PLANNING FOR SCALE BRIEF #1

TOOLS FOR SCALING

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1 – Who will find these briefs useful?

These *Planning for Scale Briefs* are targeted for use by donors and practitioners in agricultural development, informing investment opportunities as well as the structuring of programs and partnerships. We hope the issues raised in these pages will spur discussion and lead to higher caliber strategic thinking about scaling the commercialization of agricultural technologies to benefit smallholder farmers.

The briefs will also be useful for policy-makers seeking to understand the issues of scale in greater depth. Legal and policy frameworks critically determine the success of scaling, and we have therefore included an entire brief (*Planning for Scale Brief* #6) devoted to the components of the enabling environment that impact scaling. However, we note upfront that these briefs were not intended to deliver policy recommendations. Rather, our intention has been to provide advice for those developing scaling strategies *in practice* and those funding investments that will improve our ability to scale.

Both public and private sectors

Scale that is sustainable over time cannot be achieved, of course, without involving both public and private sectors. In fact, one commonality among success stories of scaling seed that we came across in the course of our research is that they *all* depended on measures that enabled significant collaboration between public and private partners.

In these briefs, we identify opportunities for the public sector to *amplify* existing commercial activities, leveraging the resources of large and small companies, as well as the many entrepreneurs engaged in the seed value chain across both formal and informal systems. Additionally, we identify potential investments that could create new commercial opportunities. While they are not our primary audience, companies engaged in any side of the development, manufacturing, distribution and marketing of technologies for smallholder farmers will find important insights in these briefs. The same is true for companies whose commerce depends on the outputs from smallholder farmers, as they also have direct interests in the adoption of new technologies. Our work, however, recognizes the vital continuing role of the public sector; no matter how advanced a seed system becomes, there will be certain crops, geographical areas and people not adequately served by the private sector.

The boundaries of private sector activity are determined fundamentally by returns and risks. These boundaries define three central roles for donors in scaling the commercialization of technologies: (1) identify where private sector interests align with the social and environmental priorities of the public sector; (2) work within the calculus of risk and return to shift those boundaries in ways that increase the overlap with public sector priorities; (3) target investments supporting activities that do not warrant private sector interest, but are essential to benefit the poor and underserved and therefore remain the responsibility of the public sector. These three are all moving targets and the changing balance between public and private roles in technology commercialization is at the core of the framework presented in *Planning for Scale*.

2 – Defining success

Because scaling means many things to many people, we offer clarity, here, on the definition of successful scaling used in this work:

Successful scaling will result in sustainable improvements to the functioning of a seed system so that it delivers value to large numbers of smallholder farmers.

The term 'sustainable' in our definition deserves further attention. To avoid confusion, we use the term sustainable in the sense of 'continuing over time.' This particular use is not meant in any way to detract from the importance of environmental sustainability in scaling strategies. We also note that scaling can be achieved in an *unsustainable* way. Large public expenditures, for instance, can succeed in delivering seed and agricultural technologies to rural areas at scale. In some contexts, and for some households, that kind of *pushing out* is needed. But in many others, public sector resources can be focused instead on catalyzing scale, kick-starting private sector engagement, which then takes on a life of its own and continues to grow after public funds stop flowing. Our work is focused on this type of sustainable scaling because it represents an efficient expenditure of scarce public resources.

In addition to sustainability, the second part of our definition is a focus on smallholder farmers as the center of our analysis, with impact on their livelihoods assumed to be the ultimate purpose of scaling. Understanding farmers' wants and needs is where successful scaling begins; sustainable transformation of a seed system has to be driven by attention to the value farmers derive from varieties. This may seem obvious, but it makes the farmer's decision-making around adoption of seed drive many parts of the seed value chain.

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This perspective is not challenging for the private sector, where the market remains the ultimate driver. For international development organizations, however, it can be a difficult shift away from a long history of supply-driven innovation and deployment of technologies. The demand-driven perspective is critical to scaling up. Systems that are scaled with a focus on demand are more sustainable, cost less to scale, and can change in responsive ways over time.

While focusing on success defined by these two goals (*sustainability* and *serving smallholder farmers*), we have tried to remain reasonably agnostic about how scale is best achieved. For example, we consider possible scaling strategies in both formal and informal seed systems, examining certified, quality declared and locally-produced seed. We consider seed companies as an essential component of scale, but also recognize that they will not serve some poorer, more remote markets and cannot supply the diversity of varieties demanded by smallholder farmers. Seed systems have many functions, including: breeding, foundation seed production, quality control, processing, production of marketed seed, distribution and more. Good scaling strategies set out to consider the feasibility, merits and risks of multiple ways to scale these functions, ranging perhaps from the activities of multinationals through to farm-level production and trading of seed. All the options for scaling are then analyzed through the same lens, considering cost-effectiveness, implementation challenges, potential impact on smallholder farmers and sustainability over time.

3 – What scope of technologies are considered?

The *Planning for Scale* project focuses primarily on scaling seed systems. However, as we note elsewhere, much of this work relates to scaling agricultural technologies in general. Readers who are interested in other agricultural technologies will find relevant information applicable to many different technologies in this brief, as well as others. Some briefs in this publication, however, are by nature more narrowly focused on scaling seed (for example, Brief #4: Foundation Seed).

Within the area of seed, our mandate has been to focus on food crop varieties of seed, and specifically those originating from *public breeding programs*. This is a logical scope for several reasons. First, the public sector's supply-driven frameworks tend to hinder scaling. There exists, for instance, a history of developing varieties without a high level of attention to market demand and commercialization strategy and the interface between research and delivery remains challenging for public sector organizations. Second, in many countries in sub-Saharan Africa (the primary focus of our study) private sector activity in seed is still very limited. Lastly, even in areas where there is a burgeoning private sector seed industry, commercial focus is currently limited to a small subset of the crops and varieties needed to

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address food security. Given that our definition of scaling relates to the impact of improved varieties of seed on food security among smallholder farmers, the focus on *public sector varieties* is important.

In the writing of this work, though, we still take an integrated approach, examining the roles of both public and private sectors. While focusing on the challenges of commercializing varieties of seed from public sector breeding programs, we cannot fully consider food security impacts of scaling if we exclude the current and potential roles of the private sector throughout the length of the seed value chain.

4 – About scaling

Scaling only one part of the system won't work

The goal of having many more smallholder farmers planting improved seed can only be achieved by an interconnected scaling of multiple parts of the seed value chain. Scale in some parts may have a sort of catalytic effect that produces scale in others, but that is not always the case. Failure in any one piece of the system can cause growth to slow down or stall out. Growth in systems of production and distribution, for instance, will fail without parallel growth in access to foundation seed. Scaling demand will not be sustainable without matching scale in production and distribution, in order to consistently provide seed to farmers when and where they need it. Scaling also requires changes in breeding programs. Even though our focus in *Planning for Scale* does not extend to look as far upstream as plant breeding programs, we note throughout the work that a key component of scale lies in changing the responsiveness of the research agenda to market demands.

Some growth challenges can be anticipated

Growth is extremely challenging for enterprises and industries alike, but enough research exists for us to understand a few basics that contribute to success or failure. Donors, practitioners and policy-makers can target their investments to anticipate needs in some of the following areas that are critical to successful scaling:

Knowledge of the customer. Scaling requires the use of different methods for accessing customer information and market intelligence. In the early stages of a business, or pilot phase of a program, organizations may understand the needs of local communities, but when reaching larger markets it becomes more difficult to understand how customers interact with the products and services being scaled, and to make decisions about market expansion.
Communication and coordination. Growth requires exceptional communication and coordination. The anticipation of communication challenges will

be critical to successful scaling within a program or organization. But also on a system-wide level, among different organizations, a lack of investment in communications can cripple the coordination necessary to achieve scale in rural markets.

Talent. The availability of trained professionals is one of the greatest constraints to scaling up. The availability of management talent is often a constraint for growing small-to medium-enterprises (SMEs). For example, the in-depth technical knowledge held by the founder of a seed company may have been perfect for the startup phase, but growth requires people who have strong management skills. The need for talent in a growing industry, however, goes far beyond management. Scale rests on the shoulders of technicians, salespeople, machinists, warehouse managers, processors, accountants, agronomists, entrepreneurs and others.

Access to capital. Lack of access to the right type of capital (for example, working capital, or capital to invest in equipment), at the right time is a major constraint for growing organizations.

Business models for scale. Business models for scaling usually require a departure from the original business model used in a small organization or a pilot program. The transition of abandoning (but learning from) initial business models to form models that will support scale is difficult for many programs, organizations and companies. We provide a survey of basic business models for scaling below, but finding the right one requires data-driven thinking and often combinations of models.

Flexibility. Navigating the enormous challenges of growth requires the flexibility to change plans in response to changing information and context. Flexibility and built-in responsiveness to be able to change is an under-valued component of good scaling strategies. Flexibility can go hand-in-hand with good metrics that indicate, in relatively real-time, whether the chosen strategy is working or needs to be changed.

Finding the right business models for scaling

We digress here momentarily from our focus on seed and consider the scaling of agricultural technologies in general. At a very high level, this section strives to put together a typology of business models for scaling. Although these models form the basis of business strategies anywhere in the world, their application to rural markets in developing countries requires some changes in the models. For example, a franchise model in a developed economy is highly dependent on contract law and agreements that obligate franchisees to retain quality and other brand aspects. Franchise models in developing countries are powerful scaling tools, but quite different models. In part, the differences arise because in rural markets the rule of law is not well enough developed to support the same contractual relations. Another example of the differences can be seen when a scaling model depends on investments in brand equity for a product. As the well-known issues of counterfeit seed show, products in rural developing country markets face distinct brand equity challenges compared to more developed markets. These, and many other differences mean that business models for scaling taken from traditional business literature require some translation to be used in these markets.

When evaluating which business model may best support scale, the first distinction is to consider what you are scaling: a product, a service, knowledge, or some combination.

Scaling models are vastly different for scaling the adoption of an agronomic practice (knowledge), for example, than they are for the adoption of micro-irrigation (product). Often, scaling requires a combination. Scaling an expensive piece of mechanization equipment, for instance, might involve business models for catalyzing better distribution of the product to local entrepreneurs who then make a service business from renting one piece of equipment to multiple farmers (product and service). Often the scaling of one technology depends on parallel growth in the availability of complementary technologies. The scaling of the agronomic practice of zero-till farming in Brazil, for instance, depended critically on famers' access to desiccant herbicides and adapted seed drills (Landers, 2001). We also note the critical role of knowledge here. Our work focuses on scaling products and services, but much depends on parallel models for scaling knowledge. For example, if consideration is not given how to scale knowledge, the value of a product can be vastly different. Farmers who receive training in fertilizer application will derive significantly greater value from their input purchase.

Beyond this first distinction of *what* you are scaling, there is another set of questions that should be asked before evaluating potential business models for scaling. These contribute to the process of practical development of scaling strategies that is further discussed in *Planning for Scale Brief #8: Summary & Conclusions*. We provide a few examples here to illustrate how answers to each of the following questions can inform the choice of business model for scaling.

Does the product require training or installation services before benefits can be derived from its use? Micro-irrigation business models are built around the need for sales strategies to include installation as well as training in use, maintenance and repair.

Does the product need to be delivered through sellers with particular qualifications? Livestock vaccines in many countries can only be administered by licensed veterinarians or, in some cases, para-vets. This informs the design of business models for scaling.

How difficult is it to control quality? Controlling the quality of a treadle pump as a shipment leaves a mass manufacturer is different than controlling quality when treadle pumps are manufactured using a distributed network of local artisans. Controlling the quality of agricultural extension advice at the farm-level will require a different business model than controlling whether fertilizer has been mixed with other ingredients somewhere between the original supplier and delivery to the farmer. Control of quality is a major determinant of business models and this is particularly true of seed.

Other questions might include: **Do customers need demonstrations of the product before purchasing? Are after-market services important for sales, including spare parts networks? How perishable is the product? Are there differences in use of the product among men and women?**

Once a full set of questions has been answered, there are a number of business model options to think through in terms of scaling. Some are described in Figure 1.

Figure 1 – Business models for scaling.

Replication (with adaptation)	In this model, scale is achieved by creating business fundamentals that can be replicated easily, but adapted. In seeking to scale a software platform, for instance, that connects smallholder farmers with buyers, the organization might choose to scale through replication and hope that many new uses (outside of their direct control) occur across crops and regions. Alternatively, they could choose to hold on closely to their software and only implement it themselves in different contexts.
Franchise	Sometimes called the 'business-in-a-box' model. The translation of the franchise model from developed markets to rural developing country markets requires some adjustments, but this is a common model for both products and services. Franchisees are incentivized by profits, rather than receiving a pay check as an employee. If franchises are sold, the franchise model can provide much needed capital for expansion that does not exist in some other scaling models.
Shifting of the enabling environment	This business model follows a somewhat hands-off approach, seeking to catalyze scale by reducing key barriers that might be constraining it. Providing improved access to credit, for instance, changes the enabling environment. It does not benefit the scaling of one particular technology, but tips the landscape toward a higher likelihood of scaling in general.
Rental and shared-use	Rental and shared-use business models are particularly important for technologies that are not affordable for purchase by a single household. For example, a group of farmers might purchase a more expensive technology, and coordinate shared use across the members of the organization. Alternatively, a farmer might borrow to purchase a low-horse-power diesel engine and then rent it out over time to repay the loan.

Licensing	Some technologies can be scaled by licensing. Licenses can be with or without royalties, exclusive or non-exclusive. The exclusivity can be time-bound, offering non-exclusive rights after a particular period, or it can be bound by geography or field of use. In short, licenses can have as many variants as the parties can agree on. If a licensing model is used, the difference in negotiated terms can critically either constrain or catalyze scale.
Subscription	One option for scaling data, information, services and products is through a subscription model. This also can be adapted for products. Subscription models can be hard to manage in rural markets and the price points are particularly challenging to find. But if it is successful, it often provides a type of capital flow that is conducive to scale. Access to agricultural expertise through call-in centers, for example, might be based on a subscription model.
Partnerships	The term partnerships is used to cover a wide range of relationships between entities from licensing arrangements, to joint ventures and many more. They can be a particularly flexible model for scaling if the contracts are structured well, but capacity for brokering scaling partnerships is a key constraint.
Mergers or acquisitions	Mergers and acquisitions, similar to the model above, leverage the resources of other companies, combining to allow for more opportunities for scale.
Centralized expansion	Centralized expansion occurs when an organization chooses to simply put more of its own staff out there, to reach new markets, new production facilities, and new distribution channels.
Development of new channel intermediaries	Channel intermediaries are middlemen in the chain from producer to the point of sale to the customer. This strategy involves exploring new channels, instead of scaling up the existing channels. There are often opportunities in rural markets that lie outside more traditional distribution channels. For instance, distributing children's vaccines in mobile clinics that also sell livestock vaccines can increase immunization rates.
Leverage of the supply chains of other organizations	This strategy involves accessing another organization's supply chain(s). It might involve, for instance, a product sold alongside another organization's products or it can sometimes take advantage of 'bundling'. If, for instance, you sell micro-insurance services bundled with another organization's seed, you may be able to scale by leveraging the seed company's pre-existing supply chains.
Direct selling	Direct selling seeks to cut out intermediaries and shorten the supply chain, ideally from the producer straight to a network of sales agents.

5 – Competitive advantage and scaling

In this section, we continue with a review of how rudimentary business practices, when applied to rural markets, form the basic foundations of scaling strategies. This time we shift from the level of single enterprise, to the industry level, looking at scaling issues in how businesses compete in the market. Business models for one enterprise must be developed, of course, with a view toward competitive advantage and market-level dynamics. For example, if your competitors offer the same product (e.g. the same variety of seed), and you cannot compete by offering a lower price or higher quality, then a scaling strategy to increase your market share might involve, for instance, a business model that focuses on customer service.

This section also considers how business models are built with attention to changing market dynamics over time. Scaling critically depends on market entry. There are key opportunities for donors and policy makers to influence market entry, and these issues are also relevant to those designing specific scaling strategies for one technology. Suppose the barriers to enter a market are high. For example, new seed companies might need access to land, equipment and enough operating capital to sustain them in startup. Scaling the number of new seed companies may be achieved by partial guarantees of working capital loans to new seed businesses, or tax exemption for a limited period of time.

We begin with a discussion of the importance of public sector support for private businesses. Especially in rural markets consisting of smallholder farmers, there is a long history of using public funding to encourage businesses to stretch further, or deliver different products and services. Subsidies, tax incentives and a performance-based grants are used. But their structures are challenging and the intended incentives are often not put into place.

Public support for private businesses

Demand-driven scaling of a seed system fundamentally requires strategies that create incentives for seed enterprises to grow over time, ultimately improving service to their customers – smallholder farmers. Our definition of 'private' includes commercial operations in the informal sector as well as the formal. Although some of this section relates directly to the part of the seed system that is private and formal (i.e. seed companies), much of the section has implications for the many small-scale businesses and entrepreneurs that operate in the informal seed system. As with any others, the growth of these businesses is also determined by competitive advantage. If a local village producer of cassava plantlets, for example, can earn a higher price compared to her competitors for marketing disease-free plantlets, she will have the incentive to invest in maintaining quality production and growing her business, ultimately allowing more farmers access to disease-free planting materials.

There are many good examples of public sector support for catalyzing private sector activities that align public interest goals to impact smallholder farmers. In the example above, support might be provided for training, marketing assistance or access to improved varieties of germplasm. These types of investments are components of many scaling strategies discussed in the following *Planning for Scale Briefs*, but they are not easy to structure. Particularly, the public sector interventions struggles with time-limited and targeted nature of how to provide incentive to companies to reach more smallholder farmers. This is a key area for continuing investment in understanding what has worked and what has not.

In addition to considering support for an individual business, these interventions must be able to consider the larger issues of how seed enterprises compete with each other. Analyzing how to sustainably scale one business, whether in the formal or informal seed system, can only be understood within the context of how that business competes in the market and for this we return to the very basics of business.

The four 'P's' – modified for seed

The old adage of the 'four P's' of competition still holds true. Competition depends on place, price, promotion and product. Some examples follow:

- **Differentiating by place.** A non-profit may compete with an agro-dealer by having more *boots on the ground* that allow them to get seed closer to smallholder farmers. If farmers do not have to travel to the ago-dealer where other seed is sold, they may purchase from the non-profit. These enterprises compete by *place*.

- **Differentiating by price.** A medium-sized seed company may be able to bring down costs in a way that means they can offer the same variety as their competitors, but for a lower price.

- **Differentiating by promotion.** A small seed company may decide, if they cannot differentiate themselves by product, place or price, that they might invest in a large radio campaign in the hopes of building brand equity and connecting with their customers.

- **Differentiating by product.** A seed trader in the informal market, for instance, might be the only one in the region offering a particular variety, and therefore his business is differentiated by *product*.

Modifications have been made to these over time in many industries. For seed, there are perhaps two key modifications needed. First, 'product' needs to be split into two: (1) variety and (2) quality. Quality turns out to be so crucial to competitive advantages and to scaling strategies in seed systems that it deserves to stand on its own. The second modification would be to include *timing*. In seed systems, demand has a narrow window around planting time. Timing also depends on available storage facilities, and because seed is perishable, it is integrally related to the quality of the product.

Exclusivity issues in access to public varieties

This section builds on the discussion of how enterprises in seed systems compete with each other. Here we consider particularly the competitive advantage issues in how seed producing enterprises access to genetics. Public sector organizations allow, and promote, the use of their genetic resources under specific exclusivity rules. While these rules vary across institutions, there has been an ongoing debate about differences in impact between providing public varieties solely for non-exclusive use, and alternatives allowing for some limited exclusivity in licenses governing their use. This section focuses on formal sector seed production more than informal, but the dynamics of access to genetics are at the core of the evolution of all seed systems.

Suppose there is a market where every seed producer has access to the same genetics and there is no significant capacity for in-house breeding. This might be a market where seed is produced by small companies that access their foundation seed from public sources without opportunities for exclusivity in use. In such a case, there is little or no competition on product differentiation by variety. Most competition centers on place, price, promotion, timing and quality. Growth strategies for expanding markets may be based on getting to a new market first, building good customer relations, creating a brand, offering lower prices, or improving the capacity to deliver higher quality seed than others in the market. These are important consequences of certain structures in providing access to genetic resources from public breeding programs, and they need to be evaluated when structuring scaling strategies.

Thinking through the consequences of non-exclusive access to genetics is particularly relevant for donors investing in improving the licensing strategies of public sector breeding programs. Scaling strategies must consider issues of limited exclusivity in access to public varieties. Limited exclusivity in accessing germplasm can be structured with time limits, with geographical limits, with preference for size of seed producer and in many other ways. There are a range of options for managing access to genetic resources bred in public institutions and these have direct impacts on the seed system's ability to scale. Management mechanisms then become paramount. Having a good licensing strategy that directly aims to get better varieties to more smallholder farmers is only part of the battle, there is a need for staffing up with trained professionals who can use limited exclusivity strategies in practice to support public interest goals.

The type of market structure described above (non-exclusive access) can sometimes favor larger market entrants who may have the capacity to compete on quality, or may be able to access different genetics. If large multinationals, for example, purchase national seed companies, or create a local presence through partnerships, they may be able to offer a differentiated product that is superior to their competitors because they have exclusivity over particular traits.

While it is difficult to predict how the opportunities of sub-Saharan African seed markets fit into the diverse strategies of multinationals, it is important for public sector organizations and donors in the international development community to consider the changes at hand. Scaling strategies designed to serve smallholder farmers should anticipate changes in the roles that multinationals play. Recent histories in Brazil and India may hold particularly important lessons for this stage of seed system evolution.

Competitive advantages in hybrids vs. OPVs

Hybrids are a fundamentally different business product than open-pollinated varieties (OPVs). First, their revenue structure is different. Unlike OPV revenue, hybrid revenues integrate the potential for repeat custom for new seed in each season. That means farmers must find enough value in one season of the seed to warrant purchasing it again in the next season. If this does not happen, the farmer will revert to planting other available varieties or other crops. Sales are predicted, at least in part, based on whether producers can provide hybrid varieties that meet this value standard for farmers.

Sales for OPVs have higher uncertainty and a very different pattern. For OPVs, a farmer's repeat custom could be based on renewing some percentage of their seed (purchasing the same variety). The rule of thumb outlined in Brief #5 notes: if a farmer renews 20% of her seed each year, the entire crop will have an average of no more than two years replanting from the improved seed. Estimating a rate of renewal for your market is an important component of scaling up open pollinated varieties. In practice, the rate of renewal is highly variable and dependent on many factors, but scaling strategies can track this number through metrics and adjust estimates over time. The above assumes, of course, that the farmer replants the same variety. In addition to the rate of renewal, sales of OPVs also depend, of course, on which other new varieties are offered.

Beyond different revenue patterns, hybrids and OPVs require different marketing strategies. If a seed company is the only source of a particular hybrid, its market can last a long time. Marketing strategies for hybrids can be a long-run game. Marketing strategies for OPVs may be short-run, based on maximizing sales around the initial release.

Branding, including the enforcement of intellectual property rights (IPRs), is also fundamentally different between OPVs and hybrids. The types of intellectual property right mechanisms that govern seed are diverse, including: trademarks, patents, plant variety protection, material transfer agreements and a combination of trade secrets and 'biological' IPR protection integral to hybrids. For hybrids, if the parent lines can be closely guarded as trade secrets, the product itself cannot be re-engineered and the owner of the parents retains the value over time resulting from intellectual assets embodied in the development of that variety.

6 – Seed markets: intrinsic challenges

The production, marketing and distribution of seed have intrinsic characteristics that make the seed business different from most commercial endeavors. Some of these are primarily characteristics of more formal enterprises in seed systems, but others are common in informal as well as formal contexts. This section delineates some of the factors that make scaling seed very different from scaling other agricultural technologies.

As an example, consider one question that lies at the heart of every scaling strategy – what kind of financing is needed to scale, and where is this going to come from? Small- to medium-scale enterprises (SMEs) engaged in seed production that hope to access external financing must compete for funds against a range of other potential investments. Private equity funds investing in agriculture, for instance, might compare potential investments in vegetable or livestock production against the returns and risk associated with investing the same capital in a seed business. Recognizing the differences in seed markets, relative to other products, drives a better understanding of any individual scaling strategy. But it also highlights cross-cutting opportunities for investments that would have a larger, more systemic, impact on the ability to scale seed. In the financing example above donors may make a difference in scaling seed systems by mitigating some of seed-specific risks perceived by private capital so as to increase access to finance in scaling seed more broadly.

We consider five characteristics of seed markets in this section that inform the feasibility and structure of scaling strategies.

Anti-cyclical effect

Supply and demand for seed are separated by considerable lags in time, and can sometimes head in opposite directions to that which is required by the market. There can be larger fluctuations in the supply and demand of seed than occur in other products. This dynamic can have implications for managing seed production enterprises.

In the demand for seed, a seasonal anti-cyclical effect can occur in some crops whereby a lean harvest can increase the demand for that seed the next planting cycle. A scarcity in the market for maize one season might, for example, lead to high prices, which in turn could encourage farmers to plant more maize in the next season. The problem comes when the same lean harvest impacts seed producers, leaving them with lower harvests. For the next season, the seed company has less to sell, but this is just at the time when the market wants to buy more.

Conversely, if there is a bumper harvest in a good year that results in lower prices as maize floods the market, farmers may plant less maize seed for the next season, lowering demand in the seed market. Those same favorable conditions leave seed producers entering the next year with a higher inventory, with lower market demand.

Easily reproducible goods

Some seed markets are defined by the fact that the goods being marketed are easily reproducible. This is not true for hybrids and some crops where viability is lost in continued multiplication. For many non-hybrid varieties, however, seed for next year can be produced from this year's seed. Seed markets involving smallholder farmers often function around the substitution choices of farmers deciding whether to buy seed or use saved seed. Demand for seed each season depends on this choice.

Lessons for seed industries can be derived from other markets of easily reproducible goods. For example, intellectual property rights (IPRs) are key in markets for digital goods like software or recorded music that can be reproduced at zero marginal cost. In seed, the formation of markets can depend on *biological* IPRs (e.g. in hybrid seed, protection against reproducing the seed is inherent in the biological characteristics of hybrids) as well as the institutional capacity to enforce legally conferred IPRs. A farmer's decision to save seed rather than purchase is fundamental to scaling seed systems. Farmers may not have reliable access to commercial seed, or it may not be available at the right time. Farmers may lack knowledge of the benefits of purchased seed, or those benefits may not outweigh the price of the seed. The local market may value local varieties of seed over commercially available seed. These and many other factors influence the farmer's decision.

In seed markets, the value of purchased seed can include: seed viability, freedom from disease, freedom from storage pests, and seed treatment. Lessons that do translate relate to the fundamental need to understand why a consumer would purchase something new rather than produce it themselves. These include lessons related to: branding strategies, convenience, quality, price elasticities, aftermarket support services and planned timing for the introduction of improved products. All of these have parallels in marketing seed to smallholder farmers.

Responses to disasters

Seed markets in the aftermath of disasters (e.g. civil unrest, crops wiped out by a pest or disease, drought) illustrate several dynamics. In times of disaster and insecurity, farmers may use their seed as grain, diminishing or eliminating stocks for planting in the next season.[1] Additionally, because seed is essential to food security and also highly political, it is often the subject of government intervention in the aftermath of disasters. When emergency seed is distributed via non-market channels, further instability in seed markets occurs.

Farmers behave differently in regions hit frequently or recently with disasters. The market has a memory, so to speak, and demand for seed is impacted beyond the immediate market effects of relief seed. This paper does not explicitly consider seed relief as a topic, but we recognize that the ability of a seed system to withstand disasters is key to its sustainability over time.

Information asymmetries

Information asymmetries are present in many products. In economics, the Nobel prize-winning example of information asymmetry centered on the market for used cars; when you buy a used car, the seller knows much more about the product than you do from your cursory inspection. Similarly, a seed company knows more about a bag of seed than the smallholder farmer purchasing it. Important lessons about scaling seed markets can be derived from other businesses characterized by information asymmetry. Reducing information asymmetries can be costly and these costs (for example, large-scale demonstrations of new varieties within reach of farmers) are important in planning for scale. Information asymmetries also drive customer behavior and therefore have marketing implications. Trust and brand equity are more important in marketing goods with natural information asymmetries.

Production lags, uncertain demand, and perishability

Fluctuations in the markets for seed (some of which have been noted above) are magnified because production takes time. The time required for multiplying from breeder's seed to foundation seed to marketed seed varies from two to as many as six seasons, and a production problem in any one of the seasons will impact the final volume available for the market. Due to this long production cycle, supply today is based on the forecasted demand for varieties and quantities made several years before, which may or may not

1 Authors, however, are divided on the extent to which this occurs.

ultimately be in synch with current market demand. Demand for seed is also difficult to forecast because many farmers who purchase seed for growing on rain-fed land will not buy the seed until the rains come. Late rains or missed rains disrupt the cycle of demand.

Industries characterized by long production times have low inventory turnover ratios. Lower ratios mean more inventory is kept longer and more money is tied up in inventory. Business implications for inventory turnover ratios in the seed industry vary across crops according to bulk rates and perishability (see Section 7, below). Vegetable seed inventory, of course, is less costly to hold onto than potato seed inventory. For industries with low inventory turnover ratios, financing needs to relate to long-term cash flow. Inventories held over long periods also make a seed industry react more strongly to changes in the cost of capital.

The perishability of seed, even beyond implications related to inventory costs, is a defining characteristic of seed markets. Businesses producing, storing, transporting and delivering perishable goods are particularly dependent on good transportation links and cold storage facilities. They can benefit more from modern supply chain technology (like traceability, sensor, or packaging technologies) than other industries. Sometimes perishability can impact pricing strategies. The risk profile of businesses selling perishable products can affect financing opportunities. Lastly, but importantly, businesses working in perishable goods are often subject to a wide variety of regulations, and compliance costs can drive market dynamics.

7 – Implications of crop characteristics on scaling

Section 6 provided evidence of how seed markets differ from other product markets, but the reality is that each crop (and indeed each variety) can present a different commercial challenge. Diversity across crops and varieties relate to *external* differences in agro-ecology, differences in the enabling environment, consumer preferences and more. Some of the commercial diversity, though, simply relates to the physiological characteristics of the seed itself. In this section, we hope to illustrate to our readers that there are direct commercial implications arising from particular physiological characteristics of seed.

As an example, consider the difference in logistics models for tomato seed and potato seed. The amount of seed required to plant one hectare of tomatoes roughly weighs in the order of hundreds of grams, and is packaged in a few small seed packs. Its high value per gram means you can even use logistics strategies dependent on air travel, rather than roads because you will still have good profit margins. Potato seed, on the other hand, is a different story, in terms of transportation and the associated costs of distance between production and distribution. Planting a hectare of potato seed requires seed that weighs around 2 metric tons. The crops also have different perishability characteristics. Scaling strategies for potato may require consideration of more local production and storage facilities.

We selected several important physiological characteristics of seed that have significant implications for commercialization:

- ➔ multiplication rate
- ➔ sowing rate
- ➔ isolation distance for multiplication
- ➔ weight and bulk of seed
- ➔ seed perishability

Figure 2 illustrates the diversity across crops with sixteen examples of crops and data on the above characteristics. This is designed as an illustrative tool for decision-makers to think through issues concerning transportation costs, distribution network distances, capital costs for seed production (e.g. investments in land), warehousing costs and more.

In order to produce a framework for decision-making that is broadly applicable, we are examining *crop* differences, not *variety* differences here. Within any one crop, of course, different varieties exhibit sometimes very large differences in the above characteristics; the numbers we provide are averages.

	Multiplication rate	Sowing/ seeding rate	Isolation distance m	Bulk density kg/m3	Seed perishability
Soybean	16 [G]	40–120 [T]	3 [U]	772 [C]	Moderate [U]
Common beans	20–115 [V]	100 [D]	5 [V]	528 [C]	Low [V]
Cowpeas	40 [G]	20–40 [P]	3–5 [F]	772 [C]	Moderate [Q]
Groundnut	8 [A]	125 [D]	5–10 [V]	300 [C]	Moderate [V]
Maize (OPV)	80 [G]	20–35 [D]	300 [F]	721 [C]	Low [J]
Maize (hybrid)	100 [G]	20–35 [D]	200 + [N]	721 [C]	Low [H]
Rice	80 [G]	70–150 [D]	3–5 [S]	579 [C]	Moderate [F]
Wheat	25–100 [E]	50–150 [E]	5 [E]	772 [C]	Low [E]
Millet	300 [B]	5 [B]	200 [B]	635 [C]	Low [F]
Sorghum (OPV)	200 [B]	10–20 [D]	200 [B]	721 [C]	Moderate [F]
Cassava	3–10 [K]	60 bundles [L]	50 [R]	High bulk [I]	High [K]
Banana and plantain	2–10 shoots per month (minisett) [W] 1000 shoots (tissue culture) 10–60 shoots (other methods) [X] 2–5 suckers (field production) [X]	Up to 10,000 plants [X]	200 [M]	High bulk [Q]	High [Q]
Sweetpotato	15–20 (normal vine) [Y] 90 (rapid) [Y]	500,000 cuttings [Y]	20 [Y]	High bulk [Y] 22–30 cm long [Y]	High [Y]
Yams (traditional)	5–10 [BB]	1800–2700 kg [O] 12,000–13,000 setts [O]	Low [X]	150–400 g setts [X]	High [X]
Yams (minisett and vine cuttings)	15–250 [BB]	1200 kg [O] 37,000–40,000 minisetts [O]	Low [X]	75–100 g setts (preferred in Africa) [AA] 10–25 g setts [Z]	High [X]
Tomato	500+ [DD]	0.25–0.6 [DD]	30–200 [DD]	Low bulk [CC]	Low [EE]

Figure 2 – Physiological diversity of seeds across different crops. *There are many varieties of each crop and regional preferences that influence practices and technical applications. These figures are averages and meant to illustrate the importance of including physiological data into scaling strategies. References are listed in at the end of this report.*

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Distribution strategies

Seeding rates per hectare and bulk rates in the table included in this section can be used in combination with country transportation rates to calculate average distribution costs per kilometer for different crops. Perishability, which is ranked here only as *low*, *moderate* or *high*, is another physiological characteristic that must be considered when developing a scaling strategy for a seed of a particular crop.

This information is critical for assessing geographical locations of distribution. Strategies may include designing incentives and reducing barriers for: (1) new local distributors to enter the market; (2) existing distributors to carry additional products; (3) the start of new localized seed production enterprises; (4) amplifying existing informal seed trade; or (5) extension by existing larger companies to reach new areas. A geographical mapping of market densities, including numbers of hectares per village and distances to distribution points will provide a framework to compare strategies. Of course, transportation costs are only one variable, but they can be a critical determining factor to assess feasibility.

Production strategies

Expanding production starts, first and foremost, with scaling the production of foundation seed. Failings in the supply of foundation seed, including timing of availability, quantity and quality, are widely agreed to be the largest constraint to scaling a seed system. The characteristics of crops noted in the table above are relevant to strategies for scaling foundation seed production as well as commercial seed production.

Strategies for scaling production might include investments to create incentives or reduce barriers for: (1) establishing new small seed companies with local markets; (2) improving production within public sector organizations; (3) extending the product portfolio for existing small-, medium, or large-scale seed companies; (4) expanding production of crops currently produced by existing small-, medium-, or large-scale companies; (5) expanding production through contract growers; or (6) amplifying existing informal seed production. Again, these represent just a few strategies, and there are many more. The point is not to catalog the strategies, but to illustrate that each one of the above has different cost implications based on the physiological factors of the seed.

Higher multiplication rates, for example, might mean that a scaling strategy dependent on cost-effective production is more likely to work. There may be a division between crops that are more likely to need scaling in the public sector than among companies (see below), and some crops will require more localized production than others (Minot et al., 2007). Legumes, for example have low multiplication rates and high seeding rates. These are less feasible for larger, centralized seed companies. Instead, the profitability of legumes may only be achieved with more localized production that minimizes transportation costs. The isolation distance needed to maintain genetic purity in multiplication is often seen as a constraint to models of production. Strategies to expand the engagement of smallholder farmers as contract growers for seed production will need to consider land requirements, isolation distances and economies of scale.[2]

The perishability of crops has been well explored in scholarship on post-harvest losses. That work has some parallels that can be translated from grain storage to apply to seed storage, but the consequences for loss of quality in seeds are different. For example, viability and germination rates naturally fall over time, and vary by crop. These have implications for the time-value of inventories. Viability and germination rates, as well as the rates at which seed transmitted diseases build up, are affected by moisture and temperature, with implications for investments in storage conditions. Packaging can play a major role in the quality of seeds as they reach market, and packaging needs can therefore also vary substantially across crops. Post-harvest operations, like threshing and drying, contribute to the quality of the seed produced and, again, there are significant differences across crop types. These differences can have important implications for choices between scaling strategies (for example, how easily smallholder farmers can produce under contract compared to the need for more centralized production). Perishability in vegetatively propagated crops, of course, demands very different scaling strategies altogether.

Private sector roles

Educated assumptions about where the private sector might or might not engage are part of any scaling debate from the perspective of a public sector partner. Investments from foundations and governments are tailored to anticipate where they will least crowd-out (or possibly be able to crowd-in) private sector activities. Other parts of the *Planning for Scale* analysis discuss the line between public and private shifting over time as seed systems become more advanced. The path differs by crop, by country, and even within countries. These paths of public and private roles are partly driven by the physiological characteristics of the crop.

Cassava is a good example. Despite a wealth of opportunities for uses of cassava globally, and the multiple efforts made to connect cassava farmers to markets, some countries have yet to overcome the limitations of its very short shelf-life. In these countries, cassava has remained largely in the pur-

2 Production through contract growers also requires certification capabilities, consideration of side-selling and much else. See *Planning for Scale Brief #5:* Access to Finance for a description of scaling and contract growers beyond just the physiology of crops.

view of the public sector, with little interest from private companies. Advances in scaling cassava in some sub-Saharan African countries, and related private sector interest, have led to the development of technology that addresses this physiological constraint: a mobile processing unit that can decentralize processing and bring it closer to the supply of cassava (see Shoham and Boettiger (2013)).

Some authors have simplified public-private roles, stating that companies are less likely to engage in crops with particular physiological traits. There is some merit in this simplification. A crop with a low multiplication rate and high seeding rate implies higher costs across the boards, including: land, irrigation, other inputs, processing time, transportation, and certification. While recognizing the reasons for these determinations, we include a caution against hard and fast rules regarding how scaling occurs across public and private sectors in different crops. Groundnut, for instance, fits the profile of a crop that might not attract commercial interest (low multiplication rate and high seeding rate). It is also bulky and cannot be stored for more than one year without diminishing germination rates (Ntare et al., 2008). Yet groundnut seed production in Africa is partially commercial. Physiological traits across crops certainly inform hypotheses about private sector engagement in scaling strategies, but it is important, where possible, to refrain from generalizations, and instead to examine the nuances of the particular markets.

8 – Changing landscape for seed companies in sub-Saharan Africa

Following on from the above discussion of private and public roles in scaling seed, we turn to look particularly at the private sector seed industry in sub-Saharan Africa. We offer a snapshot of the issues currently relevant to scaling, recognizing that the landscape is highly fluid and this information may become rapidly out-of-date. This section has been contributed by Aline O'Connor.[3]

In recent years, the private sector landscape for sub-Saharan seed companies has changed significantly. What has changed for these seed companies in recent years and, perhaps more importantly, what still needs to change for the private sector if seed company scaling is to be achieved in the staple food crop arena?

Among the many changes that have occurred in the sector are the following six important developments:

3 Aline O'Connor is a former US seed company CEO who has been working to develop the private sector for seed in sub-Saharan Africa since 2008. She has worked directly with over 60 companies in 14 countries, across a wide range of crops. Her work has focused on coaching and training seed company entrepreneurs and their teams, on seed company financing, and on the intersection between seed policy and private sector development.

- ➔ Greater numbers of local private African seed companies
- ➔ More involvement from large multinational crop seed companies
- ➔ Promising varieties have been released in significant numbers
- ➔ More financing, both equity and debt, from funds focused specifically on agribusinesses, and in some cases on seed companies
- ➔ Greater national competition for resources
- ➔ Risks are increasing

Greater numbers of local private African seed companies

While no reliable data on the exact numbers are available, it is safe to say that there have been at least forty pure seed company startups across the continent in the last seven years, and probably at least as many existing small companies that have grown to become larger and hopefully more stable. Many, if not most, local companies are experiencing good, and sometimes extraordinary, growth. With growth come the ever-expanding needs for technical training, regulatory supervision, and financing. These are needs that, all too often, are either not met at all, or are met only on a sporadic basis.

The training, mentoring, and development of business people who also possess knowledge on how to run a seed company is a particularly critical need. Ideally, experienced practitioners would be available, but in nascent industries there is not yet a good core of local, specialized talent. The management acumen particular to the seed industry is especially important because of the long business cycles inherent in crop seed production. As seed systems mature, specialized advisory and support services for seed companies begin to emerge, such as accounting firms specializing in the seed sector, quality control service providers, information and communication technology (ICT) specialists, and commercial banks knowledgeable about the seed industry, its risks, and risk mitigation instruments. We have not yet seen the emergence of these service providers in sub-Saharan Africa.

More involvement from large multinational crop seed companies

The growing seed industry in sub-Saharan Africa is offering opportunities for the involvement of multinational seed companies. To date, Syngenta has acquired MRI of Zambia (and has announced its intention to develop a billion dollar business within the continent by 2022, within the context of the G8 Symposium on food security); Pioneer has acquired South Africa's Pannar, which also operates in numerous other countries; SeedCo has expanded their production partnerships and research activities; and Pioneer is also directly expanding activities in countries such as Ethiopia. Monsanto has been active through the Water Efficient Maize for Africa initiative, but it remains to be seen if they will take major steps to increase their direct market presence in the crop seed sector. It should be noted that the primary focus of these companies in the crop seed sector is maize and vegetables, but not many other food crop seeds.

Promising varieties have been released in significant numbers

Businesses thrive on valuable products that meet customer needs, and recent released varieties respond to many farmer needs for higher yield, disease resistance and earlier maturity, among others. Mitigating this positive development, however, are several obstacles to scaling. In some countries, the increase in released varieties has not translated to increased commercialization because the foundation seed policies have not been liberalized. As a result, seed companies wishing to commercialize varieties are either not able to get parent material at all, or are not able to access the quantities they need. Additionally, a lack of working capital has constrained the ability of seed companies to rapidly expand their product lines. Farmer adoption rates are also often slow to change. Farmers' demand for seed through private channels is colored by their experience with a history of highly irregular patterns of commercial seed supply, prior disappointment in low quality production of seed of improved varieties, and NGO and/or government free seed programs.

In mature seed systems, hybrid releases respond not only to farmer needs but also to the production needs of seed companies. Seed companies focus time and research expertise on developing hybrids that have ever stronger large-scale production economics; for example, breeding male maize lines that are strong pollen shedders in addition to all of the other desired parental traits. Conversations with maize researchers in both the US and India indicate that as many as 80% of hybrids from a research program may be rejected at the commercial level because the production economics are not sufficiently strong. In sub-Saharan there is almost no public research focus on hybrid commercial production economics, and almost no in-house local private sector research, which means that seed companies using public material are often saddled with relatively poor production economics for hybrids.

More financing, both equity and debt

The last six years or so have seen an increase in the funding available from funds specializing at least in part on seed companies. Most of these funds have had some level of backing from Alliance for a Green Revolution in Africa (AGRA), but other donors have also contributed at meaningful levels. In general the fund managers have found that technical assistance requirements for seed company financing are extremely high, and that the willingness of entrepreneurs to give up shares in their companies is low, or sometimes non-existent. These qualities can raise risks for investors.

Further complicating the financing landscape is the relatively short-term horizon of many fund managers, who are often looking for four- to six-year exit strategies. Their horizon stands in contrast to the multi-year single business cycle of a seed company and the even longer time required by a seed company to build a strong production system, a solid product line, and customer adoption and trust. Understandably, many African seed entrepreneurs, even though they need both investment and working capital for growth, are reluctant to commit to equity investors due to the difference in perceptions around exit strategies. Frequently compounding this reluctance are cultural prejudices against giving equity to outsiders when the entrepreneur is shouldering the lion's share of the work.

As noted above, knowledgeable commercial financing is still largely absent, with seed companies having to pay extremely high interest rates for bank financing. With their rapidly growing economies, borrowing rates in most African companies are much higher than those seen at present in the West. It is not at all unusual to find seed companies paying 18% for working capital loans, and incurring penalties of an additional 2–4% on top of the base rate if repayment is delayed, e.g. due to late rains and thus late planting seasons. Companies that are growing rapidly and need to pay for the production of a full season before they can sell the seed and collect revenue easily become trapped between their growth and the high cost of borrowing to finance the growth. The choices these companies must then make, for example to forego paying outgrowers, thereby losing their seed crop; or to leave seed rotting in the field because they don't have the funds to transport it back to the processing facility, are often heartbreaking.

Greater national competition for resources

Many countries, in their drives for foreign exchange, are investing heavily in agricultural industries such as floriculture and other non-food crops at the expense of seed production activities. Large land tracts (and irrigated tracts in particular), transportation concessions, and equipment import assistance are frequently made available by governments to businesses generating foreign exchange. Meanwhile, local seed production entities may be left to work on rain-fed land, often land with isolation challenges (an important factor in seed production). They may pay high import duties or be faced with greater transportation challenges than, for instance, some non-food agricultural export sectors, causing delays during critical seed selling times.

Risks are increasing

As seed companies grow larger, the damage caused by interruptions in the supply chain becomes more disruptive and financially harmful. Primary among these interruptions are shortages in foundation seed, but others such as drought, shortfalls in financing, lack of power for drying and processing mechanization, and lack of government regulatory capacity are also highly noteworthy. In mature seed markets, risk mitigation tools, such as wide-spread irrigation among contract growers, crop insurance, cold storage, diversification of production sites, a pool of trained labor, and reliable and high quality foundation seed supply, go a very long way towards reducing potential financial losses. These tools are generally either not available, or are prohibitively costly to access, for African seed companies.

Reasons for optimism

Despite these challenges, there is good news. In a 2010 survey of over 1,542 farmers in seven countries, who had recently begun using seed of improved varieties for a number of staple food crops, 91% said that the new varieties had increased their yields by at least half, with 36% of the total saying that their yields had at least doubled (Ellis-Jones, et al., 2010). Both demand for, and usage of, high quality seed of improved varieties produced by private companies is growing. Slowly but steadily, many countries in Africa are building a cadre of experienced seed entrepreneurs – businessmen and women who are becoming battle-hardened seed professionals and are working at increasing levels of scale. Some seed companies are accessing financing and using it wisely to rapidly improve both the volume and the quality of their seed. Finally, and very importantly, a new generation of breeders is emerging that understands that research is not necessarily destined for publication and the shelf, but for farmers, and that the path to large-scale commercialization of their research can be attained by working with the private seed companies operating in their countries.

9 – Seed sector survey on priorities in the enabling environment[4]

Like any other industry, the seed sector in Sub-Saharan Africa needs an enabling environment to thrive. To determine the relative importance of different aspects of the enabling environment, a survey of industry experts was conducted online in August 2012. The survey was sent out to 414 seed industry experts who work in Africa's seed sector; 167 respondents completed the survey (a 40% response rate). The respondents identified themselves as representing the following types of institutions (the number in parentheses represents the share of respondents): private seed companies (53.9%), non-governmental organizations (6.5%), government departments (15%) and research institutions (18.6), and others (6%). On a Likert scale, respondents were asked to evaluate the importance of 16 variables in improving seed access for smallholder farmers across Sub-Saharan African countries.

4 This material has been contributed by Edward Mabaya, Cornell University. It contains excerpts from: Mabaya, E. „African Seed Access Index: Design," Market Matters, Inc., Ithaca, NY, USA (unpublished report).

We report here the findings of 10 variables that are classified into five categories, as shown in the table below.[5]

Figure 3 – Definition of variables.

Category	Variable name	Variable definition
Research and development	# of active breeders	Number of active breeders
	Access to foundation seed	Seed company (or seed producer) access to foundation seed (i.e. parent material to produce certified crop)
Industry competitiveness	# of active seed companies	Having a large number of active seed companies
	No government parastatal	Government parastatal is not competing with private sector
Service to smallholder farmers	Agro-dealer network	Availability of a strong rural agro-dealer network
	Availability of small packages	Availability of seed in small packages (e.g., 2 kg or less for maize)
Seed policy and regulations	Policy and regulations	Quality of seed policy and regulatory framework
	Fake seed control	Government regulatory and law enforcement efforts to stop fake seed distribution
Institutional support	Availability of extension	Availability of agricultural extension officers
	Seed trade associations	Strength of national seed trade association

A key finding from this survey is that nearly all of the ten variables are ranked as important across all types of institutions. This consensus is also confirmed through low interquartile range (IQR) measures for each variable (not reported herein) indicating that 50% of the responses are within two rakings.

One exception to this consensus is the importance of seed sold by government parastatals. While all other respondents, on average, consider this variable to be somewhere between important and very important, government representatives scored it as less than important. This difference in

5 For statistical analysis with parametric estimators, each of the Likert scale variables, was converted to a continuous 0 to 100 scale ranking as follows: 0 = Not at all important, 25 = Of little importance, 50 = Important, 75 = Very important, and 100 = Absolutely critical. Figure 1 shows the average importance of each variable by private companies, NGOs, government representatives, and researchers.

opinion signals the reluctance of government to exit from the business of commercial seed production.

Because most variables have high scores in the survey, it is useful to examine their ranking (relative importance against each other as an indicator of priority). Government efforts to stamp out fake seed ranks highest overall, and across almost all types of organizations. This ranking shows how much of a problem 'fake seed' is likely to become in the near future, especially as technology to produce counterfeit products improves. Almost unheard of five years ago, it has risen to become the number one concern of all seed industry stakeholders.

Access to foundation seed, quality of seed policy and regulation, and a good agro-dealership network are also highly ranked and should be considered as priority areas for intervention. On the low end of the ranking spectrum are variables capturing industry competitiveness, i.e., the number of active seed companies and the extent of government parastatals crowding out the private sector. We interpret this lower raking of competitiveness indicators as evidence that while seed industry players desire an enabling environment, they are not as keen to embrace the resulting competition that can squeeze their margins.

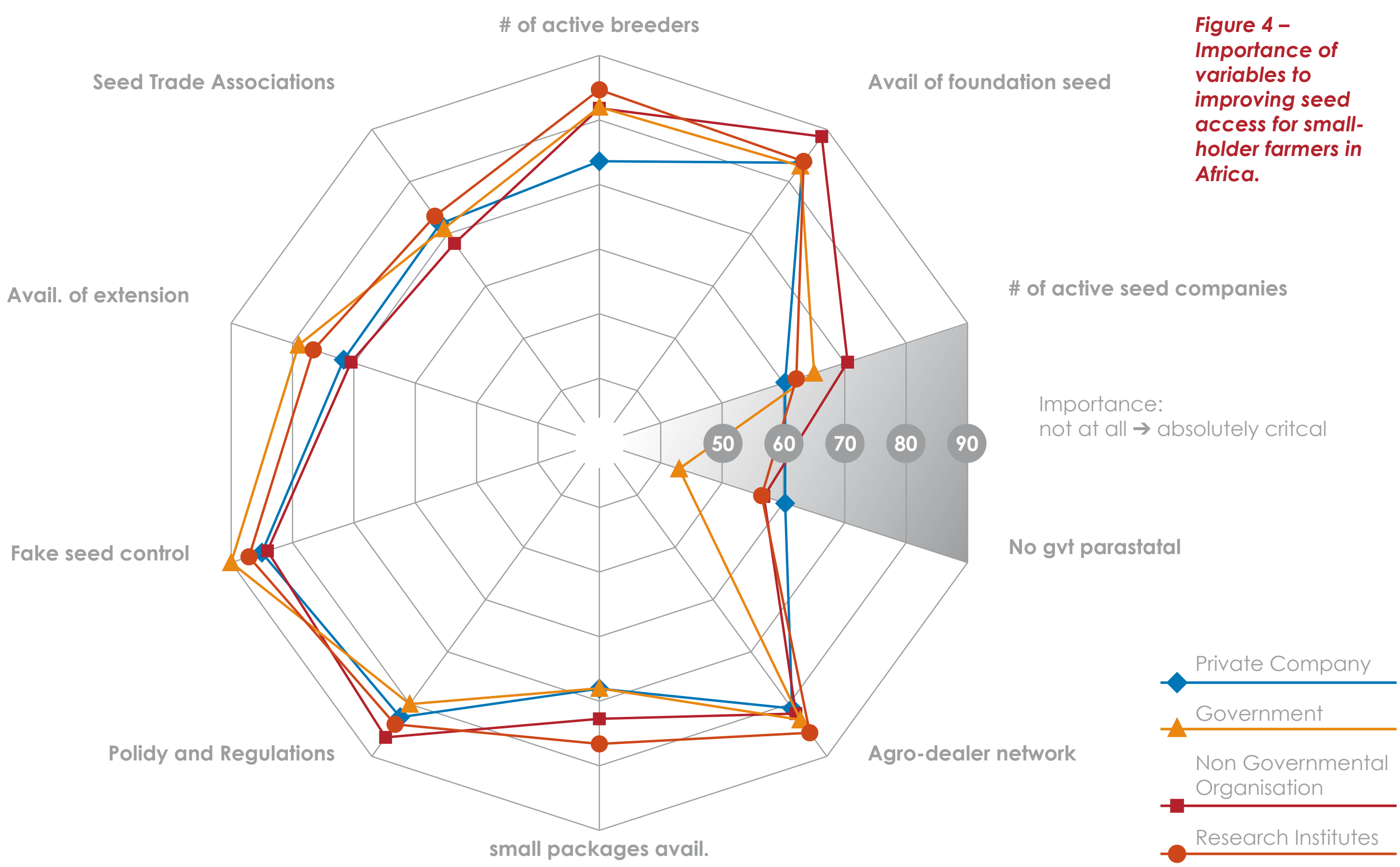

Figure 4 – Importance of variables to improving seed access for small-holder farmers in Africa.

10 – Adoption

In the last two sections of this brief, we turn to look at scaling issues in the adoption of technologies. After many decades of international development work in this field, we know a lot about technology adoption among smallholder farmers. A superb history of empirical work offers insight into farmers' decision-making when it comes to the use of fertilizer, seed, irrigation, extension services, credit, insurance, storage, mechanization equipment and many other agricultural technologies. There is still much to learn, of course (enough to keep generations of agricultural economists busy). But the larger issue is that existing knowledge in academia either does not cross the divide to inform policy-makers, donors and practitioners, or important practical implications are not extracted from the empirical work.

Adoption lies at the heart of our definition of successful scaling. Therefore, we take the opportunity in this section to highlight several important points about technology adoption, particularly regarding seed. Each of these is chosen not for the general background information, but because it specifically informs how we think about scaling strategies in other *Planning for Scale Briefs*.

Adoption is a process. Sometimes we think of adoption as binary; we think of farmers as 'switching over' to use an improved variety. Instead, there is a process, where the farmers (1) become aware of the new seed; (2) identify its potential benefits; (3) evaluate how it works for other farmers (perhaps seeing it in a neighbor's field or demonstration plot); (4) try the seed out themselves, sometimes by planting a small amount; and (5) decide whether to replant the next season (Rogers, 1962). However, the process does not end there; we know that even after farmers have grown an improved variety, and understand its costs and benefits, they will decide season-by-season whether or not to plant it, based on a wide variety of factors that can change over time. In this way, there can be switching in and out of adoption.

The stages of adoption above can be used to frame investments in scaling. The seed needs to be available (invest in logistics). We need to raise awareness (invest in marketing). Farmers need to see the varieties growing (invest in scaling up trials). In addition to these obvious investments, though, empirical work in adoption has illustrated many other necessary components of technology adoption that translate into investment opportunities for donors.

Adoption differs enormously across genders. Major failures have occurred in scaling because women were not considered in scaling strategies. For instance, scaling drip irrigation requires training the smallholder farmer in how to maintain the lines. That training may be given to men, because it is the men who purchase the drip irrigation kit, but the women in the household may be in charge of maintenance. In this case, not adapting the business model to take into consideration gender differences has introduced unnecessary potential impediments to scale, as there is a likelihood the untrained women will not properly maintain the lines, and the drip kits may earn an undeserved reputation as an expensive failure.

The roles of women in purchasing, using and maintaining agricultural technologies vary widely. Women may farm land that has different characteristics than the men in the household. They may grow different crops. They may have different access to cash for purchases. It may not be culturally appropriate for them to travel far. They may have different access to financial services. All of these and many more differences across genders have been studied. Despite the heterogeneity, though, these roles can be anticipated and implications can be integrated into scaling strategies.

The value of a variety is highly heterogeneous. Some elements of this work seem so obvious that we considered omission. This is one such element; however, it is so central to scaling strategies that we decided it deserved inclusion. Markets for seed among smallholder farmers are especially heterogeneous. Unlike more standardized agro-ecological environments for large seed buyers in advanced seed systems, where irrigation and the precision application of inputs are optimized, smallholder farmers can experience very different performances from the same variety. Smallholder farmers can also have very different access to markets, substantially changing the value of one variety of seed among multiple households. Even more fundamental is that some new varieties, although seemingly successful in research trials, may be inherently unattractive to smallholder farmers, meaning that they create little additional real value in many environments. The notion that all recently released varieties are worthy of scaling is one of the many assumptions that need to be challenged.

Comparative advantage. Comparative advantage is a part of any farmer's decisions about what to plant. Adoption not only depends on characteristics such as farm size, access to inputs or access to market; it also depends on what farmers perceive others are growing, and how they can maximize their own comparative advantage.

Distance. Distance to market is a common determinant of adoption that informs scaling strategies. Distance to potential outlets where a farmer can buy seed may be different. It is particularly important to identify the cost-distance relationship of alternative sources of seed the farmer may access. A neighbor's seed, compared with a seed market, or a trip to an agro-dealer may have very different costs. Economists find that adoption of agricultural technologies drops dramatically over quite short distances.

Post-harvest. What happens to seed following harvest is sometimes overlooked when assessing adoption patterns. While much recent literature and study has championed the importance of connecting farmers to markets and destination networks, challenges of post-harvest processing and storage are not always considered. Ricker-Gilbert and Jones (2012) look at the changes in the likelihood of farmers to plant improved maize in response to a subsidy for storage protectant introduced by the Government of Malawi. The protectant chemicals were available for purchase at the subsidized rate from extension offices and coincided with existing voucher subsidies for improved maize seed and fertilizer. The authors found that the availability of the storage protectant was a 'highly positive and significant driver,' not only of the decision to adopt the new seed, but also of how much land the farmer was willing to dedicate to the improved maize.

Risk. Risk is an area about which we still have a lot to learn in relation to the adoption of technologies by smallholder farmers. Economists have a wide range of models they can employ to understand decision-making under risk, but the behavior of smallholder farmers often seems to raise more questions than the models answer. For scaling work, however, strategies to reduce risk still need to be integrated based on what we do know. The key, however, is to retain flexibility in this part of the scaling strategy, anticipating unexpected outcomes and the ability to learn from them. New varieties of seed, for instance, linked to insurance, or forward contracting for purchasing the farmer's crop, can have much more complex adoption patterns than expected.

Trust. Some marketing intelligence for African markets cites relatively high levels of loyalty to brands among consumers. This is not always associated with low-income rural markets, but for certain products it can be. Seed is often one of those products, particularly because the costs to a farmer are large when seed does not germinate or is of poorer quality than expected. Recently, issues of trust have been visible in the media in relation to counterfeit seed. The estimated prevalence of fake seed in some countries in Sub-Saharan Africa is high and prosecution rates are low.[6] The Kenyan Agricultural Research Institute (KARI) is reported as having estimated that as much as 40% of seed packets in the country may contain fake seed (Koigi, 2012). The African Seed Trade Association reported in 2010 a prosecution rate of 38% for fake seed cases brought to court in Kenya (Sikinyi, 2010). Although a number of legal and regulatory measures are needed to address counterfeit problems, the choice of business models operating in environments where counterfeiting is prevalent is also important.

Assets. Assets receive limited but important attention in the literature on technology adoption. Beyond the obvious assets like the land owned by the farmer (including its position in terms of distance to the nearest roads or markets), asset theory in adoption includes livestock. Livestock are a major consideration for scaling seed. Crop-livestock interactions can be determin-

6 Many non-African countries also suffer from fake seed problems. In Andhra Pradesh in India, an estimated 10–15% of seed marketed is counterfeit (Rao, 2013).

ing factors in the farmers' choice of what varieties they choose to plant. Scaling strategies, however, rarely consider livestock interactions and breeding programs often overlook variety traits like those that impact the quantity and quality of stover (Ertiro et al., 2013). Additionally, livestock can play a role in creating markets for the adoption of seed. For example, India's scaling of sorghum among smallholder farmers is linked to markets for livestock feed.

11 – Examples of scaling adoption of agricultural technologies

There are not as many examples of scaling seed and agricultural technologies into widespread use by smallholder farmers as we would like. We have developed a set of short case studies, which are available online at AgPartnerXChange (www.apxc.org) that give examples of scaling seed. We consider, for instance: early results from scaling beans through the Pan African Bean Research Alliance; the potential for cassava to scale through better processing technology; scaling up the adoption of improved varieties of maize in Thailand; and others. Good lessons can be learned from a wide range of countries, both within and outside sub-Saharan Africa, but we must be careful to translate lessons across borders and into local contexts before making assumptions.

The Green Revolution in South Asia, of course, remains the most famous for scaling up the use of improved varieties of seed. This has been well-documented over the years, including related challenges in translating that model into an African context, and we will not repeat that history here. Instead, in this section, we highlight briefly two other examples of scaling agricultural technologies. Then we look at recent data from the Diffusion and Impact of Improved Varieties in Africa (DIIVA) Project (2010 – 2013), the final report of which was released during the course of writing this paper (Walker et al., 2013).

Zero-till agriculture in Brazil

In three and a half decades, the adoption of zero-till agricultural practices jumped from less than 1000 hectares in 1973 to close to more than 25 million hectares in 2007 (Bolliger et al., 2006; and Esteves, 2007). More than 60% of cultivated land in Brazil is farmed using zero-till technology. Zero-till agriculture was initially adopted among very large-scale farmers where the land was flat, and the weed pressure was low. Since then, however, adoption of the technology has scaled wildly, including among smallholder farmers. This scaling model is one we see elsewhere: technology is initially adopted among larger farmers and then, over time, by smallholder farmers. International development investments often focus on direct engagement of markets of smallholder farmers rather than considering scaling strategies the target the adoption of technologies by larger farmers while simultaneously providing funding for adaptation of the technology or other incentives for adoption to spread to poorer households.

As everywhere, it was the economic benefits of the zero-till technology drove initial adoption. The role of key stakeholders, however, deserves mention. In particular, agrochemical companies were strongly supportive of the spread of zero-till practices. But there were important interactions between researchers, equipment manufacturers and farmers. One lesson lies in the innovation of new networks and partnerships that worked to spread the information as well as adapt the technology for more widespread diffusion. Another lesson is that complementary technologies played a major role in the diffusion of zero-till practices. As equipment, including planters, sprayers, and combines advanced and were adapted to different types of farms, the technology could take off (World Bank, 2012). This was particularly true of its adoption among smallholder farmers, which depended in part on the lowering of costs of specialized seeding machines (Esteves, 2007).

Seed industry scaling in the United States

The United States provides an early example of 'push' scaling, with its long history of giving away free seed, starting at the beginning of the 19th century. By 1855, according to Bennett (2006), the US Government had sent over 1 billion packages of free seed to farmers through the mail. Without questioning the interim impacts of the free seed program, we note that it was not a sustainable approach and, by many accounts, it went on long enough to hinder the scaling of the seed industry. The American Seed Trade Association petitioned the US Congress to document the impact the program was having on the seed industry and in 1924 the program was terminated (Bennett, 2006). The ending of this program, along with a number of other changes that were taking place in the United States in the early part of the 20th century, was responsible for catalyzing rapid scale in the US seed industry. Scientific advances, including hybridization among many others, vaulted the industry forward. Hybrid varieties catalyze scale in part because of their superior yields, but also because they offer commercial incentives for investment that would otherwise depend on a system of intellectual property rights. The fact that hybrids cannot be easily reproduced from purchased seed means that companies can reap long-term returns from investments in research and development.[7] Other critical pieces of the seed system also fell into place in the middle decades of the 20th century; a wide variety of laws, regulations and strong institutions played key roles in scaling.

Part of the transformation of the U.S. seed industry derived from a legal environment in which the enforcement of quality allowed for ex post options. 'Truthfully labeled' laws maintain standards by requiring producers to list

7 In countries with less advanced legal and court systems, this 'biological' form of IPR can be a good alternative to more traditional IPRs.

quality attributes on the packaging and enabling enforcement through tort law where those labels are found to be falsely representative. The economics of this system are important to seed industry development for a number of reasons. For example, the speed of getting new varieties to market is different. Also, ex post enforcement requires different government resources.[8] The dual system of certification and truthful labeling was later adapted and adopted in different forms by India, the Philippines, Thailand, Japan and others (FAO, 1999). The European Union and many African countries have opted for mandatory certification (Tripp and Louwaars,1998). *Planning for Scale Brief #6: Enabling Environment* discusses truthfully labeled laws.

The DIIVA study's seed adoption findings

The final report of the Diffusion and Impact of Improved Varieties in Africa (DIIVA) Project (2010 – 2013) provides estimates of modern seed[9] adoption in Sub-Saharan Africa (Walker et al., 2013). The study uses a combination of data from the Food and Agriculture Organization of the United Nations (FAO) for hectares harvested, together with expert opinion and national focus group surveys, to estimate a time series of adoption levels across 20 crops in 30 sub-Saharan African countries, comparing 1998 estimates to 2010 estimates. Collecting this type of data is highly challenging and for some crops there are only a few observations. The findings must be interpreted with the limitations of information in mind, and we include in the tables below the number of observations on which the data is based.

Overall, the study confirms limited use of modern seed varieties (MVs), but identifies significant progress made since 1998 and many opportunities for the future. The area-weighted adoption average for all crops and countries is 35%. Soybean, maize, wheat and pigeonpea all demonstrate at least 50% use of MVs, whereas the remaining sixteen crops fall below 40% use, with sweetpotato and banana use falling below 7%.

8 We note that the capacity to detect and prosecute violations in labeling is an important government investment, whether or not certification is voluntary or mandatory.

9 Modern seed varieties are defined as varieties released after 1970 'inclusive of escapes, products of participatory varietal selection from improved materials, and breeding output in countries that do not have a functioning formal release and registry system. Focusing only on released varieties would understate the performance of investments in crop improvement…Some released landraces are included in the list of improved varieties.'

Crop	Country observations	% MVs
Soybean	14	87.9
Maize-WCA	11	65.7
Wheat	1	58.5
Pigeonpea	3	49.9
Maize-ESA	9	44.0
Cassava	17	39.7
Rice	19	38.0
Potatoes	5	34.4
Barley	2	32.7
Yams	8	30.2
Groundnut	10	29.2
Bean	9	29.0
Sorghum	8	27.4
Cowpeas	18	27.2
Pearl millet	5	18.1
Chickpea	3	15.0
Faba bean	2	14.0
Lentils	1	10.4
Sweetpotato	5	6.9
Banana	1	6.2
Field peas	1	1.5
Total/weighted average	**152**	**35.25**

Figure 5 – DIIVA estimates of %MVs. *Source: Walker et al. (2013)*

From a country perspective, Zimbabwe demonstrates very high use of modern seed varieties, peaking at 92% adoption. Historically, Zimbabwe has had effective and efficient public and private sectors. Zimbabwe also benefits from a favorable agrological environment with relatively high altitudes. Commercial interests also drove adoption such as in the case of early adoption of improved wheat varieties by larger-scale farmers, which spilled over to smaller-scale farmers (Heisey and Lantican, 1999).

Mozambique, on the other hand, competes with Burkina Faso and Eritrea for the poorest adoption rates. This could be due to a number of factors, such as the slow recovery from a devastating civil war (1977 – 1992), lack of rural infrastructure, low capacity public sector institutions, and poor soil quality. Eight other countries reached over a 50% adoption rate: Central African Republic, Cameroon, Zambia, Kenya, the Gambia, Cote d'Ivoire, Ghana and Benin. Many countries hover in the 30% range, and Mozambique, Burkina Faso and Eritrea demonstrate the poorest performance with only a 13% usage rate.

	Number of crop observations	MV adoption %
Zimbabwe	4	92
Zambia	6	67
Kenya	8	63
Ghana	6	53
Malawi	8	47
Senegal	6	45
Nigeria	9	41
Mali	6	35
Ethiopia	9	33
Tanzania	10	32
Mozambique	5	13

Figure 6 – Weighted area adoption levels by country in Sub-Saharan Africa in 2010.
Source: Walker et al. (2013)

Changes in adoption rates over time tell a much more positive story, averaging a 97% increase in adoption across 10 crops, between 1998 and 2010. Groundnut and barley, in particular demonstrated changes higher than 200% and beans, cassava and maize demonstrated over 100% of growth in adoption. One important caveat here though is that while the total adoption of improved varieties may be high, turnover and the continued introduction of new varieties may be low. In Kenya, for example, the average age of maize varieties in 2010 was 18 years, with the most popular variety being 26 years old (O'Connor and Wamache, 2012).

	1998 MV adoption (%)	2010 MV adoption (%)	Percentage change
Groundnut	12.6	56.7	350 %
Barley	11.0	33.8	207 %
Bean	14.6	35.1	140 %
Maize	25.6	52.8	106 %
Cassava	21.0	42.0	100 %
Sorghum	19.3	32.4	68 %
Pearl millet	22.0	31.1	41 %
Potatoes	49.2	37.1	-25 %
Rice	48.4	36.5	-25 %
Wheat	56.0	58.5	4 %
Average	**28.0 (not weighted)**	**35.0 (weighted)**	**25 %**

Figure 7 – Adoption change over time (1998–2010) *Source: Walker et al. (2013)*

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