are necessary, then it might be best to bundle a scaling project with another project that can deliver such results.

The case studies demonstrated that ***flexible and adaptive management is critical*** for both those organizations implementing scaling and, where USAID was involved, the country Mission. In both Senegal and Bangladesh, the IPs and the Mission worked together closely each year to identify problems, constraints, and proper targets in the annual work planning process and adapt iteratively over time.

Promoting awareness and adoption, and assessing impact

A key part of any strategy for scaling up through commercial pathways is increasing the awareness of potential adopters of the innovation package and its benefits. This includes persuading target beneficiaries to adopt it, providing the training and support necessary to use it successfully, and determining who are likely to be early adopters and where they are located. A scaling effort should ***focus on early adopters who have the financial means and commercial orientation to adopt, and who will have the most demonstration effect for friends and neighbors*** (i.e., influencers). This is different from the common practice of enticing large numbers of early adopters ("quick wins") using non-market incentives, for example giving farmers transportation and food money to attend a demonstration and providing free samples.

In Kenya, Purdue University and Bell Industries chose local dignitaries for the initial PICS demonstration sites because of their influence and greater means, and this did encourage take-up by others. In Bangladesh, the initial targeting of actual and potential wheat and maize farmers proved to be less

successful than the spontaneous adoption by fish, horticulture, and rice farmers. These tended to be higher-yielding cash crops in which farmers had more of a commercial orientation, openness to new technology, and the financial means to invest. CSISA-MI quickly shifted from its initial target population to those who were actually buying, thanks to its flexibility and that of USAID/Bangladesh. In Uganda, the blanket approach to promoting Kuroilers ended up having many smaller farmers disillusioned with their results, because (in addition to other factors) they were not good candidates to adopt the innovation. A crucial lesson is that – even if small, staple farmers are the ultimate target – to establish momentum for scaling and creating an initial market it may make more sense to start with emerging farmers and/or those growing high value-added cash crops.

It may make the most sense to ***start scaling in areas that are closer to input and output markets – where transaction costs are lower and population densities are higher*** – before moving to more remote, rural areas. This seems likely to be true even when the ultimate goal is to reach smaller-scale poorer farmers. When scaling up through commercial pathways, the shortest distance between early adopters and desired beneficiaries may be not having them be the same. A targeted, sequential approach to scaling gives time and incentives for the private sector to fill in the distribution system as the adoption frontier moves, or for a scaling project to strengthen major upstream or downstream value-chain institutions. In Zambia, seed companies started with farmers near major roads and towns, and then scaled outwards. This inward-outward approach was an explicit strategy in Bangladesh, and is being implemented in Senegal in the follow-up to PCE. PCE also sequentially filled in the value chain as it identified obstacles — a virtuous circle. A commercially oriented monitoring system is essential to make course corrections, since the market response will evolve, often in surprising ways. (Both monitoring and evaluation [M&E] and the virtuous-circle approach are expanded upon below.)

Scaling-up strategies used a variety of awareness-creation techniques across the five cases, and ***often went well beyond field demonstrations to great effect***. These ranged from traditional demonstration sites in Bangladesh, Zambia, and Senegal to mostly mass marketing through radio spots in Uganda. For the simplest innovation packages, like PICS bags and hybrid maize seed, only awareness building and adoption promotion were necessary, and demonstration sites proved largely sufficient to achieve awareness. This was not the case in Senegal or Bangladesh. Many components of the innovation package in Senegal, like the *Chemin de Bon Riz* (a package of GAPs) required ongoing training, follow-up, and support over at least a few seasons for farmers to achieve competency. In Bangladesh, demonstration sites were tried initially and proved insufficient. Demonstrations had to be linked to trained sales agents from the machinery companies, who in turn referred them to local dealers once a purchase was likely. Dealers and companies also had to provide training for initial use as well as after-sales service.

The business case for adopters, and – to the extent needed – all actors in the value chain, was a key part of the awareness-building and promotional efforts in all countries. In Bangladesh, summaries of the budget and income stream for LSPs were used as part of marketing efforts. The high potential returns to Kuroilers were the major marketing message in Uganda, and in Kenya the main appeal for PICS bags was the savings on post-harvest losses. In persuading adopters to take up new innovations, ***risk – especially in the form of reduced investment costs and cash-flow requirements – were at least equally as important as increased returns*** from greater yields and productivity. In Bangladesh, the fact that some of the machines could be used with multiple crops over multiple seasons reduced risks and made them much more attractive.

The time dimension of risk was critical for adoption decisions in several countries. In Senegal, farmers were particularly attracted to GAPs that allowed them to plant and harvest on time (or have a longer season), and the same was true for purchasers of LSP services in Bangladesh. Time was a key element in Kenya as well, as PICS bags extended the storage life of maize and allowed farmers to keep their grain through the hungry season, or sell it in the off-season at higher prices.

In Bangladesh and Zambia, ***private companies – sometimes with donor support – used sophisticated marketing techniques successfully***. Both introduced promotional deals, giveaways, small sample sizes, and a variety of branding mechanisms. One of the review team's recommendations based on the case studies is that a scaling-up strategy should employ innovative, high-impact marketing and awareness-building activities that are commonly used in commercial operations, such as aspirational advertising.

In all five cases, the public agricultural extension service was involved in the process and potentially played three roles: (1) building awareness, (2) encouraging adoption (and providing advice), and (3) providing technical assistance and extension support. In Kenya, Zambia, and Bangladesh, the focus of the extension service was mostly on building awareness and adoption, whereas in Uganda, the emphasis was only on awareness building (with some technical advice that often proved to be inaccurate). The extent and nature of public involvement also varies at the local level, especially in decentralized countries like Uganda and Kenya, and to a lesser extent Bangladesh. ***The importance of public sector involvement lies in ensuring buy-in to, at a minimum, avoid political interference or opposition***. However, the on-the-ground impact of public extension officers with respect to commercial scaling was limited; in no country were they mentioned as the primary source of information, the major factor in decisions to adopt, or a major source of follow-up support. Therefore, ***the involvement of the public sector is necessary but far from sufficient***, even at the initial stages.

When scaling is, at least initially, funded and driven by a donor project and IP, ***the public sector cannot be expected to take over promotion or assessment roles adequately; commercial partners need to be in the lead***. This can be a problem when substantial training and extension support is needed to realize the benefits of adoption, yet delivering this training and support is not profitable enough for the private sector to internalize these costs. This constraint is especially true where multiple commercial actors are involved and the provision of training and extension amounts to a public good in which all actors share.

Partnerships with the private sector

P***artnerships between the donor-funded IPs and the private sector proved to be essential*** in every case examined, with the exception of Zambia where the private sector led scaling efforts. PSPs were essential for providing expertise in marketing and commercialization, understanding of local markets and customers, providing investment capital, and ensuring long-term sustainability. The review team found that for scaling, it is generally better to work with a partner on the upstream, supply, or push side of the value chain, rather than on the downstream buyer or pull side. Seed producers, for instance, care about whether they sell seeds, not about the quality of the crop, but the buyer wants to ensure quality and good practices.

The key point in ***engaging PSPs was to ensure a solid, attractive business case*** (i.e., that this was a good deal for them to invest in). In none of the five cases did corporate social responsibility or other similar altruistic motivations play a role. In Bangladesh, CSISA-MI demonstrated to large agricultural companies that importing axial-flow pumps, PTOS and reapers were money makers, and that buying them was an attractive proposition for LSPs. The same was true in Senegal and Kenya; seed multipliers and rice mills in Senegal have largely proved profitable, as has Bell Industries in Kenya.

While these PSPs believed that the deals they were being offered were likely to be profitable, they also perceived them as risky. ***Donor or public-sector activities to reduce the initial risk to early investors (and adopters) was often critical to private sector involvement***. Without it, private sector participation probably would not have occurred except for in Zambia. A key risk-mitigation effort was the use of subsidies to early adopters of the innovation package, which helped create or grow a market for suppliers and reduced their risks. In Zambia and Senegal, public-sector input subsidies were

crucial. In Bangladesh, CSISA-MI provided subsidies to LSPs and farmers to try agricultural machinery and services, respectively.

Risk mitigation to attract private-sector actors took several other important forms: absorbing the costs of awareness creation, strengthening the value chain, and helping coordinate demand and supply. Covering the costs of initial marketing, training, and extension support was equally important. CSISA-MI absorbed the initial costs of marketing, awareness building, and sales agents in the early years, which addressed the issue of free riders for a public good. More recently, in Bangladesh PSPs have begun to take these over, now that a critical mass has been reached. CSISA-MI helped its PSPs improve after-sales services and the availability of spare parts, both vital links in the value chain for LSPs that reinforced sales. In Senegal, PCE helped to ensure that increases in the production of certified seed, paddy rice, and rice-milling capacity were more or less synchronized, which created a virtuous spiral for all actors.

In exchange for offering attractive deals and various forms of risk mitigation, ***successful IPs insisted that private investors invest their own money (so that they "have skin in the game")***. In Bangladesh, private investors imported the first and subsequent rounds of machines with their own money. In Senegal, *Locafrique* put its own money into machinery leasing and many rice mills combined their own investment with subsidized machinery and technical assistance from the Japan International Cooperation Agency. Bell Industries and all of the Zambian maize seed companies invested their own money, although Bell required a cash flow injection from the KAVES project. Critically these partnerships were largely on commercial terms.

Investors were also attracted when the deal was presented to only one partner, at least initially. In other words, commercial scaling projects were able to leverage the ***greater profits in first-mover advantages***. The PSPs in Senegal, Kenya, and Bangladesh all had exclusive initial deals (albeit on different machines in the Bangladesh case), while in Uganda the PSP was the sole private partner of the promoting institution. However, in no case were the PSPs guaranteed long-term exclusivity; in Bangladesh, CSISA-MI brought in new PSPs once it was clear that there was a (established) market, and in Kenya competitors and copycat producers also emerged.

A strong commitment from the senior management of the PSP is necessary, although far from sufficient. In some cases, as in Bangladesh, the review team found that the incentives of mid- and junior-level management were different from senior management. One reason appears to have been that lower-level managers were less interested and incentivized to introduce new products to small farmers in remote areas, when they could instead make more money and reach sales targets with traditional products and markets. Another reason is that, at lower levels, private-sector actors seem to have less of a culture of innovation and are more risk averse.

Strengthening the value chain downstream and upstream

The penultimate piece in a scaling strategy is identifying gaps and weaknesses in the value chain, and addressing them. The gaps that must be addressed vary by country and sector. Little effort was needed in Zambia, Kenya, and – to a lesser extent – Bangladesh. The process of closing gaps and eliminating weaknesses is of intrinsic importance because without either input supply or access to markets, scaling will stall or falter. It also helps reinforce buy-in and partnerships with the private sector and adopters. Value chain actors are more likely to move forward in their niche with knowledge that they will not get ahead of supply and demand.

Perhaps the best example of this was in scaling the irrigated rice package in the SRV. PCE worked on strengthening almost the entire chain as it identified different weaknesses and bottlenecks. These included: increasing foundation and certified seed production; creating seed certification and processing;

improving access to credit and crop insurance; strengthening machinery services; increasing milling quality and capacity; and reviving downstream links to wholesalers and urban markets as part of the package of innovations. In Uganda, failure to create chick nurseries proved to be a vital missing link in the value chain. In Bangladesh, by contrast, the missing links were the lack of after-sales service and spare-parts availability. A key lesson in strengthening the value chain is that the process should simultaneously create supply and demand for: (1) inputs, (2) the innovation itself, and (3) outputs (assuming that there is not already the capacity to meet expanded demand).

There are sometimes losers in scaling up, and ***it is important to identify winners who do not have conflicting incentives and anticipate political or economic pushback from losers. In the case of PICS bags, the losers from scaling were pesticide producers, importers, and distributors***. The PSP in Kenya, while an agricultural input supplier, did not handle pesticides so for them it was a clear win. While political pressures from such losers in Kenya were minimal, this has not been true in Kenya when other new technologies have adversely affected vested economic interests, e.g., the introduction of agriculture netting to prevent insect damage.

Scaling up can only be feasible if there is ultimate demand for any resulting increase in production. There already was demand in all five cases studied, though some downstream market linkages had to be strengthened in Senegal and Uganda.[20]

A role for the public sector in scaling strategies

Strong public-sector support can be vital to successful scaling, but it appears to be necessary that such support is pre-existing. In none of the five cases did donor-funded IPs or other actors create this support. In almost all the cases, a favorable policy environment pre-dated scaling. Hence, advocacy to change policy or create new programs was not necessary in any of the countries, and it seems likely that any attempts to create it would have taken significant time and resources. The importance of PSPs with donors or promoters depended on the country, the sector, and the innovation package. They were vital in Senegal, where the public sector played a key role in supporting seed certification (among other innovations) and in Uganda, where the animal research center assumed responsibility for chick breeding and marketing. In all five cases, public-sector extension workers were part of the strategy to build awareness, conduct demonstrations, and provide advice and technical assistance. However, inadequate resources and weak capacity limited the impact of these services.

The value added from the public-sector extension support was highly variable across and even within countries. In most cases, donor projects or their private sector or NGO partners delivered the majority of training and extension support. However, in all cases it was vitally important to partner with public extension services, for two reasons. First, public-sector participation legitimized and provided official sanction for donor and private efforts. Second, even where public actors' contributions were limited, their inclusion reduced their tendency to block, delay, or otherwise impede scaling-up efforts.

[20] However, in some other cases of scaling up under FTF projects (e.g., demand for soybeans in Mozambique), this has not been the case.

VI. RECOMMENDATIONS FOR DONORS

Based on the findings from the five case studies and the July 2016 workshop, the review team provides the following recommendations for donors to promote effective scaling up of agricultural innovations through commercial pathways.

1) **Introduce a focus on scale at the outset of the project design and procurement phase.** Project Scopes of Work (SOWs) should be as general as possible and focus on ultimate results, but not on specific pathways to achieve them. This flexibility should extend to the choice of locations, sectors, commercial partners, and innovations, as well as sequencing of beneficiaries or target markets. Mandating local public or commercial partners can place unnecessary constraints on IPs.

2) **Adopt a phased approach to enhance the quality of project design.** This should include an inception/detailed design phase to facilitate the full engagement of local private and government actors before key decisions are made. This inception phase may last from six months to two years, depending on the number of seasons and opportunities for testing and getting feedback. This phase allows for the identification of the potential market for the innovation and the incorporation into research designs of elements of human-centered design (i.e., feasibility, usability, and desirability). Expectations and projections of the "available market" should not be based exclusively on agronomic and economic potential, to avoid overestimation. Projections need to be significantly discounted to reflect the variability of knowledge and competencies within a given market.

   Once designs are ready, innovations should be tested in different geographic and demographic markets to improve designs, narrow technology choices, and develop a sequence of targeted markets and early adopters. During the design and initial market-testing phases, the following issues should be considered:

   - Whether the technology's results and business case are still robust under different, less favorable conditions, including use by "average" farmers;
   - The risk associated with adoption, including price points and repayment periods;
   - The possibility of multiple uses over time, seasons, and crops;
   - The sensitivity of rates of return to variance in yields;
   - Sales data on who buys the technology, why, where, and for what purpose; and
   - The nature and extent of changed practices needed to utilize the new technology properly.

3) **Recognize that, with rare exceptions like PICS bags, what is being scaled up is often much more complex than a single product or technology and requires adoption of other components to produce (maximum) benefits**. In most cases, scaling involves a multi-component package – perhaps centered on a technology – that includes innovations in the value chain. Scaling efforts in which the intervention package has multiple components represent a significant departure from the existing practices of most donors. In scaling cases where this is true, it will usually require greater levels of training and support to adopters. In these cases, there should be a strategy as to how some actor, with the incentives and resources, will provide training and support at large scale and, if necessary, on an ongoing basis – assuming that this is beyond the means of the initial donor. This has implications in terms of a need for greater time, resources, and flexibility than simple interventions (as seen when comparing PICS bags to self-propelled reapers in Bangladesh or Kuroilers in Uganda). For technologies that are bundled with GAPs (e.g., hybrid maize in Zambia and irrigated rice in Senegal), adoption is not a binary variable. Rather, packages of innovations are often adopted incrementally, partially, or on only a percentage of a farmer's land. This places a premium on continuing to assess fidelity and efficacy as innovations scale.

4) **Select innovations for scaling based on the application of scalability assessment tools or screens**. Such criteria would include reduced costs, increased productivity, and profits, as well as:

   - Affordability, relative to existing wealth or cash flow;
   - The extent of change from existing practices;
   - Prior familiarity with something similar;
   - Risk and potential for risk mitigation;
   - Potential for time and labor savings; and
   - Relevance to existing expressed needs by farmers (rather than needs as determined by agronomists).

   Several models for such screens exist, such as MSI's scalability assessment tool. Current practice tends to be driven by evaluations of benefits in terms of crop budgets or their equivalent. Equally or more important are assessing the riskiness of adoption and considerations of most adopters' short time horizons for recouping their investments. Any scalability assessment needs to be confirmed with actual market trials. As discussed below, donors should consider basing a project on an initial pilot phase that conducts market testing of a portfolio of innovation packages but then narrows in response to the market reaction.

5) **Build into project designs and budgets at least equal resources for developing or strengthening the value chain and market system**, in addition to building awareness and encouraging adoption by intended beneficiaries, since scaling up through commercial pathways almost always involves systemic changes in those areas. Scaling efforts that require significant strengthening of the value chain (as was the case in Senegal and to a lesser extent Bangladesh) are more complex and time- and resource-intensive than scaling simple products where this is not needed (e.g. PICS bags and hybrid maize seed). This is especially true in low-income and less-developed countries, where the private value chain and public institutions are both weak. These efforts tend to take much longer than awareness building, marketing, and adoption efforts, so there can often be a time mismatch between potential or actual demand for an innovation and the value chain's ability to meet that demand both upstream and downstream.

6) **Contracting mechanisms should allow for flexibility and an adaptive management approach**. More important than the specific type of mechanism is having flexibility within the mechanism and SOW. Donors need to allow for trial and error in multiple dimensions of strategy and implementation. This flexibility should allow for appropriate activities to be adapted and revised to focus on and achieve desired outcomes. Such adjustments are made through regular reviews and course corrections. Budget categories should also not be overly constrained, to allow for room to reallocate within a project through annual reviews.

   Scaling and agricultural experts in the July 2016 workshop agreed that almost any funding mechanism can work with a flexible SOW and a good relationship between the IPs and the donor. Nonetheless, the legal constraints of a contract may prove the most challenging, while grants may allow for too much autonomy as the incentives for research institutions that receive grants may not be aligned for scaling without regular consultation. Cooperative agreements, which at least in USAID's relationships implies a middle ground, may be the best solution, when done with organizations with the right skillsets for scaling (i.e., commercialization skills, experience, and internal culture). While USAID Missions and IPs attest that the flexibility and adaptability needed for scaling can be made to work through any existing type of mechanism, the mechanics of how to do this are not widely understood by Contracting or Agreement Officer's Representatives, or even by contracting officers. New or modified instruments may also be necessary.

USAID and other donors need to use a mechanism that allows not only for flexibility in design but also in implementation. Adaptive management is particularly important when using a commercial-pathway approach, as strategy and tactics (e.g., the choice of innovation package, target market, sequencing, marketing activities, value-chain strengthening) need to be constantly adjusted based on market feedback. The five case studies show that, in general, early adopters are not the populations that FTF is trying to target; it takes four years or more to reach the poorest of the poor. It can be incredibly difficult to start the scaling process with FTF's target population of people who live on less than $2 a day or districts that have comparable levels of poverty. It may be more effective to work initially outside of the ZOI or with better-off farmers to eventually have an impact on a target population. Similarly, in many cases, even if the ultimate targets are (small-scale rural) farmers growing staple crops, it may make sense as part of a commercial strategy to create a market first by targeting (emerging) farmers growing cash crops near towns.

7) **Create and sustain an environment that allows for entrepreneurship through adaptive management**, which – combined with a phased approach – involves different challenges and risks than standard approaches, as well as a possible change in organizational culture. Donors should encourage continuous monitoring, regular evaluative reviews, course corrections, and training of their staff and IPs who can support this approach.

   Since commercial scaling needs to be equally balanced between being supply and demand-driven, scaling strategies should focus on creating supply and demand simultaneously to reduce the risks for both producers and adopters. USAID and its IPs may have good ideas of innovative technology packages and important poverty-reduction objectives, but it is equally important that farmers are interested in buying the technology and that other value-chain actors see a business case in producing, distributing, and supporting the technology package. Commercial actors will not produce, promote, or distribute without a market, and creating demand for an innovation that farmers cannot purchase makes no sense. In providing oversight, donors need to monitor progress and profitability not only for farmers (or relevant adopters) but other actors in the value chain.

8) **Support strategies that include early risk mitigation**, often in the form of subsidies or cost sharing of marketing and awareness building activities, but in the context of commercially sustainable strategies. Virtually all successful cases of commercial scaling at the bottom of the pyramid involve some form of subsidy from the project or from the host government to buy down risk for early adopters or PSPs. It may be possible to phase out some or all subsidies to early adopters and PSPs once a market and awareness are established, and in most cases, this should be an explicit part of the strategy. Donors will need to distinguish carefully between traditional project practices that encourage early adoption through incentives (e.g., giving free technology or financial incentives for farmers to participate), versus bringing down the cost and risks to early adopters in ways that do not spoil the market in the medium-term. This means using temporary discounts that will be phased out, sharing marketing costs with suppliers and producers, or temporary assistance with financing. If longer-term subsidies are part of a scaling strategy, they will need to come from the public or private sector and be politically, fiscally, or financially sustainable.

9) **Ensure that SOWs, contracting mechanisms, and incentives are aligned with the timeframe for scaling, which in most cases is a long-term process that has several phases:** design, market testing, creating the foundations for scaling, and going to large scale. Creating the foundations includes building awareness, fostering early adoption by both customers and value-chain actors, and ensuring a functioning value chain that can expand supply, distribution, etc. as demand accelerates. It may take 15 years for the full design-to-large scale process to occur. Re-competing projects every few years and slicing up contracts into three- to five-year increments can present huge problems for scaling, depending on the contract structure and the innovation.

Donors should explore other ways to support adaptive management and need to either anticipate a series of projects through the phases of scaling, or use a long-term contracting mechanism that has tranches, criteria, gateways, and conditionality to move from one phase to the next. Participants in the July 2016 workshop reported that the Agency's Global Development Lab has been experimenting with this kind of mechanism, using milestones and 10-year periods of performance.

10) **Recognize that M&E for commercial scaling is different from most current donor M&E systems**, such as those used by FTF, that have as their primary purpose to ensure project accountability, fulfill reporting requirements, and allow for aggregation across projects in reporting to Congress. While these systems serve essential purposes, they are inadequate for supporting the flexible decision-making necessary for adaptive management, as they tend to focus on counting abstract numbers. At a minimum, IPs should be encouraged to use monitoring systems that include typical commercial indicators that any business would use to track and refine its sales and marketing strategy: why people are buying, who bought, and how they accessed or purchased the innovation. IPs also need to consider issues such as transaction costs and risk, why only part of the innovation package was adopted, what parts are being adopted, where, and why. Monitoring needs to be able to identify real-world challenges, such as activities not being implemented correctly, gaps, or misunderstanding in training or barriers to the adoption of GAPs. This could include value-chain analysis, adopters' analysis, market systems, or adoption potential.

    Other indicators that workshop participants noted as important in this space included:

    - Number of users, area (hectares), income, gross margin, repeat customers, customer demographics, and time lag to sustainability.
    - Private-sector investment and especially reinvestment in cash and in-kind, and other indicators of real private ownership and buy-in.
    - Number of businesses entering the same market beyond initial private partners, and systematic enterprise surveys.
    - Understanding and measuring financing constraints and issues.
    - Measuring throughput at every stage of the value chain, with clear indicators of capacity and change by commercial actors. This means tracking changes in production, sales, and distribution, as well as access to innovations, finance, spare parts, technical assistance, and extension support.
    - The impact pathway (i.e., how interventions impact a specific value chain).
    - Direct and indirect adopters. It is impractical and counter-productive to focus performance indicators exclusively on the direct effects of donor expenditures. Evidence from the case studies and from the review team's discussion with a range of experts suggests that "plausible association," rather than direct attribution, should be the standard for linking donor interventions with impact at scale. Monitoring of indirect adoption (i.e., farmer to farmer), and research on the pathways and drivers by which this happens, are critical to understanding the true impact of scaling, as well as to learning how to do it more cost effectively.

    Most of this monitoring data needs to be available in as close to real time as possible, to allow for the kind of nimbleness that characterizes the best business practices. If donors choose to continue with mid-term (or end-of-phase) evaluations, they need to be conducted at the actual project midpoint and receive approval for use/release quickly so they can be utilized in the field in a timely way. For USAID, this could be combined with a review and simplification of the current 64 FTF indicators. There was a strong consensus among workshop participants that continuing to use *all* 64 FTF indicators and combining them with commercial indicators would pose a heavy financial cost

and data collection burden on FTF projects around the world. Under FTF, data are already being collected at the household level, but there is a need to adjust this focus and consider using technology (e.g., tablets, open data kits, open source software, GeoPoll[21]) to collect data.

Adoption rates and other outcomes must be tracked for several years following the completion of project funding or donor involvement, including adoption outside the ZOI, to assess the full impact of donor-supported scaling. In this sense, M&E of commercial scaling has much in common with infrastructure or other commercial investment projects. As with indirect adopters, a criterion of "plausible association," rather than direct attribution, should be the standard for linking donor interventions with long-term impact beyond project life.

11) **Have a clear understanding of the pathway(s) for scaling at the onset of a scaling project,** even though these pathways will likely have to be adjusted annually based on market feedback. Visualizing pathways means having a clear idea of who are expected to be early adopters, secondary adopters (in terms of both users and value-chain actors), and what the numbers of adopters will look like over time. In most cases, this will take the shape of the standard adoption S-curve – the level of adoption graphed against time – and points within that, though this is less likely to be true in cases where the benefits are high and very obvious, entry costs are low, and therefore cost-benefits are very high. In these cases (e.g., PICS bags and Kuroilers), demand can expand very rapidly. In more typical cases such as the other three studies, adoption is likely to be slower and it will be important to anticipate tipping points, critical mass, and the transmission from direct to indirect adopters, and monitor progress in achieving these intermediate goals.

    Measuring the S-curves presented challenges in all five case studies. It is difficult to collect *ex post* S-curve data, and none of the cases collected it in real time or collected data on indirect adopters or adoption pathways. This is particularly problematic for evaluating the role of direct versus indirect adoption, and how each will play out over time. Estimates for market size, for example, were substantially inaccurate in Bangladesh (too high for initial years) and Uganda (too low) and required significant adjustments to equate efforts to match supply with demand. Despite these challenges, the studies did show that indirect adoption and tipping points do exist and indirect adoption was extremely important in most cases. This is true in terms of adoption by the value chain as well; in Bangladesh, Uganda, and Kenya, copycat producers and distributors emerged within a few years.

    Measuring the levels of adoption — who, how, where, and why — needs to be integrated into future scaling through commercial pathways, so that an S-curve methodology can be gradually developed and refined. Despite a great deal of effort, the review team was not able to find the data necessary to estimate the potential market demand of a technology and the innovation take-off point derived from potential market demand. While the critical mass for scaling is generally thought to be around 16 percent (1 out of 6), the review team was unable to confirm if this rule applies to developing markets or to all developing markets equally.

    As this could be vital to the design, deliverables, and monitoring of donor-funded scaling projects, further applied research and application are necessary. The review team recommends that additional resources be provided to selected ongoing projects so that they can collect the necessary data that could then be used to estimate such models. Such data would include:

[21] GeoPoll Mobile Surveys. Available at: https://research.geopoll.com/

- Who adopted which version of an innovation and why.
- Whether adoption was partial or complete (i.e., whether they adopted the whole innovation package and whether they applied it to all the relevant crops or breeds).
- How adoption by individuals varied over time, both in terms of being partial or complete and sustainability, and the willingness to buy the innovation commercially.
- Where the innovation was adopted, and for what applications (i.e., spatial patterns).
- Tracking direct and indirect adopters and determining what marketing and transmission mechanisms were most effective in reaching and persuading them. Or, if resources permit, disaggregating adoption patterns demographically and spatially, and determining which marketing and transmission mechanisms were most effective where and for what types of adopters.

Once the data to estimate such models are available, adoption models could be estimated and used prospectively in new projects.

12) **Ensure that at least one IP – preferably the lead partner – have commercial experience**, including the IP's Chief of Party. The IP must behave entrepreneurially, know how to identify good deals and make the business case, understand value chains and market systems, negotiate and manage partnerships with the private sector, flexibly address challenges and opportunities as they arise, and hold the joint goals of achieving impact on poverty and commercial sustainability (with sustainable subsidies if necessary). They must understand the judicious use of subsidies and other forms of risk mitigation, without spoiling the market in a drive to reach big numbers early in the process.

13) **Research organizations should play an important role in developing innovations, conducting applied research, and making continuous improvements in response to market feedback**. While caution must be taken from the fact that in only three of the five case studies were agricultural research organizations involved, it appears that in general, such organizations do not have these capabilities or the necessary commercial experience. The models that appear to work are neither those where research organizations drive the entire scaling process nor those involving sudden handoff from research organizations to commercial actors, with no further research involvement. The "handoff" model makes insufficient allowance for the need to modify and adapt technologies iteratively in response to market responses. Research institutions need to remain involved throughout the scaling-up process, but, at least with their current capabilities and organizational structures and cultures, are generally ill-equipped to drive it, especially on their own. Further study is necessary in a few areas, including: (a) how to ensure that incentives and accountability exist for research institutions to successfully hand off their innovations to actors with commercialization capabilities; (b) how to structure partnerships between research institutions and commercialization actors; and (c) whether strengthening the commercialization capabilities of what are now primarily research institutions is a viable option for addressing this issue.

14) **Private-sector partnerships are critical to scaling and need to be involved from the very beginning of the process**. However, existing practices of either mandating specific partners or expecting that it is easy to achieve authentic private sector involvement simply by requiring it need to be reexamined. In the two primary cases examined where USAID projects leveraged multiple PSPs, the relationships took years to develop and required extensive and continuous relationship management. The former point has implications for timing and contracting, since if scaling up is to start quickly, those relationships need to pre-exist and thus IPs need to already have a presence in country. In fact, when private companies know that an IP has contractual requirements to identify and partner with private companies, it can drastically distort bargaining incentives to the detriment

of all parties in the long run. In procurement relationships, PSPs may initially perceive a donor-funded, risk-free contracting opportunity rather a real investment opportunity and partnership.

Partnerships need to be largely demand-driven, and patience is necessary since it can take time to identify what PSPs want to do, what is consistent with their corporate goals, and what they can contribute. There is a "slow-burn" to be worked out over time, so it is important to remain flexible throughout the project and the whole scaling process. This allows relationships to be based on trust and a more 'conversational' approach to evolve. Additional innovative ways to build trust and share decision-making with commercial partners should be sought by focusing from the outset on disrupting the traditional donor/recipient mindset. This includes ensuring that commercial partners have cash investments from the outset and that they immediately focus on establishing a sustainable, commercial rationale for their participation. This reinforces the case for a phased approach to scaling, as a year or more of market research, market testing, and modifying the innovation and package would allow time for the relationship between the IP and the company to develop.

Donors can play a role of convener and facilitator, instead of mandating partnerships. IPs need to assess whether businesses have the capacity, capability, and incentive to help scale an innovation in a partnership. IPs and donors can monitor the quality and role of their partners on commercial criteria, and make changes as necessary, as happened in the Kenyan case. It may be necessary to consider initially granting exclusivity to allow companies first-mover advantages as a reward for taking the initial risks. At the same time, encouraging competition is necessary and projects should move towards opening up as early as possible. Donors should be aware of this and accommodate the competition.

15) **Donors need to assume that, in the context of scaling efforts, the local policy environment is fixed at least for the medium-run** (i.e., up to five years). Even though all of the case studies examined scaling through commercial pathways, the policy environment was often critical to achieving a successful result. This includes the presence of input subsidies, output purchase programs, input quality certification and control systems, public credit provision, and overall support for a sector or food security. While most of the projects in the cases examined identified and, in some cases, actually attempted to modify public policies and programs that could be modified to facilitate or accelerate scaling up, there was little to show for their efforts in the standard five-year project timeframe. These policy environments were almost all in place when scaling started. Donors should understand that, in most cases, a favorable environment needs to be already present, and that more complex innovation packages usually cannot scale without a favorable environment. Donors need to think twice about scaling up a technology-innovation package in a country context where the policy environment is not supportive, even where there is great potential demand and impact.

16) **In the context of an adaptive, flexible, and phased approach to commercial scaling, there must be ongoing communication between donors, IPs, and PSPs**. In successful cases of scaling, USAID Mission staff engaged closely and regularly with IPs, while avoiding micro-management. Annual work plans should be co-created annually between donors, IPs, and PSPs using annual reviews and planning to identify constraints and opportunities, assess progress against outcomes, and make significant and timely course corrections where necessary during the calendar year. This often implies different communications and expectations between Missions and USAID/Washington, or in the case of other donors, other national capitals.

17) **Recognize that integrating scaling up into USAID programming has significant implications for the selection and training of Agency staff in Missions and Washington**. Direct-hire staff can play a meaningful and satisfying role in developing viable partnerships,

supporting locally owned changed processes, ensuring needed coordination with the host-country government and with other donors, and supporting adaptive management. To play these roles effectively, a donor should:

- Encourage a greater focus on business perspectives by recruiting staff with significant business background and by providing in-service training on commercialization and commercial pathways to scaling;
- Find ways to bridge the current separation between research and market development, both within the Agency and with its partners – especially research partners;
- Develop guidelines, templates, checklists, and training programs that support staff in integrating scaling considerations into their projects and programs; and
- For USAID, equip BFS Country Support Officers to provide scaling support.

ANNEX A: ADDITIONAL OPTIONS FOR MAINSTREAMING SCALING INTO FTF ACTIVITIES

USAID/BFS also requested that the review team identify a "menu" of additional actions that might be undertaken by the team or others to assist the Bureau in mainstreaming a focus on scaling into the next phase of FTF operations. That menu of possible actions includes the development and implementation of:

- Templates and checklists for incorporating scaling considerations in strategic planning and project design processes.
- Procedures for incorporating scaling considerations into procurement and operational guidelines.
- Metrics and procedures for monitoring commercial scaling that can be used by Missions and IPs for tracking and reporting on indirect adoption, partial adoption, how weakness in the value chain and market system are being addressed, size of the potential market, reaching critical mass or tipping points, and progress towards commercial sustainability.
- Training of BFS, Mission, and IP staff in scaling indicators, as well as the implications of scaling for project design, procurement, and implementation.
- Training and technical assistance with research partners, Innovation Labs, and Consultative Group for International Agricultural Research institutions on integrating scaling and sustainability into research designs and commercialization plans.
- Advice on incorporating scaling considerations into research programs and agendas.