PLANNING FOR SCALE BRIEF #4

FOUNDATION SEED

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1 – Introduction

The production of foundation seed has long been a constraint to the growth of seed systems in most African countries.[1] While many authors have written about foundation seed, this brief focuses particularly on the relationship between foundation seed production and scale. *How do failures in the production of foundation seed constrain scale? How do you approach changes to a foundation seed production system if you want to scale a seed system?* Our approach, as elsewhere in these briefs, is to consider the challenges in a practical context, with attention to cost-effective demand-driven solutions. These are the elements we consider essential in thinking about *how to scale* the production of foundation seed.

In this brief, we begin by defining the problem. We discuss the role of foundation seed in a seed system, characterizing it from the perspective of those who purchase and use foundation seed. From that demand-driven benchmark, we work backward to catalog some of the costs incurred when foundation seed production does not meet demand.

Having framed the problem, we begin an examination of potential solutions. To ensure we are comparing solutions through a practical lens, we discuss firm-level and industry-level challenges in the production of foundation seed. Lastly, we outline current practices in sub-Saharan Africa, with particular attention to our target countries[2] and then discuss a range of possible solutions for improving current models in foundation seed production.

This brief wrestles with a part of the seed system that is notoriously difficult to change. Foundation seed production systems are the result of deep-rooted public policies, laws, regulations and institutions. The political economy around foundation seed tends to be resistant to change. In part, this is because there is a lag between significant initial investments and the benefits eventually delivered by a robust foundation seed production system. Against the backdrop of all these incentives for *inaction*, real change requires high-level commitment at a national level. While we lay the ground-

1 The term 'foundation seed' is used in this chapter to describe seed that is one generation after breeder's seed, but will be multiplied again before being sold in the market to farmers.
2 Ethiopia, Ghana, Malawi, Mozambique, Senegal and Tanzania.

work in this brief and call for a renewed discussion of foundation seed production, we also recognize that progress on foundation seed issues takes time, demands continuing advocacy and ultimately can only be driven by leaders that are prepared to work toward longer-term goals. At stake, however, is the ability of a national seed system to successfully scale to serve the country's needs.

Demand for foundation seed

In formal seed systems, research institutions, companies and universities produce breeder's seed. This seed is then multiplied to produce *foundation seed*. In turn, foundation seed provides the basis for multiplication of seed that will eventually go to market.[3] Without diminishing the issues that exist in production of breeder's seed or marketed seed, this brief is focused solely on foundation seed as a commonly cited bottleneck in the flow of seed from plant breeders out to market.

Demand for foundation seed comes primarily from registered seed producers (including public sector organizations, farmers and seed companies) in the formal seed system. Foundation seed, however, also flows into producers' organizations and growers that operate in the more informal side of the seed system. Readers who are familiar with the *Planning for Scale Brief #3: Integrating Seed Systems* will know our emphasis in this work includes attention to scaling in the informal seed system. Particularly for goals of scaling the adoption of improved varieties of food security crops among smallholder farmers, there is a need to engage beyond the formal seed system and the limited reach of seed companies. However, much of this chapter targets the formal sector, and we acknowledge the limitations of such a focus. In particular, we note the absence of discussion of vegetatively propagated crops. Expanding the availability of high-quality cuttings and seedlings of vegetatively propagated crops, for instance through scaling of tissue-culture

3 Recognizing that this process has more detailed stages to it, we limit references in this brief to only three stages of seed: breeder's seed, foundation seed and marketed seed. The latter is often described as 'certified seed,' but we use the term 'marketed seed' to include the possibility of channels that use foundation seed for non-certified seed production.

services, has clear parallels to the foundation seed system discussions in this brief, but was beyond the scope of this project. We identify this as important for future analysis.

The demand for foundation seed is, of course, a *derived demand*. Marketed seed producers are forecasting which varieties and amounts of seed they believe will be demanded by the market and this is translated back up the seed value chain to form the demand for foundation seed. This derived demand for foundation seed is an important place to start. Foundation seed production that can scale and be sustainable over time needs to be informed by demand, and responsive to demand. Current problems cited by organizations that comprise the demand for foundation seed include the following:

- ➔ Mismatch between varieties supplied and varieties demanded
- ➔ Insufficient or inconsistent physiological quality
- ➔ Problems with genetic purity
- ➔ Inadequate amounts of foundation seed to meet demand
- ➔ Variability in the amounts supplied
- ➔ Poor timing of availability

Each of the six factors above has separate implications for considering changes to how foundation seed is produced. Some previous analyses of potential foundation seed solutions fail to break out these factors and therefore recommend solutions that, in practice, may not deliver the improvements anticipated.

We also note that a demand-driven foundation seed production system will necessarily include the ability to deliver seed varieties and crops outside of those demanded by the commercial formal sector. A well-designed system will deliver foundation seed for improved varieties that are critical to food security and largely the purview of public sector seed multiplication, as well as serving commercial needs. It is especially important to design a system that is flexible enough to retain a high degree of responsiveness as the interface between public and private sector roles shifts.

A good example of the complexities and fluidity of public and private sector seed production comes from the *Planning for Scale* case on scaling Thailand maize. In this case, we discuss how the government of Thailand kick-started demand for a new variety by selling it simultaneously with seed companies. Instead of creating competition that crowded out private sector seed producers, the market was segmented by differentials in price and quantity available. A market expansion was achieved that enabled private sector supply to scale up (Le Page and Boettiger, 2013). The relevant implication for foundation seed production is that these types of market expansion are encouraged when foundation seed is simultaneously available to multiple production channels across both public and private sectors.

Costs of a poorly-functioning foundation seed supply

Just as the demand for foundation seed includes the six components outlined above, the costs incurred by not meeting that demand are similarly multi-faceted. The most straightforward cost occurs when foundation seed simply is not available. Seed producers cannot make plans to meet market demand for varieties when they do not have access to the foundation seed they need.

Even in advanced seed systems, the challenges of demand forecasting can prove difficult to manage. This is due, in part, to long lags over seasons needed to create stocks of foundation seed. In 2013 in the United States, Tom Burrus, president of a corn and soy hybrid seed company noted: '*We do have some allocated new products that are coming to the market because there weren't adequate supplies of foundation seed to plant, but in most cases, supply is very good* (Brooks, 2013).' In many developing and emerging market economies, however, the problems of insufficient supplies of foundation seed are not signs of market adjustment; they are endemic and provide significant constraints to the scaling up of a seed system.

Van Mele et al. (2010) write that in Uganda '*…there is little or no foundation seed available for most food security crops such as sorghum, millet, beans, cowpea and groundnut, so seed enterprises often sell standard seed rather than certified seed of these crops.*' This constraint has been evident in many African countries for years. A 1995 World Bank report noted: '*The multiplication of breeder's seed into basic (or foundation) seed has been the weakest link in the chain of seed multiplication in Ethiopia*.'

» Inadequate supply of quality seeds of improved varieties remains one of the greatest impediments in bridging the wide gap between potential and harvested yields. The breeder's seed production has increased … However, the efforts have been inadequate in meeting the seed requirement mainly due to poor conversion of breeder seeds into foundation and certified seeds. «

Ali and Gupta (2012)

Beyond contributing to, or causing, a basic lack of availability of improved varieties of seed, a poorly-functioning foundation seed system creates a number of other costs. When the supply of foundation seed is *uncertain* (in quantity, genetic purity or quality) it significantly raises the risk profile of seed producers. Larger companies may be able to withstand a more uncertain supply because they can implement other strategies. They may be able to keep larger inventories, or perhaps focus more on other crops in their portfolio, making them more resilient to short-term cash flow and input supply interruption issues. Larger companies may also be more responsive in their ability to take advantage of bulking up good seed when it is available.

Small seed companies, however, may not be able to cope with these risks. An important cost of uncertainty in the supply of foundation seed is that it makes it comparatively harder for small seed companies to survive and discourages new, small seed companies from entering the industry.

» A seed company with ongoing operating expenses, working capital loans to repay, and experienced staff to keep employed during periods of low activity, must pay extremely close attention to cash flow. Loss of foundation seed production and/or quality will have enormous impact on cash flow.

For example, suppose a company is planning to sell 700 metric tons of a three-way hybrid maize variety by season 3. However, supply of the male inbred for the female parent (one of the three parental inbreds required to make the three-way hybrid) is 17 kg less than planned. It is important to note that production of this additional 17 kg would require only .013 ha. As a result, based on average assumed multiplication and yield rates, by season 3 the company has only 200 mt of certified seed, not 700 mt – a loss of 500 mt. At $2/kg, the lost revenue to the company is $1,000,000. This is staggering, and it happened simply because 17 kg needed to create the ultimate parent seed was not available 2 seasons earlier. «

Aline O'Connor

A third cost found in current foundation seed production systems, especially those in sub-Saharan Africa, relates to their *supply-driven* nature. Feedback from the market needs to reach back to both the plant breeding research agenda (so that the supply of breeder's seed is demand-led) as well as foundation seed producers. This has always been a challenge in publicly driven, often centrally planned, foundation seed production. In scaling strategies for public provision of foundation seed it will be critical to include governance and decision-making processes that explicitly integrate feedback from the market, on varietal attributes as well as timing of supply and amount supplied.

A key problem facing public suppliers of foundation seed is the demand for open pollinated varieties. Some differences in business models between hybrid and open pollinated varieties of seed are discussed in *Planning for Scale Brief #1: Tools.* Seed companies, governments and non-profits supply farmers with open pollinated varieties of seed by basing their demand forecasts in part on an estimate of *seed replacement rates* by farmers (as well as estimates of market expansion for varieties). Farmers' demand depends on whether they choose to purchase new seed, or they save and replant last season's seed. This seed replacement rate dynamic is part of the derived demand and makes forecasting even more challenging for public provision of open pollinated varieties of foundation seed.

Where private enterprises are allowed to produce foundation seed, it is likely to be more demand-driven than in publicly driven production, but the truth is that demand forecasting is challenging for any organization producing foundation seed.

» … [G]overnment estimates of the purchase of seed for replacement by farmers were too optimistic but there is a further and probably more important influence. Suppose a farmer does wish to meet the objective of replacing self pollinated cereal seed every fifth season (i.e. the 20% replacement rate proposal). Rather than replace all his seed every fifth year, he can replace 20% of his seed every year (making his seed an average of two years away from being certified), and he is more likely to multiply his seed. For instance, if seed multiplication rate of wheat is taken as twenty, he could purchase just a percentage of his seed every year, multiply once and plant all his crop to second generation seed the subsequent year. In practice, this principle is doubtless followed, substantially reducing seed requirement. «

Venkatesan (1994), quoting from a Project Completion Report for India's National Seeds Projects I and II.

A fourth cost of poor foundation seed supply lies in damage to the brand of existing seed producers. This can occur because the variable quality of foundation seed, or intermittent supply of foundation seed, constrains the seed producer's ability to consistently offer high quality products. Damage to a brand is not something limited to seed companies. It impacts any seed producer, even NGOs or traders in the informal market. Sometimes the impacts of intermittent supply can be long-lasting and can erode the trust of smallholder farmers more broadly.

A further cost of poor foundation seed supply relates to the ability of a seed system to evolve. In order for a seed system to scale sustainably, the roles of public and private organizations must shift over time. We distinguish this cost from the benefits of being more responsive to demand in the market. Instead, this cost relates specifically to the changing public-private interface. Ideally, for instance, the private sector grows to serve markets for hybrid seed of some crops, and in some geographies, leaving the public sector to focus its resources more efficiently on under-served markets. The responsiveness of a seed system to these changes will depend in part on how the supply of foundation seed is organized and governed. Successful strategies for scaling seed systems will depend on built-in anticipation of flexibility so that the production of, and access to, foundation seed can meet the multiple needs, including creating opportunities for growth in seed companies.

2 – What does successful foundation seed production require?

The landscape of potential foundation seed producers is diverse, including: government seed agencies, universities, national agricultural research institutes (NARIs), international agricultural research institutes (IARIs), government farms, seed cooperatives, producers' organizations, contract growers, non-governmental organizations (NGOs), large companies and small companies. Despite the diversity, foundation seed producers share common constraints. Scaling production of foundation seed cannot be successful without a deeper understanding of these challenges.

The maize seed survey produced by Langyintuo et al. (2008) shows three major bottlenecks across the length of a seed system: (1) lack of access to suitable germplasm; (2) technical constraints; and (3) lack of production credit (see Figure 1). These three constraints also constrain the production of foundation seed.

	Eastern Africa		Southern Africa	
Production bottleneck	Established	Emerging	Established	Emerging
Lack of access to suitable germplasm	30	47	43	28
Technical constraints	60	29	36	43
Lack of production credit	Ø	16	14	28
Other	10	9	7	3

Figure 1 – Seed production bottlenecks as perceived by region and size of seed company. *Source: Reproduced from Langyintuo et al. (2008)*

Accessing breeder's seed

Sourcing high quality breeder's seed, the primary input for the foundation seed process, is critical to improving the reliability and competitiveness of foundation seed production in sub-Saharan Africa. Poor quality breeder's seed results in poor quality foundation seed, which in turn results in an inadequate supply of commercial seed or a related lack of product performance. The earlier on in the process that quality is managed, the less cost there will be reflected in the final product. Poor genetic and trait purity of breeder's seed can multiply problems in foundation seed fields. In maize, one off-type kernel at the breeder's seed level can lead to over three hundred off-types at the initial increase, and result in contamination leading to rejection of the foundation seed production or additional roguing expense to meet certification standards.

Breeder's seed physiological quality is important also, as poor vigor of parent lines can throw off stand and delay pollination, potentially causing a missed synchronization in single-cross parent crossing blocks. As a result the block may have very low yields with high contamination and resulting foundation seed field rejection. At times, breeders may have no option but to provide poor physiological quality seed, but clear communication of this in a timely manner to foundation seed units and growers, will allow for better planning.

Production of foundation seed requires supervision

Foundation seed production is always closely supervised with stringent requirements in every aspect, from field selection and preparation to conditioning and storage. These processes are designed to ensure specific standards in genetic identify, purity and quality. Field inspections, seed sampling, and certification requirements are key to ensuring foundation seed conforms to standards. Critical choices for scaling a seed system must be made in determining: who performs these processes; how they are implemented; and what enforcement mechanisms are in place.

In many sub-Saharan African countries, public plant breeders play a dual role that includes certification supervision for foundation seed production. In countries where foundation seed units fall under funding mechanisms for public breeding and research, and are not stand-alone units, the entire management of production is often under the purview of public breeders. Some authors have noted the presence of conflicts in interest where the same organization produces, certifies and markets seed.

Aside from potential conflicts of interest, there are inherent resource allocation problems that constrain a seed system from scaling when foundation seed is entirely managed in a public sector agency. The breeders responsible for managing foundation seed units are challenged to keep up with

required foundation seed certification inspections, particularly during planting and flowering periods when their other duties may also be demanding. Lack of financial support for basic essentials such as travel to the fields, and experienced support staff creates additional burdens on national breeders. Even where private production of foundation seed is allowed, government breeders and inspectors have limited travel budgets and have been known to ask foundation seed producers to transport them to foundation seed fields or other certification requirements and pay for expenses.

Lastly, in order to interface with inspectors in the roles above, organizations producing foundation seed need both technical and managerial expertise to manage the processes of foundation seed production. We have noted elsewhere the importance of scaling up the training of seed technicians and this remains an important component of any scaling strategy for foundation seed. Scaling models, for instance, that depend on a group of smaller contract growers demand very different training strategies than, for example, foundation seed produced by larger seed companies where there is already a culture of seed technician work and training. Provisions and plans for continuing access to technical and managerial talent should be included in any scaling strategy.

Production areas and grower selection

Production of foundation seed requires suitable land in specific geographies, irrigation, financing, considerable investments in equipment and expertise. Where the value of the seed is higher, conditions for production are more stringent and the costs of producing are also higher. In some countries, preferential treatment is given to export crops, including access to irrigated land close to supply routes. This can have implications for scaling strategies in the production of food security crops and varieties.

As in any seed production, a foundation seed producer seeks the most reliable production areas for the product while at the same time getting the adequate isolation distances required. Mitigating the usual grower's risks, however, can carry even more of a premium for foundation seed producers than for marketed seed producers. Irrigated production and fenced or guarded locations may be essential for foundation seed as the impact of losing a field due to drought or animals can be devastating in terms of final product timelines. Lack of irrigated production reduces reliability of supply and increases vulnerability to drought and especially heat loss causing abortions or pollen viability challenges.

These foundation seed production areas can be a great distance from the final seed producers and seed markets, as preference is given to irrigation, isolation from contamination sources, and reliability and experience of producers. Land allocation, investment in equipment and other technical

aspects are particularly important to integrate into scaling strategies. For example, a strategy to scale up foundation seed production that includes contract growers farming small fields may mean more field edge, making production more vulnerable to mammalian and insect pests. In any expansion of foundation seed production, a strategy must account for land expense. Because foundation seed units often compete for growers in irrigated areas that already produce high-value vegetables or cash crops, foundation seed production contracts tend to be more expensive per hectare than standard seed production.

Demand planning and risk management

Demand planning and risk management are two other critical factors to consider in scaling up foundation seed production. Many small companies, and even some larger ones, collapse due to inventory write-off or lost sales resulting from poor demand planning in both marketed and foundation seed.

As we note above, foundation seed demand is a *derived demand;* it is the demand for the seed marketed to farmers that drives the demand for foundation seed. Demand forecasting in scaling-up foundation seed is especially important as foundation seed lines may take two to five years to bulk into sufficient quantity and purity. In sub-Saharan Africa many smaller companies barely survive from year to year, and are constrained from growing due to poor foundation seed planning internally, and from limited sources of public foundation seed.

The figure below from CIMMYT illustrates the typical foundation seed supply needed for a three-way certified hybrid (MacRobert, 2009). For example, the calculations work backwards from forecasted demand in 2012 to assess the amount of breeder's seed needed four seasons earlier in 2008.[4]

Within this same period, demand for a certain variety, inbred, hybrid or crop may have shifted due to changes in crop and seed markets, competitor products, new regulations, weather shocks, new diseases or new pest profiles. If demand for this product fails, or for some reason the product does not meet customer requirements in 2013, two to four years of foundation seed and commercial seed amounting to millions of dollars is lost, as well as the hidden costs of lost market confidence and market delays for alternative products which could have been produced if the change was known sooner.

On the other hand, any shortfall in 2008 breeder's seed supply or foundation seed in 2009, 2010 or 2011 would have had an impact as far reaching as 2012 and 2013.

4 Note that Figure 2 uses OECD terminology for stages of seed production, including 'pre-basic' and 'basic,' instead of United States terminology.

In general, under-supply of foundation seed presents a larger cost impact and production risk than over supply but it is difficult for any seed company to calculate what the cost of short supply really is. In a competitive environment it is hard to project sales that *might have been* if the seed had been available.

Upswings in demand are also a source of problems, where sometimes foundation seed that was to be used in the following year is used ahead of time. Short supply in publicly available breeder or foundation seed may lead to

			2008	2009	2010	2011	2012	2013
Certified	**CZH1**	**Sales Target**		**200 t**	**400 t**	**1000 t**	**5000 t**	**10000 t**
		Production		200 t	400 t	1000 t	5000 t	10000 t
		Area Required		57 ha	114 ha	286 ha	1429 ha	2857 ha
Basic	CML444/CML395 (A/B Female)	Production	1.03 t	2.06 t	5.14 t	25.71 t	51.43 t	
		Area Required	0.9 ha	1.9 ha	4.7 ha	23.4 ha	46.8 ha	
	CML312 (C Male)	Production	0.40 t	0.80 t	2.00 t	10.00 t	20.00 t	
		Area Required	0.3 ha	0.7 ha	1.7 ha	8.3 ha	16.7 ha	
Pre-Basic	CML444 (A Female - female)	Production	34 kg	84 kg	421 kg	842 kg		
		Area Required	0.022 ha	0.056 ha	0.281 ha	0.561 ha		
	CML395 (B Female - male)	Production	13 kg	33 kg	164 kg	327 kg		
		Area Required	0.011 ha	0.027 ha	0.136 ha	0.273 ha		
	CML312 (C Male)	Production	17 kg	42 kg	208 kg	417 kg		
		Area Required	0.014 ha	0.035 ha	0.174 ha	0.347 ha		
Breeders	CML444 (A Female - female)	Production	1.40 kg	7.01 kg	14.03 kg			
		Area Required	9 m^2	47 m^2	94 m^2			
	CML395 (B Female - male)	Production	0.68 kg	3.41 kg	6.82 kg			
		Area Required	6 m^2	28 m^2	57 m^2			
	CML312 (C Male)	Production	0.87 kg	4.34 kg	8.68 kg			
		Area Required	7 m^2	36 m^2	72 m^2			

Figure 2 – The Minimum Quantities and areas of breeders and basic seed required to produce the certified seed production goals of a three-way hybrid. *Source: Reproduced from McRoberts (2013)*

arbitrary allocation decisions by the breeder or public foundation seed unit. When foundation seed units supply multiple companies with the same foundation seed line, clear and transparent rules are required to plan how the production will be allocated during shortfalls, to avoid corruption or favoritism. Additional rules are necessary where the right volume of foundation seed is available but at different physiological quality levels which could result in variable commercial seed production. Low vigor of foundation seed can cause poor or delayed emergence, which, in the worst case, could cause missed pollinations resulting in no usable yield for commercial productions.

Producers and companies find mechanisms to mitigate the risk of demand forecasting. Producers of hybrid crops, for instance, may choose to produce several products that utilize common lines. Some seed companies may have options to 'make-up' shortfalls by importing foundation seed from other sources, but generally only larger regional or multinational companies have these options available to them. In addition, this is not possible where government controls restrict import of breeder, foundation or commercial seed, or restrict private production of foundation seed.

Another risk mitigation strategy is to ask for more foundation seed than may be needed. As a result, public foundation seed enterprises can be shouldered with carry over inventory, additional storage needs, and expensive seed write-off. Anticipation of these and other risk mitigation mechanisms in demand forecasting must inform strategies for scaling foundation seed production.

Coordination, communication and data

Coordinating foundation seed supply of public lines to meet demand requires that producers have regular communication with, and support from, a diverse range of customers (producers of marketed seed). Although Tanzania, Malawi, and Ethiopia have robust seed associations (AFSTA, 2013), accurate seed production data by product, by crop and by parent line, remains generally poor across many countries in sub-Saharan Africa. The European Union-funded national seed stakeholder dialogs led by the African Seed Trade Association (AFSTA) have improved communication, but accurate seed demand data is hard to come by, resulting in poor demand signals for foundation seed production. Under-production and over-production of foundation seed lines or varieties are a natural function of the lags in the seed production system, and communication and coordination are critical to minimizing of these risks.

Ethiopia provides a recent example of the benefits of coordination and communication among stakeholders. In 2009 the government of Ethiopia launched a seed 'Crash Program' to increase national seed production. The program had positive results for farmers, but also some unanticipated conse-

quences. By using maize foundation seed and breeder's seed stocks, the program significantly constrained seed supply in the following year. A secondary effect was to strengthen the comparative position of companies that had long-term relationships with foreign partners or those that could source foundation seed from outside the country, as they were the only ones with production capacity (Admassu, 2013).

Coordination between the public sector producers of foundation seed with the private sector is an essential role played by seed associations in Asia, Europe and the Americas. When this coordination works well, foundation seed is more likely to be available to all companies that need it, as witnessed in Ethiopia in 2010, which was a vast improvement from the previous year. When the process is not well coordinated or is conducted on a first-come, first-serve basis, challenges emerge.

In Asia, Europe and the Americas, seed industry and farmers associations, statistical authorities, universities as well as government agriculture, trade and statistical authorities coordinate regularly to agree upon accurate data for seed production supply and demand. As in any data management that crosses public and private sectors, there are coordination challenges. Although private companies view data collection and management as part of their business planning and are careful to avoid divulging detail that might be used by competitors, there are still opportunities to coordinate. This stakeholder alignment and commitment to work together ensures accuracy. It can be led jointly and funded by the government and seed associations. A national seed database strives for 'near-live' data and results in more accurate planning and decision-making. In Thailand and in India, breeders from national seed association member companies work directly in a consortium with government breeders and universities and research institutes (Sriwatanapongse, 1993). This enables improved information flow, and helps breeders, foundation seed production and commercial production to have more accurate supply planning.

3 – Enabling environment considerations

Seed commercialization laws and policies

We have noted already the most fundamental enabling environment constraint that inhibits progress in improving the supply of foundation seed in sub-Saharan Africa: laws and policies that mandate a sole producer of foundation seed and prevent the pluralism needed for an efficient foundation seed supply. Beyond this constraint, however, there are a number of other important areas of the enabling environment that have considerable impact on foundation seed production.

Seed laws are explored in more detail in *Planning for Scale Brief #6: Enabling Environment,* but we note here several particular impacts on foundation seed systems. *First, seed laws have a major influence on time-to-market for new varieties of seed.* In some cases, seed commercialization laws and policies require linear processes and do not allow for parallel processing through the stages. This can add significantly to time lags that already exist in the seed industry, making demand forecasting and inventory management more difficult. We note that the lengthy processes governing seed commercialization also significantly impact the resources required to operate in the industry, including issues related to accessing finance as well as technical and managerial talent. Recommendations found in *Brief 6* and noted by many experts as applying generally to delays in the seed commercialization process are perhaps even more crucial to scaling the supply of foundation seed.

Figure 3 illustrates the seed registration process in Tanzania, a fairly typical formal seed registration system in the region. Once breeders are confident that their variety meets distinct, uniform and stable characteristics (DUS testing), they conduct multi-location trials under the oversight of the Tanzanian seed certifying body (TOSCA). The results of these trials (in some countries up to 2–3 years) are reviewed by the national seed release and production committee for approval.

All foundation seed produced in Tanzania for local certified seed production is produced by government institutions, and directly under breeder's control.

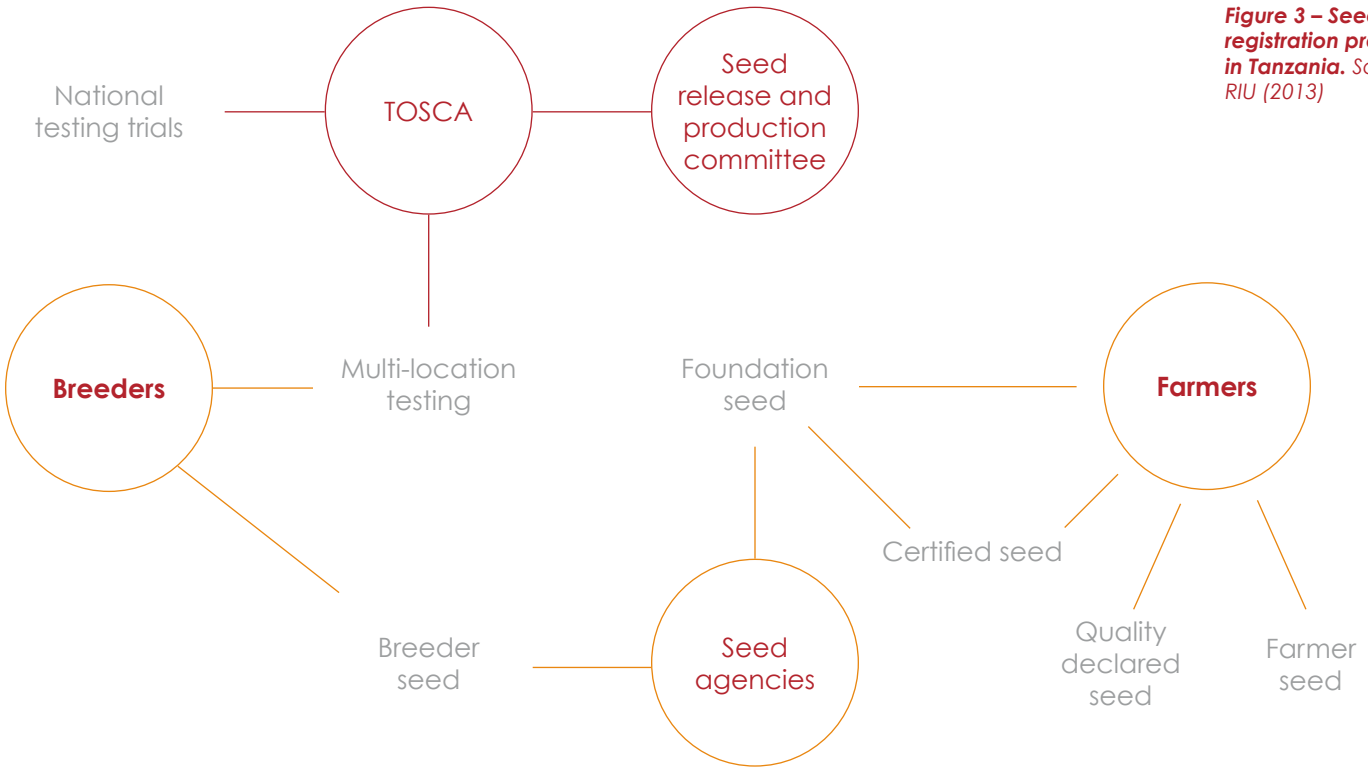

Figure 3 – Seed registration process in Tanzania. *Source: RIU (2013)*

This can be a major bottleneck and also an impediment to foreign breeders who do not want to release breeder's seed outside of their own control, due to intellectual property concerns. In the case of Tanzania, foundation seed can be produced outside of government controls only if it is produced for export and not for local sales. Some foreign companies have taken advantage of this option, producing foundation and commercial seed in Tanzania for other markets. Seed agencies, foundation seed producers and the private sector may utilize farmers under contract to produce foundation seed from the breeder's seed, but this must be under the control and observation of breeders and TOSCA.

Once foundation seed is harvested and conditioned, it is packaged and officially labeled ('white label'), then disseminated to commercial seed producers, agencies or companies. In turn, these utilize out-grower farmers to increase (and in the case of hybrids, cross) the seed. At this stage the agency, company or producer can choose whether the seed should be certified, quality declared or utilized on farm. Truthfully-labeled or quality declared seed typically requires less costs in inspection, depending instead on the reputational incentives of the seed producers. These mechanisms have worked in both community-based systems as well as more advanced systems. Countries such as India successfully utilize a truth-in-labeling system to maximize the number of companies and products available.

Lack of harmonization and seed movement challenges

The lack of harmonization remains another important impediment in scaling strategies for foundation seed production. Variations in regulations across countries have critical implications for any scaling model that involves cross-border efficiencies in foundation seed supplies. Among the range of solutions discussed below in this brief, the implementation of any model requiring operations across multiple countries will be challenged by the lack of harmonization among seed commercialization laws and policies.

Cross-border issues are sometimes under-emphasized when sub-Saharan African countries look to other, more advanced seed systems for lessons. There is a fundamental difference in market size that drives many scaling strategies in sub-Saharan Africa. Despite the diversity of the seed market in countries like India or Brazil, their enabling environments allow for very large markets under a consistent set of laws and policies compared to the challenges of serving multiple, much smaller national markets in sub-Saharan Africa.

In addition to a harmonization of variety registration and release laws, there are great benefits to making progress in the area of seed movement regulations. Seed movement is important to scaling foundation seed systems in sub-Saharan Africa for three main reasons. Foundation seed systems will improve if: (1) foundation seed producers can source breeder's seed from

across borders with ease; (2) the foundation seed produced can move across borders to meet regional demand; and (3) the selection of locations for foundation seed production can be determined regionally, providing better optimization for land quality, isolation, disease or pest pressures and more.

Market entry for foundation seed production

As we have noted in other *Planning for Scale* briefs, market entry issues are a necessary consideration in creating scaling strategies. Even though market entry for new producers of foundation seed is currently prohibited by law in some countries in sub-Saharan Africa, the constraints that govern industry dynamics must be considered in any evaluation of future changes to foundation seed production systems.

Market entry dynamics in foundation seed are similar to those found in seed production in general. Perhaps the largest barrier to entry (beyond absolute prohibition of new foundation seed producers) occurs where government agencies act as *super-competitors.* Super-competitors produce seed without being governed by the same cost and risk structures as others in the market, they may be the default beneficiaries of unanticipated changes in government policies (e.g. subsidies) and they may also have regulatory roles that impact other producers. It should be noted that successful scaling seen in some advanced seed systems has been marked by governmental commitments to limit these roles, instead focusing on government agencies fulfilling functions in the seed system that *complement* rather than *compete with* non-government actors.

Other barriers to entry for foundation seed producers include difficulties accessing breeder's seed, a range of regulations governing certification, lack of access to finance, limitations accessing high-quality irrigated land, lack of availability of talent, and transportation challenges. Designing scaling strategies to account for industry-level dynamics will include consideration of how enterprises manage barriers to entry. This is true for strategies of existing market players who depend on current comparative advantages as well as for the strategies of potential new market entrants. Consider, for example, a scaling strategy for a country that liberalizes production of foundation seed, but not that of breeder's seed. Potential expansion of foundation seed production may ultimately still be constrained because new entities will not risk large investments in capital without also being able to integrate backward to produce breeder's seed and mitigate their input supply risks.

Market entry dynamics are particularly important when scaling strategies involve fostering startup companies to expand production of seed. If scale in the production of marketed seed is going to be achieved, for example, through a proliferation of small-to-medium enterprises (SMEs), this has implications for their access to foundation seed. For seed companies to startup

they need ease of access to the market (e.g. dependable access to foundation seed); for survival and growth they need a comparative advantage.

A key comparative advantage for seed company SMEs derives from exclusive access to germplasm, resulting in the ability to offer traits not supplied by competitors. As we note in Planning for Scale Brief #1: Tools, when small companies are not able to offer better traits than their competitors, scale must depend on creating comparative advantage in other ways. They might do this by being able to offer their seed at lower prices, investing in customer relations, or building a brand in an as-yet unserved market. Business strategies for scaling are also entirely different for hybrids and open-pollinated varieties.

In the case where foundation seed is available on a non-exclusive basis and there is little research and development (R & D) capacity for creating innovative hybrids, the landscape can be conducive to startups, but difficult for those companies to then establish a comparative advantage for growth. A high failure rate in startups can result unless scaling strategies anticipate comparative advantage needs. This is the case in some sub-Saharan African countries.

Policies have been designed in many countries to support this balance of encouraging startups as well as growth, favoring smaller firms through preferential treatment in taxes, financing, or access to licensing publicly-owned technologies, but allowing flexibility for the companies to find their comparative advantage. Most important in the policy framework, though, is a recognition that the industry must have the flexibility to change – sometimes rapidly.

Consider an example from the US seed industry.[5] Prior to the consolidation of the US seed industry, it was much easier for a new company to enter the market. Carlson (2007) notes that in this earlier era, seed corn genetics were available from multiple private firms (including Holden's Foundation, Seed Genetics and an estimated twenty other suppliers). These foundation seed companies did not have market power, some would not survive, others would be acquired or would need to change their business models, but the diversity of options at that point in time meant that it was easier for new seed producers to enter the market. The foundation seed industry looks very different in the US today.

Intellectual property rights and access to genetics

New varieties of seed are subject to a range of potential intellectual property rights (IPRs) that can be used either alone, in combination or not at all. Meth-

5 Throughout these briefs, we use parallels to the evolution of the United States seed industry. We recognize the stark differences and do not intend for the examples to be prescriptive or offer possible solutions for countries in sub-Saharan Africa. The last century in the US seed market does offer, though, illustrative examples of some of the concepts discussed here.

ods of providing legal control over the marketing of varieties include: plant variety protection, trademarks, material transfer agreements,[6] patents, trade secrets, and geographical indications. In advanced seed systems, many foundation seed entities have evolved to manage the business aspects of commercializing new varieties of seed, often allowing for a separation that allows scientists to focus on breeding and research with the knowledge that the intellectual property embodied in their new varieties is being managed in a way that is consistent with individual or institutional goals. These goals should not be assumed to be synonymous with maximizing licensing revenues; they can, instead, be goals of widespread dissemination or adoption.

The management of intellectual property rights in new varieties of seed is an area where particularly those institutions with public interest goals of widespread adoption of improved varieties of seed are struggling to catch up. IPR management is a key focus for scaling strategies that extends beyond seed to a wide range of other products and services for adoption among smallholder farmers. IPR management strategies for new varieties of seed produced by public sector breeding programs must critically consider issues of exclusivity. Managing the legal rights of access to a variety (through any combination of the IPR mechanisms above) means strategically deciding whether to allow non-exclusive access or institute limited exclusivity.

This discussion on exclusivity and access to genetics is explored elsewhere in these briefs, but a core message is that the public interest goal of widespread adoption of publicly-bred improved seed varieties among smallholder farmers likely depends on some level of exclusivity for certain varieties. Suppose, for example, a new variety will move further and faster into markets of smallholder farmers if a seed company produces and markets it, but that seed company will not invest unless it gets at least limited exclusivity. Limited exclusivity can be based on time, use, geography and other factors.

As noted above, in some seed systems, foundation seed producers managing public sector varieties are the conduit between those who own the intellectual property rights (e.g. research institutions and universities), and the commercial seed producers that use them. In this sense, they can perform an important IPR management role. We have good models from which to learn about defining the decision-making channels and understanding the resources required. Well-run IPR management entities in foundation seed production can: (1) obtain, maintain and enforce the rights, recognizing that without enforcement options the rights lose their value; (2) negotiate and monitor licenses; (3) advise scientists on IPR management issues in the lab, such as *freedom-to-operate* considerations; and (4) actively market new varieties.

6 Material transfer agreements cannot be considered in the same category as 'intellectual property rights' but their complementary use is so common that they must be included in any discussion of legal tools to manage the commercialization of plant varieties.

4 – Current Landscape

Historically in sub-Saharan Africa, foundation seed has been produced by government breeders and national research institutes, assisted by international research institutes. The chart in Figure 4 shows current seed supply structures for public sector bred foundation seed in Ethiopia, Ghana, Mozambique, Tanzania, Malawi and Senegal.

	Seed Authority & Research Institute	Foundation Seed Unit
Ethiopia	➔ Bako, Debre Zeit, Melkasa, Kulumsa and Pawe Agricultural Research Centres, part of the Ethiopian Institute of Agricultural Research (EIAR)[7]	➔ Ethiopian Seed Enterprise (ESE) and certified multipliers (e.g. regional seed Enterprises, licensed private seed companies like ANO and AgriCeft Ethiopia)[8] ➔ AGRA's 'Seed System Enhancement through Development of Improved Varieties of Maize, Teff, Sorghum, Soybean and Fava Bean in Ethiopia' aims to provide 20 tons of breeder and foundation seeds through the EIAR research institutes.
Ghana	➔ Ministry of Food and Agriculture (MOFA): Grains & Legumes Development Board (GLDB). ➔ Crops Research Institute ➔ Ghana Seed Inspection Division GSID (cert. agency), part of Plant Protection and Regulatory Services Directorate (PPRSD) ➔ Savanna Agriculture Research Institute (SARI) ➔ National Seed Technical Advisory Committee estimates production costs for certified seed and then allocates a 5% markup over these costs to serve as a price floor for domestically produced certified seed.	➔ The Seed Producers Association of Ghana (SEEDPAG), which is primarily involved with the production of cereal and legume seed ➔ The Ghana Agri-Input Dealers Association (GAIDA), which is primarily involved with the production of vegetable seed

Figure 4 – Current landscape of foundation seed production in selected countries.

7 Jones, R. et. al. (2006)
8 Alemu (2010)

Malawi	➔ Department of Agricultural Research Services (DARS) Agricultural Research Stations	➔ Department of Agricultural Research ➔ Services (DARS) for locally produced hybrids and OPV maize varieties and all legumes. ➔ Larger companies import foundation seed. ➔ Association of Smallholder Seed Multiplication Action ➔ Group (ASSMAG) producing foundation seed ➔ ICRISAT foundation seed production.[9] ➔ East Africa Bean/Cowpea CRSP ➔ Farmers, estates and NGO's produce foundation seed.
Mozambique	➔ National Agricultural Research Institute (IIAM) ➔ National Seed Services (SNS), part of Ministry of Agriculture (DNSA)	➔ IIAM Basic Seed Unit (USEBA): All public lines – shortage of some lines, too much of others. Poor coordination with companies. ➔ IKURU seed company also wants to produce foundation seed.
Tanzania	➔ SARI ➔ TOSCI (Tanzania Official Seed Certification Institute)	➔ Agricultural Seed Agency (ASA) provides all foundation seed from public lines. ASA also markets agricultural seed (potential conflict of interest) ➔ Kizimbani Research Station (Cassava) ➔ Foundation Seed Farms ➔ Private companies supported by AGRA (FICA) also exported foundation seed.
Senegal	➔ ISRA (National Ag Research Institute) ➔ DISEM (Ministry of Agriculture) : set norms, operate labs ➔ to test seed purity ➔ DRDR/Ministry: verify/approve seed	➔ ISRA (National Ag Research Institute)

Figure 5 provides a summary across countries. As can be seen, in each of the five key countries studied, foundation seed production is generally driven by government research institutes and in three countries this is supported by a semi-autonomous foundation seed production unit. In all of the countries, government research institutes contract seed producers, and in four out of the five countries, private seed companies either produce their own breeder and foundation seed from public lines, or import privately from other locations. In at least three countries non-profit organizations also produce foundation seed from public breeder sources. *(production of Foundation seed to be confirmed for final version)*

9 Nakhumwa and Kaudzu (2011)

	Foundation Seed Breeder Driven within NARI	Semi-Autonomous Foundation Seed Unit	Govt contracted Seed Farms	Private Seed Co's (local or imported)	IARIs	Non Profit
Ethiopia	■	■	■	■		■
Ghana	■		■	■		
Malawi	■		■	■	■	■
Mozambique	■	■	■	■	■	■
Tanzania	■	■	■	■	■	■
Senegal	■		■	■		

Figure 5 – Summary of foundation seed supply sources across selected countries. *Shading indicates that a country derives foundation seed from that source.*

Figure 6 provides an example of the various seed sector components of the Ethiopian seed system.[10] In terms of foundation seed supply, for example, the Debre Zeit Agricultural Research Centre (DZARC), part of the Ethiopian Institute of Agricultural Research (EIAR) provides chickpea breeder's seed to the Ethiopian Seed Enterprise (ESE). The ESE produces several stages of foundation seed on its own farms and also sells on to out-growers that produce seed for sale throughout the county, working in coordination with government extension and CGIAR Consortium center, ICRISAT.[11]

10 Alemu et al. (2008)
11 Jones et al. (2006)

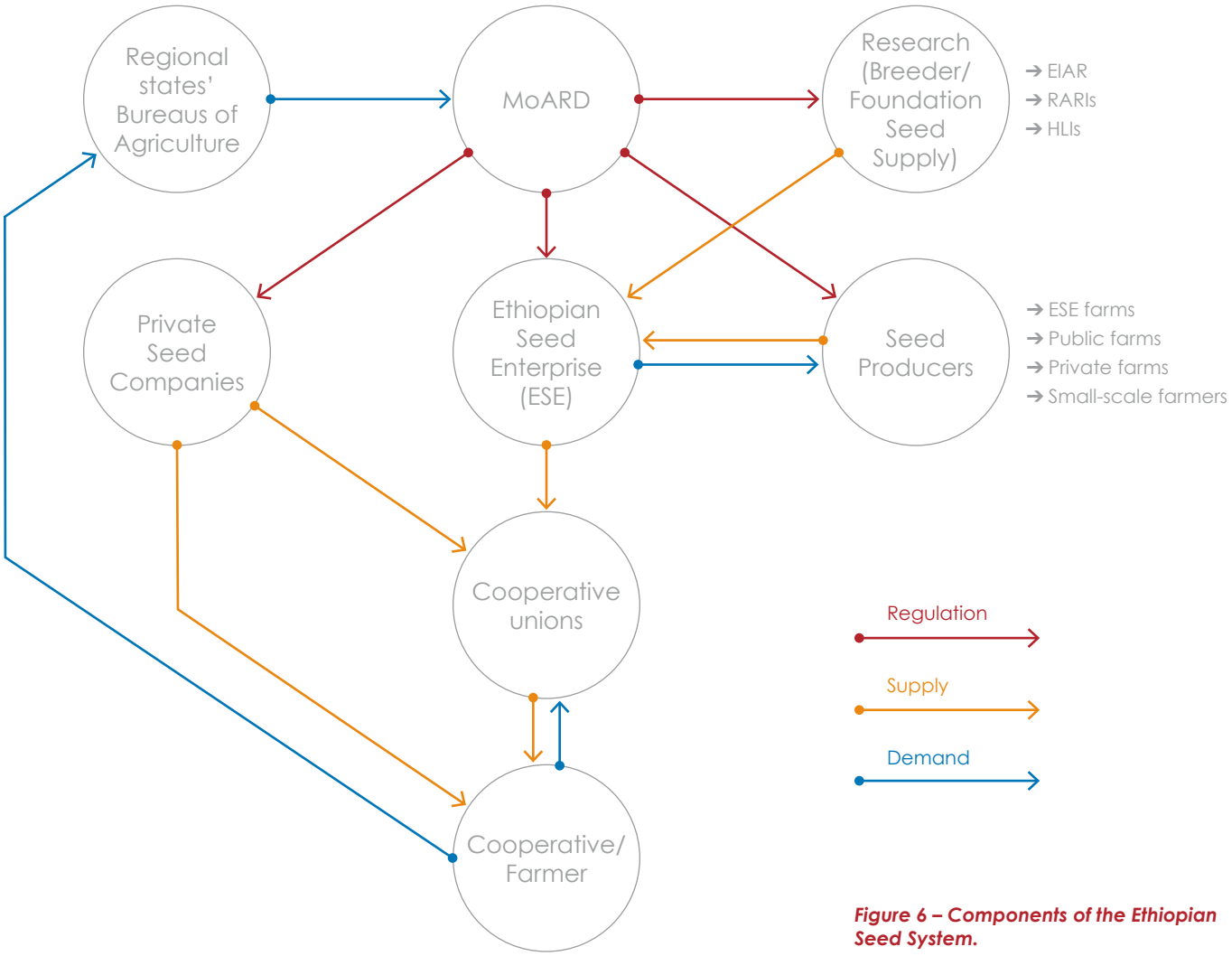

Figure 6 – Components of the Ethiopian Seed System.

5 – Foundation Seed Production Models

We have divided foundation seed production models into three structural categories: public sector-driven, company-driven and independently governed. This representation of three main models is simple, but provides a useful way of thinking critically about scaling foundation seed production. We note, however, that the set is neither collectively exhaustive nor mutually exclusive. The total supply of foundation seed in any country comes from a combination of sources that fall into these categories. In fact, advanced seed systems illustrate that the demand for foundation seed cannot be successfully met without a pluralism of production sources. The majority of foundation seed in sub-Saharan Africa is produced within public sector-driven models, with a small amount produced through company-driven channels. In this section we first elaborate on current supply models in sub-Saharan Africa and then discuss the models more broadly, looking ahead to potential alternatives for scaling.

Problems with the current landscape of models supplying foundation seed to sub-Saharan African seed systems have been well documented by past authors. It is of note, however, that despite evidence that a poor supply of foundation seed fundamentally limits the widespread adoption of improved varieties by smallholder farmers, there has been relatively little action from the donor community to explore alternative models. The Bill & Melinda Gates Foundation, Syngenta Foundation for Sustainable Agriculture, USAID and a few other donors have recognized the importance of this issue, but it has not been a priority, even though this bottleneck in the seed system diminishes the impact of donors' investments in plant breeding. From a donor perspective, reform in foundation seed production models must confront challenging political hurdles compared to more science-based initiatives. Although not included here, analysis of the political economy of foundation seed reform may be of greater relevance to making progress in scaling than analysis of optimal institutional structures.

Another reason we have not seen a great deal of movement on this problem perhaps lies in the fact that there are few short-term consequences for the failures in foundation seed supply and the damage done is not always clear-cut. Mid-term reviews by AGRA-PASS (Ellis-Jones et al. 2010) and previous papers confirm the ongoing shortfalls of the current sub-Saharan African public sector-driven approach to foundation seed supply. But foundation seed shortfalls in public foundation seed units in most countries result in few immediate consequences, apart from difficult to document losses for commercial seed producers, companies, and longer term national food security implications resulting from a loss of seed.

Public sector-driven foundation seed supply in sub-Saharan Africa

In the *public sector-driven* model, either an in-house or semi-autonomous foundation seed unit produces the foundation seed that comes from public lines, developed by public plant breeders who have worked with farmers and seed enterprises to develop suitable products for each market. Within the public sector-driven model, we discuss two current examples of foundation seed supply in sub-Saharan Africa. First, foundation seed production can be led from within the plant breeding department of a public research institute. Second, it can be led from within the national agricultural research institute more broadly, or a national university.

For example in Mozambique, IIAM Basic Seed Unit (USEBA) produces foundation seed for all public lines. However management challenges and poor coordination with seed companies have left a shortage of some lines and too much of others (AGRA, 2010b). In Tanzania, the Agricultural Seed Agency (ASA) provides all foundation seed from public lines to seed companies in Tanzania. Cassava foundation stock is provided by the Kizimbani Research

Station. However ASA's foundation seed production is unable to meet demand and quality has been less than optimal, limiting competitiveness of Tanzanian seed companies that use public lines. A potential conflict of interest is also apparent as the ASA also markets its own commercial seed (AGRA, 2010d).

Led by breeders	➔ Breeders are responsible for foundation seed supply. ➔ Breeders produce foundation seed directly on own research land or with contracted out-growers. ➔ Breeders supply multiple commercial producers, often with with the same germplasm on a 'first-come, first-served' basis. ➔ Model is in widespread use, but constrains scale as it cannot accommodate: (1) larger volumes; (2) demand for foundation seed from multiple organizations/companies; and (3) multiple crop products.
Led by NARIs or universities	➔ Often a semi-autonomous department within the national agricultural research institutes (NARI) or national university. ➔ Collaborates with breeding department. ➔ Acts as direct liaison between seed companies and national breeders. ➔ Coordinates production with seed producers. ➔ Supplies multiple producers with the same germplasm from national breeders, usually on a non-competitive basis. ➔ Locally-focused and exclusively uses germplasm from own breeding department or indirectly from international agricultural research institute (IARI)

Figure 7 – Public sector-driven foundation seed production in sub-Saharan Africa. *Adapted from Tripp (2006)*

Company-driven foundation seed supply in sub-Saharan Africa

Figure 8 represents the most typical, medium to large company production of foundation seed.

Company-driven	➔ Section of company production or research division. ➔ Proprietary germplasm sourced from multiple sources, including local, regional and global sources. ➔ Foundation seed efficiency and reliability seen as a competitive advantage.Accounatbility to internal production, sales and marketing 'customers'. ➔ Copes with mulitple new proudcts on an annual or biannual basis. ➔ Must now cope with multiple trait purity issues and stewardship, along with germplasm purity. ➔ May bulk / cross foundation seed for other production locations and be responsible for import or export of breeder or foundation seed ➔ Maintains foundation seed working directly with company or public breeders.

Figure 8 – Company-driven foundation seed production in sub-Saharan Africa. *Adapted from Tripp (2006)*

Due to the critical importance of foundation seed in the commercial seed supply chain, emerging local companies regularly express an interest in producing and securing their own foundation seed. This is not limited to the private sector. In Malawi, the Association of Smallholder Seed Multiplication Action Group (ASSMAG) was established to produce certified seed of neglected crops. However as market opportunity was realized, companies got involved in seed multiplication of the same crops and public foundation seed production could not keep up with demand. ASSMAG therefore started multiplying its own foundation seed. Foundation seed is multiplied by the key farmers within the SMAG who have skills, experience and capacity (Nakhumwa and Kaudzu, 2011).

Change within the status quo

Although foundation seed production driven by NARIs has met with limited success, when additional resource commitments and skills are provided to NARIs and their foundation seed units, positive results can be achieved. AGRA's '*Seed System Enhancement through Development of Improved Varieties of Maize, Teff, Sorghum, Soybean and Fava Bean in Ethiopia*' will provide 20 tons of breeder and foundation seeds through the Ethiopian Institute of Agricultural Research (EIAR) research institutes at Bako, Debre Zeit, Melkasa, Kulumsa and Pawe.

Unfortunately national dependence on public sector supply of foundation seed has not been matched with adequate growth in national budgetary resource commitments in public research institutes to meet the ever increasing complexity and demands of research and foundation seed production needed to support the emerging seed sector. In addition breeders have limited *time* resources for foundation seed production, and new staff in foundation seed units may lack knowledge, skills and experience required to scale.

More generally, the most immediate opportunities to scale foundation seed production lie in these and other improvements to the existing models. Even where no institutional changes are made and no new laws or policies are put into practice, progress can be made in improving the supply of foundation seed. Perhaps the largest set of solutions within the institutional status quo relates to transparency and accountability. Putting in place good metrics will begin to drive behavior within the system, allowing for a recalibration of incentives. If they are structured well, metrics will also provide critical operations information, indicating where the biggest opportunities are for improvement. Instituting multi-stakeholder review and strategy development around these metrics will provide key insights into how the system can be improved. Additionally, as is almost always the case, simply the process of creating a strategic metrics framework will spark discussions that may open up further avenues for change. Once a metrics strategy has

been deployed, other solutions may involve investments in training, partnerships or strategies for advocacy to better inform future policy changes.

Independently governed models and alternatives

Our third category of models is one that is characterized by some level of independence in governance and an autonomous or semi-autonomous institution with a central mandate to produce foundation seed. Governance mechanisms in these models may be nested within larger governance of host organizations, but they are still characterized by a higher degree of independence and more singular focus of purpose in producing foundation seed than the other two models.

In this model, the foundation seed enterprise itself takes the lead in working with breeders and multiple genetics and trait providers of seed to develop a range of foundation seed lines, as well as prescriptions for the combinations thereof, and produces these under advanced sales contracts to emerging seed companies through a catalog of products. Within the *independently governed* category of models we present two types that are worthwhile exploring as future options. First, we consider a model with a *public* governance structure, effectively a parastatal type of company. Second, we discuss a fully *private* foundation seed company.

Public	➔ Autonomous, government-funded foundation seed enterprise promoting use of national agricultural research institute (NARI) germplasm. ➔ Ideally run on a cost recovery basis. ➔ Supplies multiple companies under contract, with the same germplasm and/or some exclusivity on one or more lines. ➔ Works in collaboration with breeders from NARI and international agricultural research institutes (IARIs) where appropriate. ➔ Will require ongoing public support for an extended period, especially where required to maintain foundation seed. ➔ Focus is local and generally on non-exclusive products. ➔ May need provide some additional services over time to maintain financial viability.
Private	➔ Autonomous company with independent management and majority of private shareholders, potentially including customers. ➔ Run on a for-profit basis, but may require initial start up capital and 3-5 years working capital from public sector till sufficient demand ➔ Works with companies' breeders and contract production of exclusive lines from public or private local, regional and global germplasm. ➔ Can produce public lines for distribution under contract, or may sell foundation seed under license. ➔ Can serve national and regional foundation seed markets. ➔ May, over time, extend into services or proprietary products outside foundation seed production.

Figure 9 – Independently governed foundation seed production. *Adapted from Tripp (2006)*

Launching a foundation seed enterprise within this category demands high-level commitment and long-term investment of resources. By the nature of the business, commitments for foundation seed need to be made some 12–36 months in advance, but startup production could perhaps be covered through a range of options (e.g. 'sliding contracts' that would allow more flexibility earlier on or through managed shared market risk solutions). Even among the more advanced seed systems in the US and Canada, foundation seed companies have taken time to reach stable business income; some have failed, others have changed business models over time and the industry has evolved. Services outside foundation seed production[12] as well as management of proprietary assets have proved to be important tools within their business strategies (Tripp, 2006).

Recognizing that long-term business models require more than foundation seed production services is critical in assessing options for scaling. When moving from a public sector-driven model, traditionally government-provided services being offered by another entity, as well as the management of proprietary assets can create immediate conflicts. Legal and political challenges may warrant an especially robust governance structure that avoids conflicts of interest and navigates issues of preferential allocation or preferential production that inevitably arise.

The full set of options for institutional models in foundation seed production includes, of course, the many variants of the model types discussed above, as well as hybrids that combine components from different models. Three variants deserve particular mention.

Pooling resources. Consideration in sub-Saharan Africa has been given to the use of 'pooled' resources that seed companies could access, in order to make their foundation and commercial seed supply more reliable. This could include labs, testing facilities, planting and harvesting services, GIS, cleaning equipment, cold storage, finance, risk management and logistics.

Regional approaches. These might include, for example, commercial production under irrigation in other areas or countries with contract commercial farmers. This could also evolve into a type of regional hub approach where for example in each region of Africa. However each country, crop type and company has differing needs for foundation seed production and costs and risks must be carefully addressed in a regional model.

Narrow focus for inventory. In the other direction, some have suggested that risk is best mitigated by focusing on a narrow inventory for new foundation seed producers outside existing entities. For example, this might involve making available a narrowed down 'breeding pool' list of male and female

12 For example: seed quality testing, inspection services, contract production or own products.

lines available to seed companies. Companies would know available options and work with breeders to make their own combinations, including other 'external' lines. However a question must be asked as to whether such a narrowed down pool can keep up with competition coming in the form of imports from India, China, Brazil, US, South Africa and beyond.

6 – Implementation considerations

In this section we note a range of implementation considerations that will be critical in the evaluation of the models above. Section 7, below, then proposes selected scaling solutions for foundation seed production.

Risks are especially high for SMEs. Africa's emerging seed companies require a constant source of high quality foundation seed to allow them to grow and compete. Larger companies do not face the same needs. Sometimes larger companies are surviving because they have secured their own sources of foundation seed (from public or private sources or from imports, where allowed). Raising the profile of SMEs and advocating for their specific needs may be an important investment.

Central, third-party supply of foundation seed may limit competition. Supply chain management, including foundation seed bulking, is an integral part of a competitive market environment. In addition, experienced private breeders can gather competitive market and product 'intelligence' from centralized foundation seed plots/production locations, therefore there is often hesitation about central third party production of foundation seed.

Foundation seed production is a powerful pivot point in the seed system. Limiting sources of breeder and foundation seed to one or two local public or private seed sources is fraught with potential risks including: supply risks, favoritism, conflicts of interest, uncompetitive practices, and lack of genetic diversity.

Operational costs and risks demand innovative financing models. The costs and risks of producing, maintaining and storing foundation seed over 2–3 years to meet uncertain demand can be prohibitive for smaller foundation seed companies and a substantial burden on national breeding programs.

Contractual risks are everywhere. Foundation seed production, like any seed production, depends on a multitude of contractual relationships, including those with: input suppliers, bankers, out-growers and more. Understanding contractual relationships, especially where they may be unwritten or operate in environments with less than advanced rule of law, can determine success in scaling.

Breeders rarely have the perspective or commercial acumen to manage foundation seed supply. Breeders tend to want to focus on smaller seed niches, arguing that they need unique products and resulting probably unique foundation seed lines. This presents tremendous supply reliability and cost challenges for foundation seed units. Increasing complexity of new technology versions will magnify this problem.

7 – Potential scaling solutions

Providing a more reliable source of quality foundation seed enables improved productivity and competitiveness among seed producers in both informal and formal seed systems. Improvements to the foundation seed supply can be achieved through changes to existing models as well as the adoption of new models. The key is to allow sub-Saharan Africa's emerging seed sector to be able to access the best breeder's and foundation seed from multiple sources. These changes require long term commitments on the part of national governments, civil society, donors and private sector partners. Resources and skills are needed to implement change, as well as provide the flexibility to adapt and refine. We close this brief with a selection of potential solutions, both long- and short-term that may help to further national and international debates about improving the supply of foundation seed in sub-Saharan Africa.

SCALING GOAL — **Improve transparency and accountability in foundation seed production**

HOW TO DO IT

- ➔ Coordinate collaborative metrics planning workshop among multiple stakeholders, benefiting from the process of defining goals and how to measure them.
- ➔ Implement cost-effective systems of data collection that provide publicly available indicators of operations of the system, including: costs, inventory, timing and more.
- ➔ Implement regular institutional reviews of metrics to assess possible improvement strategies and engage multiple stakeholders in the process (providers of breeder's seed as well as users of foundation seed).

SCALING GOAL **Improve demand-driven aspects of foundation seed production**

HOW TO DO IT

- ➔ Implement simple web-based user feedback mechanisms for users of foundation seed that log user-generated assessments including, for example: quality, timeliness, variety availability.
- ➔ Focus on implementing cost-effective systems of data collection that provide publicly available indicators for each of the six aspects of demand noted in Section 1.
- ➔ Engage farmers' groups and users of the end-product (commercially marketed seed) in discussions and feedback about performance of foundation seed production system.
- ➔ Conduct parent and commercial trials in key foundation seed and commercial seed production areas.
- ➔ Assess parent performance, and suitability of inbred and parent crosses during seed product advancement selection.
- ➔ Engaging multiple stakeholders, evaluate impact of choice on cost, reliability and yield of commercial seed production and potential impact of availability and cost to farmer customers.
- ➔ Implement processes to maximize the likelihood that products selected for advancement have wider area of adaptation, and preferably common parent lines across agro-ecological zones to improve reliability, foundation seed quality and reduced cost.

SCALING GOAL **Enhance communication between public and private breeders with public and private foundation seed units and seed businesses.**

HOW TO DO IT

- ➔ Ensure breeders have a structured forum to meaningfully and regularly engage on breeder and foundation seed issues.
- ➔ Engage key foundation seed stakeholders and seed company custom-

SCALING GOAL **Enhance access to breeder's seed**

HOW TO DO IT

- ➔ Secure and improve breeder's seed sources from local, regional and international options.
- ➔ Provide training for foundation seed producers on how to access breeder's seed.
- ➔ Encourage access and provide training to increase access from IARIs directly rather than through NARIs.
- ➔ Develop and implement advocacy strategies to promote the relaxing of foundation seed policy to allow multiple sources of breeder's seed and foundation seed.
- ➔ Evaluate potential improvements to breeder's seed maintenance breeding.

SCALING GOAL

Evaluate potential for national partnerships and consortia to improve production of foundation seed

HOW TO DO IT

- ➔ Engage local and international foundation seed practitioners as advisors to design, advocate for, and secure financial support from responsible seed authorities for the formation of breeding/foundation seed partnership/consortia – e.g. National Breeding and Foundation Seed Partnerships.
- ➔ Include both public and private sector members – breeders, foundation seed units/enterprises, and seed company managers, or informal sector 'customers' and international foundation seed experts.
- ➔ Consider examining membership based, fee paying and cost recovery models.
- ➔ Include travel to fields with breeders, seed association and company 'customers', meetings and administration.
- ➔ Engage farmer groups that will ultimately use or buy the commercial seed.
- ➔ Liaise with consortia in neighboring countries.

SCALING GOAL — **Improve operations performance within current public foundation seed units**

HOW TO DO IT

- ➔ Provide budgetary and technical support to existing public foundation seed units
- ➔ Implement training for improved foundation seed management skills and process capacity.
- ➔ Work with responsible authorities to empower foundation seed units with 'stand-alone' autonomy and cost- recovery based solutions based on demand from external seed companies and producers.
- ➔ Engage hands-on expert/s in foundation seed production to develop best practice national 'foundation seed manual' – describing parent testing, breeder hand off, traceability and inventory management, customer relations, quality management, data and information flow, IP management, etc. Conduct training workshops to deliver this training to public and private foundation seed 'practitioners'.
- ➔ Improve foundation seed supply reliability by strategic evaluation of: larger blocks of production, reasonable 'carry over' assumptions, dryers, cold-storage, improved packaging, more timely demand signals, better inventory data flow, and off-season production locations, possibly in a regional 'foundation seed production hub'.
- ➔ Engage seed accounting expertise to develop allocation and costing template for use in all countries with support from national seed association.
- ➔ Engage expertise to evaluate national and regional level demand risk management, considering possible solutions, including: insurance schemes for seed companies and producers, and 'rolling' funding through annual support fees or 'check-off' / license schemes administered in conjunction with seed associations.
- ➔ Evaluate potential improvements to foundation seed maintenance breeding.
- ➔ Improve accuracy of commercial seed supply-demand forecasting (2–5 year) and the resulting supply-demand foundation seed planning.
- ➔ Implement foundation seed producer evaluation/reward schemes (e.g. to incentivize improvements among contract growers)
- ➔ Update inventory management tools, expertise and capacity. Develop or purchase public supply/demand planning tools database with crop, inbred, company, national and regional 'lenses'.

SCALING GOAL — **Improve advocacy for changes in the enabling environment**

HOW TO DO IT

- ➔ Create policy recommendations for impact of changes in regional seed movement regulations on foundation seed production systems.
- ➔ Assess options for policy changes to allow private foundation seed production, documenting policies from other countries that have changed. Assess implementation issues.
- ➔ Examine, at the national level, a range of possible incentives needed to catalyze formation of foundation seed enterprises. Options might include, for example: 5 years financial support for the establishment of private foundation seed companies, paying for inventory 'write-off', maintenance breeding cost, cold storage and other capital equipment purchase. Transitional costs assessed for the period during which a foundation seed 'market' and customer base is built.

SCALING GOAL — **Expand supply of foundation seed**

HOW TO DO IT

- ➔ Improve access to irrigation for contracted foundation seed producers.
- ➔ Evaluate risks and costs of contract grower models and assess potential improvements to common problems, including side-selling and quality control issues.
- ➔ Improve access to finance for seed production, including equipment leasing finance and asset-based lending.
- ➔ Consider incentives, controls and market entry issues related to formation of new foundation seed enterprises.

References

Admassu, M. Chaiman Ethiopia Seed Trade Association, Telephone discussion, July 2013.

AFSTA. African Seed Trade Association. Web Site. Accessed 26 November 2013.

AGRA. *Mid-Term Review of the Program for Africa's Seed Systems Malawi*. Rep. June 2010a.

AGRA. *Mid-Term Review of the Program for Africa's Seed Systems Mozambique*. Rep. June 2010b.

AGRA. *Mid-Term Review of the Program for Africa's Seed Systems Ghana*. Rep. Sept. 2010c.

AGRA. *Mid-Term Review of the Program for Africa's Seed Systems Tanzania*. Rep. Sept. 2010d.

Alemu, D. 'The Political Economy of Ethiopia Cereal Seed Systems.' Working Paper 017. 2010.

Alemu, D., W. Mwangi and M. Nigussie. 'The maize seed system in Ethiopia: challenges and opportunities in drought prone areas.' *African Journal of Agricultural Research* Vol. 3 (4) (2008): pp. 305–314.

Ali, M. and S. Gupta. "Carrying Capacity of Indian Agriculture: Pulse Crops." *Current Science* 102.6 (2012): 874–81.

Boettiger, S. and L. Le Page. "Lessons for Africa's Emerging Seed Sector from Scaling Maize in Thailand." *Apxc.org*. AgPartnerXChange, 2013.

Brooks, R. "The Read on Seed | Farm Journal Magazine." *AgWeb*. Farm Journal, 9 Nov. 2013.

Carlson, T.R. "Finding a Position for a Firm to Succeed in the Seed Industry." Thesis. Saint Cloud State University, 2007.

CIAT. *Scaling Up and Out: Achieving Widespread Impact through Agricultural Research*. Cali, Colombia: CIAT, 2004.

Damas, Philip. 'Dr. Philip Damas_Scaling Up Agriculture in Tanzania.pdf.' 2012.

Ellis-Jones, J. J. Hella, J. Stenhouse, H. Gridley, P. Amaza, and D. Kambewa. *Mid-Term Review of the Program for Africa's Seed Systems*. Rep. The Alliance for a Green Revolution in Africa, Sept. 2010.

FAO Seed and Plant Genetic Resources Service. 'Seed Policy and Programmes for Asia and the Pacific.' FAO Plant Production and Protection Paper 160: Proceedings of the Regional Technical Meeting on Seed Policy and Programmes for Asia and the Pacific.

Ed. Seed and Plant Genetic Resources FAO Service. Rome: FAO, 2000.

Grow Africa. 'A Business Case for Investing in Savanna Seed Services Company in Ghana.' May 2012.

IFPRI. 'IFPRI Working Paper – Seed System Potential in Ethiopia.' July 2010. IFRPI Publications. 15 August 2013.

India, Govt. of. *Indian Seed Sector*. 17 July 2013. <http://seednet.gov.in/>.

Jones, R., P. Audi, B. Shiferaw and E. Gwata. *Production and Marketing of Kabuli Chickpea Seeds in Ethiopia: Experiences from Ada District*. Report submitted to project for Improving Productivity and Market Success (IPMS) of Ehiopian Farmers. Nairobi, Kenya: ICRISAT, 2006.

Kolkady, D., D. Spielman and A. Cavalieri. *Intellectual Property Rights, Private Investment in Research, and Productivity Growth in Indian Agriculture*. Washington, DC: IFPRI, 2010.

Langyintuo, A.S., W. Mwangi, A.O. Diallo, J. MacRobert, J. Dixon, and M. Banziger. *An Analysis of the Bottlenecks Affecting the Production & Deployment of Maize Seed in Eastern and Southern Africa*. Harare: CIMMYT, 2008.

MacRobert, J. *Seed Business Management in Africa*. Harare, Zimbabwe: CIMMYT, 2009.

MacRobert, J. Personal communication with Aline O'Connor, July 2013

Morris, Michael L., ed. *Maize Seed Industries in Developing Countries*. Mexico: Lynne Rienner Publishers, Inc., 1998.

Nakhumwa, Teddie and Grace Kaudzu. '*ASSMAG-seed-systems-study: Strengthening and Replicating Successes of the Smallholder Seed Multiplication Industry in Malawi*.' 2011.

Norder, Jurriën D. '*Investigating and investing in pp-scaling in Agriculture? Looking at the role of DSO/OO in stimulating up-scaling*.' 11 February 2012.

Parvan, Andrei. 'Agricultural Technology Adoption: Issues for Consideration When Scaling-Up.' *The Cornell Policy Review* (2011)

Pray, C.E. and L. Nagarajan. *Pearl Millet and Sorghum Improvement in India*. Washington, DC: IFPRI, 2009.

RIU. "Improving Lowland Maize Productivity." *Maize Farmers Strike Back against Striga and Stemborer*. Research into Use. Web. 30 Nov. 2013.

Sriwatanapongse, S., S. Jinahyon and S.K. Vasal. *Suwan 1 – Maize from Thailand to the World*. Bangkok, Thailand: CIMMYT, 1993.

Thomson, P. 'Trends in Thailand's seed sector.' Paper presented at Asian Seed Conference. 1994.

Tripp, Robert. 'The Case for Foundation Seed Enterprises in Sub-Saharan Africa.' London: Oversees Development Institute, 2006.

USAID-ATAI. 'USAID-ATAI Evidence Summit Agricultural Techology Assessment Tool.' 1–2 June 2013. CEGA. 6 August 2013

Van Mele, P., J.W. Bentley, and R.G. Guéi. *African Seed Enterprises: Sowing the Seeds of Food Security*. Cambridge, MA: Published by the Food and Agriculture Organization of the United Nations and the Africa Rice Center by Arrangement with CAB International, 2011.

Venkatesan, V. *Seed Systems in Sub-Saharan Africa: Issues and Options*. World Bank, 1 Nov. 1994.

Verma, Paresh. 'The Indian Seed Industry.' 15 July 2013. *Asia Pacific Seed Association*.

World Bank. *Staff Appraisal Report Ethiopia Seed Systems Development Project*. Rep. no. 13739–ET. 1995.

Zaaten, E. Personal communication with Lloyd Le Page, 2012.