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Early Generation Seed Study – Summary

February 10th, 2015

Monitor Deloitte.

The following content is a summary of the working draft of the Early Generation Seed Sector Study.

Data is still to be refined and validated through expert review.

Context and objectives of this study

Quality seed of improved varieties is difficult to access in many countries in Sub-Saharan Africa due to bottlenecks in the early generation seed (EGS) value chain. One key reason for this is that current policies do not always support efficient models for scaling production and delivery of early generation seed. Seed policy is either too general, treating all EGS as a public good with heavy state involvement, or too specific, applying idiosyncratic policies for specific crops in specific countries or regions.

To address this challenge, this report seeks to develop a generalizable framework that enables policy makers and donors to tailor their policies and interventions to the needs of specific crops based on market conditions, which we refer to in this study as market archetypes. The archetypes are determined by the following dimensions:

- Marginal economic value of quality seed of improved varieties
- Level of demand for varieties or crops grown with quality seed of improved varieties

We recognize, however, that several other factors contribute to a well-functioning seed sector, which we address in this report. These include, but are not limited to:

- Policy Environment: National and regional policies, including subsidies, tax exemptions, and IP regulations; the level of coordination of development interventions
- Value Chain Capacity and Resources: Capacity and resources across the seed value chain (e.g., institutional capacity, personnel, equipment, research funds, etc.); flow of information along the seed value chain
- Quality Assurance Mechanisms: Organization and implementation of quality assurance mechanisms across the seed value chain
- Supporting Environment: Quality of physical infrastructure (e.g., roads, irrigation, etc.); access to capital and financing

Based on a representative set of countries and crops, we provide real examples of potential business models that could scale in a commercially sustainable manner. In the case where the public sector still plays a role, we outline where there are opportunities for public-private collaboration and increased efficiencies in the sector. We recognize that achieving the quality of seed demanded by the market at the time it is demanded is a significant challenge separate from achieving a certain quantitative scale. However, our business models assume that seed produced would meet these quality and timing requirements. Further study is needed to understand how the capabilities of specific seed-producing entities in specific geographies might affect these models.

Finally, the report concludes by providing generalizable principles and recommendations to help guide key stakeholders as they pursue policies, investments, and interventions.

For the purposes of this study, we applied a common economic framework, which we adapted to highlight the economic characteristics of seed that have implications for the ideal state value chain

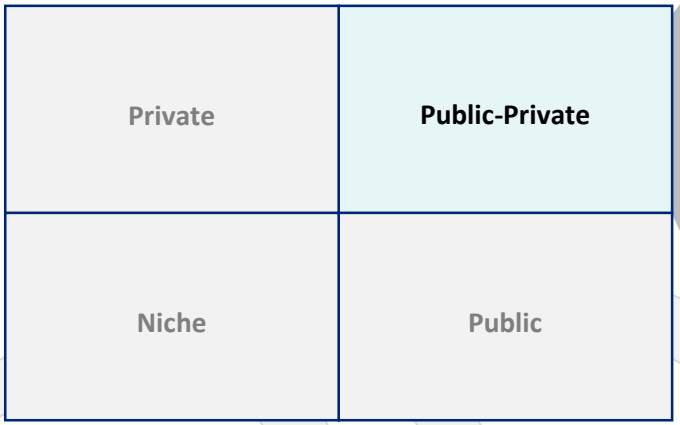
Marginal economic value of quality seed of improved varieties

Level of demand for crops grown with quality seed of improved varieties

	High	*Low*
High	**1 Private Sector Dominant Archetype** *Quality seed of improved varieties that is both attractive for private sector actors to produce and that produces crops the market demands, resulting in robust private sector investment with minimal public sector involvement* **Example seed sectors:** Maize (hybrid) *Flowers*[3] *Vegetables (tomatoes, cabbage, etc.)*	**2 Public-Private Collaboration Archetype** *Quality seed of improved varieties for crops with strong market demand but for which the cost of production or demand risk create barriers to private-sector investment and innovation resulting in public sector involvement* **Example seed sectors:** Maize (OPV)[1] Cowpea[2] Common Bean[2] Rice Cassava Sweet Potato *Groundnut*
Low	**4 Niche Private Sector Archetype** *Quality seed of improved varieties for crops with niche market demand but which are profitable to produce in certain quantities, which are produced by a vertically integrated private sector with minimal public involvement* **Example seed sectors:** Sweet potato (temporary demand due to disease) *Cotton* Sorghum or Cassava (niche demand for beer brewing)	**3 Public Sector Dominant Archetype** *Quality seed of improved varieties for crops that are not highly desirable or profitable to produce, but which are promoted by the public sector to advance a public goal such as food security or seed security* **Example seed sectors:** Sorghum (OPV) *Teff* Common Bean[2] Cowpea[2]

Notes:
(1) Examples are relevant for quality seed of improved varieties in formal seed sectors
(2) Examples given are illustrative and may not be applicable across all countries and crop varieties, which accounts for the same crop appearing in more than one box
(3) Examples in *italics* indicate crops that were outside the scope of this study's target crops

Within the public-private collaboration category we identified two archetypes based on the certainty of demand, cost, and complexity of supply



Uncertain market demand

2a

Public-Private Archetype I: Public Sector Mitigates Demand Risk

Seed that is attractive for private sector companies to produce, but for which they cannot reliably forecast demand and so are exposed to high demand risk and high cost of capital as a result

Example seed sectors:

Rice Sweet Potato

Cassava

Costly / complex production

2b

Public-Private Archetype II: Public Sector Supports Breeder and Foundation Seed Production

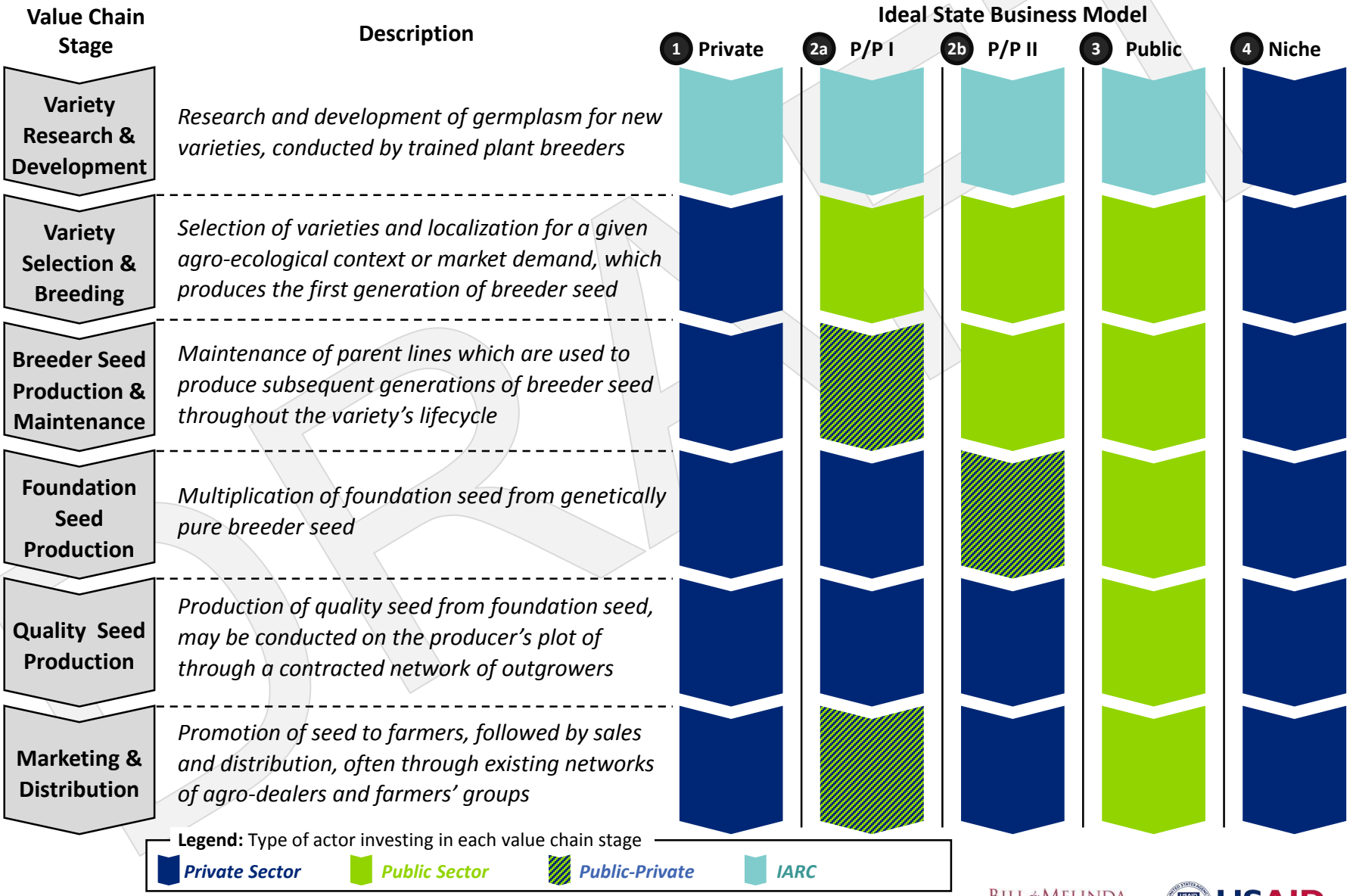
Seed that is reliably demanded by consumers, but which are unattractive to produce EGS for due to high effort or technology intensity, risk of post-production loss, or generally low margins

Example seed sectors:

Cowpea Maize (OPV)

Common bean

Within each archetype, the ideal state of who invests at each value chain stage is determined by who derives value from the activity, though the work may be contracted to other actors



1 Private sector investment and involvement in the EGS sector occurs when seed is highly profitable and when the demand is high and stable

Private	P/P
Niche	Public

	Description	Example: Hybrid Maize
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• Quality seed must be bought frequently to ensure genetic purity and crop quality • Certified seed from the formal sector is seen as providing a significant quality benefit over farmer-saved or informally sourced seed • Improved varieties offer significant benefits in certain desirable traits over local and recycled improved varieties • Seed can be efficiently distributed to consumers	• Must be purchased every year to maintain genetic purity and desirable traits • Maize seed are hardy and transportable, as they have low bulk and low perishability • Improved varieties offer large yield advantages over local and recycled improved varieties
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• High market demand for the end-market crop in general, from public or private consumers • High standards of quality in market, resulting in increased demand for certified seed of improved varieties to produce high-quality and uniform crops • Specialized demand for the variety or crop carrying specific characteristics (aroma, color) • Continuous innovation in improved varieties is valued by the market	• Certified seed of hybrid varieties is highly valued, selling for a much higher multiple of grain price on average, as opposed to OPVs • Continuous improvement is critical to growing agricultural productivity as "maize is king" in much of Sub-Saharan Africa

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

1 In this archetype, private actors produce EGS and distribute it through commercial markets, often in the context of a well-developed, mature enabling environment

Private	P/P
Niche	Public

Value Chain Stages	Ideal State Business Model: Key Actors and Roles	*Illustrative Ideal State: Hybrid Maize*
Variety Research & Development	• ***International research centers (e.g., CIMMYT)*** develop new germplasm that has generally desirable characteristics, sometimes in collaboration with private companies	***International center (e.g., CIMMYT)*** develops new varieties, and licenses on an exclusive or non-exclusive basis in exchange for royalties
Variety Selection & Breeding	• ***Private seed companies*** maintain parent lines and produce subsequent generations of parental lines as a subset of breeder seed	***Private companies***, e.g. Zamseed, select and localize lines best suited to Zambian growing conditions and market needs and conduct maintenance breeding
Breeder Seed Production & Maintenance	• ***Private seed companies*** maintain parent lines and produce subsequent generations of parental lines as a subset of breeder seed	***Private companies*** like Zamseed maintain inbred parent lines and either licenses breeder seed to other companies or uses it in-house
Foundation Seed Production	• ***Private seed companies*** produce foundation seed from breeder seed that they either maintain in-house or license from another private entity	***Private companies*** produce and market foundation seed for profit or uses it in-house or with outgrowers to produce certified seed
Quality Seed Production	• ***Private seed companies*** manage production of certified seed from foundation seed either through contractual arrangements with outgrowers or on their own plots	***Private companies*** produce quality seed primarily through contract growers to whom they provide foundation seed
Marketing & Distribution	• ***Private seed companies*** set prices in the market and either develop in-house marketing and distribution or interface with NGOs, agro-dealers, coops, unions, etc.	***Private companies*** repurchase seed from contract growers and market to local farmers' groups and agro-dealer networks

Legend: Type of actor investing in each value chain stage

Private Sector ***Public Sector*** ***Public-Private*** ***IARC***

2a Public-Private Archetype 2a: When the demand for EGS is uncertain, the public may need to play a role in mitigating demand risk

Private	P/P
Niche	Public

	Description	Example: Rice
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• Demand is highly sensitive to variable growing conditions each season • Because farmers can easily save, produce, and market seed in informal markets, demand for seed from the formal sector is not guaranteed from year to year – Demand is driven by a need for pure/healthy quality seed or new varieties	• Rice seed can be recycled for several years, so farmers only renew every few years • Rice is highly sensitive to rainfall conditions, with recurring, but uncertain demand for new drought resistance varieties • Demand exists for new varieties with clear value added to farmers that may ensure yield
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• Farmer adoption of improved varieties and their value is low and requires promotion • Consumer preference can be fickle based on grain characteristics (size, color, etc.), though market pull exists among wealthier, urban consumers for high-quality, non-broken grain • Consumer preferences shifting based on socio-economic trends (e.g., increasing wealth)	• Adoption of improved varieties is slow • Meeting consumer preferences on uniformity of grain size, transparency, and non-broken grains can be a source of price premiums, which requires quality seed along with strong agricultural and post-harvest practices • Perception that rice demand will decrease as GDP rises and more high-end grains are demanded, though this may be years away

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

2a Under P/P Archetype 2a, private companies produce EGS and commercial seed, and the public sector mitigates demand risk through contractual or financial arrangements

Private	P/P
Niche	Public

Value Chain Stages	Ideal State Business Model: Key Actors and Roles	*Illustrative Ideal State: Sweet Potato*
Variety Research & Development	• ***International research centers (e.g., IITA)*** develop new germplasm that has generally desirable characteristics, sometimes in collaboration with NARS	***International center (e.g., CIP)*** breeds new varieties of sweet potato, for example high-starch, high DMC varieties for frying and consumption, as preferred by farmers and consumers
Variety Selection & Breeding	• ***Public breeding programs*** select germplasm based on local adaptability and desirability and breed first generation of localized breeder seed	***NARS (e.g., DRD in Tanzania)*** select localized varieties best suited for end-market demands and agro-ecological context
Breeder Seed Production & Maintenance	• ***Public-private partnership or non-profit entity*** maintains breeder seed/plant material as an intermediary between the public sector and private seed companies	***NARS*** contracts with ***private tissue culture lab*** to maintain and produce breeder seed/planting material on an ongoing basis
Foundation Seed Production	• ***Domestic seed companies*** produce foundation seed from public breeder seed that they license from a non-profit intermediary entity	***Private foundation seed enterprise (FSE)/nurseries*** licenses breeder seed/plant materials in response to demand and produces and markets foundation seed for profit
Quality Seed Production	• ***Domestic seed companies*** manage production of certified seed from foundation seed either through contractual arrangements with outgrowers or on their own plots	***Private, domestic companies*** produce quality planting material through local contract growers to minimize downstream transport costs of bulky planting material
Marketing & Distribution	• ***Public sector*** guarantees demand either by buying seed directly from private companies in output-based contractual arrangements or through policy measures	***Public sector*** collaborates with ***private sector*** to guarantee demand by incentivizing private companies to purchase and use more sweet potato, for example in fuel or bread production

Legend: Type of actor investing in each value chain stage

Private Sector ***Public Sector*** ***Public-Private*** ***IARC***

2b Public-Private Archetype 2b: When EGS is unattractive to produce despite the level of demand, the public sector will support the supply

Private	P/P
Niche	Public

	Description	Example: Common Bean and Cowpea
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• Seed is highly labor or technology-intensive to produce • Seed is fragile or sensitive and thus difficult to store and transport to farmers without loss • Size or weight of seed makes it costly to transport for production and distribution • Multiplication yield rates are low making the multiplying seed costly	• Multiplication rates are low (40 seeds/plant for cowpea, 20-115 for common bean) and it is costly to multiply more than once per year, due to irrigation and input costs, increasing the time and costs associated with multiplying seed • The large size (of common bean, specifically) and heavy weight of the seed makes transportation costs high making and causes distribution challenges in areas with poor infrastructure (poor trucking systems and roads)
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• Low prices in end-markets depress margins • Reuse of varieties for long periods of time in market reduce incentives to invest in breeding new varieties and produce commercial seed • Farmers re-use seed for many seasons before repurchasing quality seed of improved varieties	• Landraces can be used for 20-30 years in-market, creating little market pull for improved varieties • Farmers reuse seed for ~3-5 years depending on skill before repurchasing improved varieties (little ROI incentive to repurchase improved seed year over year)

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

2b Under P/P Archetype 2b, public actors produce EGS and sell it in a commercial market to private seed companies for quality seed production and distribution

Private	P/P
Niche	Public

Value Chain Stages	Ideal State Business Model: Key Actors and Roles	*Illustrative Ideal State: Cowpea*
Variety Research & Development	• ***International research centers (e.g., IITA/CIAT)*** develop new germplasm that has generally desirable characteristics, sometimes in collaboration with NARS	***International center (e.g., IITA)*** breeds new varieties with superior taste or tolerance to environmental conditions
Variety Selection & Breeding	• ***Public breeding programs*** select germplasm based on local adaptability and desirability and breed first generation breeder seed	***NARS (e.g., Savannah Agricultural Research Institute in Ghana)*** select and breeds varieties for diverse agro-ecological regions of Ghana, on a regional basis for the dryer, northern regions
Breeder Seed Production & Maintenance	• ***Public breeding programs*** maintain and produce breeder seed	***NARS*** produces public breeder seed and maintains it on an ongoing basis in order to supply inputs for foundation seed producers
Foundation Seed Production	• ***Public-private partnership or non-profit entity*** produces foundation seed produces breeder seed and licenses it to seed producers on a cost-recovery basis	***Non-profit foundation seed enterprise (FSE)*** licenses breeder seed and produces and markets foundation seed to private companies on a cost recovery basis
Quality Seed Production	• ***Domestic seed companies*** manage production of certified seed from foundation seed either through contractual arrangements with outgrowers or on their own plots	***Private, domestic companies*** produce quality seed through local contract growers to minimize downstream transport costs of bulky seeds
Marketing & Distribution	• ***Domestic seed companies*** set prices in the market and either develop in-house marketing and distribution or interface with NGOs, agro-dealers, coops, unions, etc.	***Private, domestic companies*** manage and facilitate distribution to local agro-dealers or farmer's groups

Legend: Type of actor investing in each value chain stage

Private Sector ***Public Sector*** ***Public-Private*** ***IARC***

Draft

3 Strong public involvement in EGS occurs when seed is not profitable or when the output crops have low commercial demand but may be valuable for public goals

Private	P/P
Niche	**Public**

	Description	Example: Sorghum (OPV)
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• Seed can be saved from season to season by farmers with limited decline in seed quality and purity • Seed is difficult to distribute and transport • Low variety turnover rate, as any improved varieties meet farmers needs for many years	• Farmers tend to be attached to their own local landraces that suit their specific needs • Seed can be saved and most sorghum seed is produced by the informal sector and is available to farmers through those channels • For OPVs, most new variety development tends to focus on improving existing landraces • Seed is not bulky, but is moderately perishable
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• Low commercial demand for the crop, as its primary value is in offering food/seed security so farmers are reluctant to invest heavily • Crops are mainly for subsistence or local markets with low quality standards so lower quality seed of local varieties are accepted • Consumers are not discerning about discrete crop traits so genetic purity is not highly valued • No price premium available due to lower-end demand or limited differentiation	• Often grown in areas with marginal growing conditions, so farmers tend to not have high income for purchasing quality seed of improved varieties • Outside of brewing—which mainly uses hybrid sorghum—sorghum does not command a premium in most markets • Crops often grown for on-farm consumption and for household uses such as fuel, animal feed, and building material

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

3 In this archetype, public actors produce EGS and distribute it under subsidized, non-commercial arrangements to advance public goals such as food or seed security

Private	P/P
Niche	**Public**

Value Chain Stages	Ideal State Business Model: Key Actors and Roles	*Illustrative Ideal State: OPV Sorghum*
Variety Research & Development	• ***International research centers (e.g., ICRISAT)*** develop new germplasm that has generally desirable characteristics, sometimes in collaboration with NARS	***International center (e.g., ICRISAT)*** breeds new varieties of disease-resistant sorghum to further bolster food security
Variety Selection & Breeding	• ***Public breeding programs*** select germplasm based on local adaptability and desirability and breed first generation of breeder seed	***NARS (e.g., Tanzania's Department of Research and Development)*** selects varieties and localize them to agro-ecological context
Breeder Seed Production & Maintenance	• ***Public seed producer*** maintains breeder seed on behalf of the public breeding program, as an independent entity from the breeding institute	***Public seed enterprise,*** separate from the breeding program, maintains breeder seed on a regional basis on behalf of the national breeding program
Foundation Seed Production	• ***Public seed producer*** produces foundation seed from breeder seed and distributes it to seed producers on a non-commercial basis	***Public seed enterprise*** produces foundation seed for dissemination to seed producers on a non-commercial, subsidized basis
Quality Seed Production	• ***Public seed producer*** manages production of certified seed from foundation seed through non-commercial, subsidized arrangements with outgrowers or small seed companies	***Public seed enterprise*** produces quality seed through subsidized, non-commercial arrangements with contract growers
Marketing & Distribution	• ***Public seed aggregator*** collects, prices, and promotes demand, and distributes seed, possibly through state apparatus, NGOs, or agro-dealer networks	***Public seed enterprise*** aggregates seed under non-commercial contractual arrangement and distributes it under a subsidized system to farmers

Legend: Type of actor investing in each value chain stage

Private Sector ***Public Sector*** ***Public-Private*** ***IARC***

Draft

4 A sustained niche occurs when there is a strong but inherently limited demand for a unique seed characteristic

Private	P/P
Niche	Public

	Description	Sustained Niche Example: Hybrid Sorghum for Brewing
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• Variety has a unique trait to serve a niche demand • Desirable trait driving niche market demand is not widely demanded for other applications • Seed is profitable only for a limited production	• A specific variety of sorghum is commissioned for a specific beer production, in cases where an existing variety does not possess required traits • Specific variety demanded sometimes does not have wider market demand or applicability • The variety of sorghum will only be valuable until the beer production capacity is met
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• There is strong, but limited demand • Once the limited demand is met, there is no remaining value for the seed • Often a closed market chain, where the end user is funding the production of the seed for exclusive use	• The brewery has limited beer production capacity, and only demands a limited amount of sorghum • Once beer production is at full capacity, there is no additional demand for the sorghum variety (no remaining value for the crop) • Often the beer producer will commission the production of the sorghum variety for their exclusive use

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

4 A temporary niche can emerge when there is a time-boxed demand for a specific seed characteristic, such as a disease-resistant variety while a disease is rampant

Private	P/P
Niche	Public

	Description	Temporary Niche Example: Sweet Potato
Seed Characteristics *Inherent characteristics of the crop and seed's biology and associated agricultural practices that impact the design and viability of seed systems*	• A certain trait or characteristic is in high demand for a finite amount of time • Production of the trait is limited due to time constraints (cannot meet the demand)	• Disease-prone tuber crops can have temporary high demand depending on current diseases • A disease resistant variety will be in high demand only for a limited period of time (while the disease is prevalent)
Demand Characteristics *Economic characteristics of the end market for crops that impact the incentives of various players within seed systems*	• Demand is limited to a specific period of time; after which demand either disappears or becomes stable (moving the seed to the Private-Sector Dominant archetype) • The trait experiences a rapid high spike in demand (demand subsides in the same fashion)	• In time, as the disease subsides, the demand for this variety will either disappear or move to a stable state (moving to the Private –Sector Dominant archetype)

Source: Boettiger, Sara et al. "Planning for Scale Brief #1: Tools for Scaling," Ag Partner Exchange, 2013, Figure 2, page 18; Interviews with crop and country experts

4 In this archetype, few oligopolistic private companies vertically integrate across the value chain, producing EGS and quality seed using a limited number of outgrowers

Private	P/P
Niche	Public

Value Chain Stages	Ideal State Business Model: Key Actors and Roles	*Illustrative Ideal State: Hybrid Sorghum*
Variety Research & Development	• ***Private companies*** lead development of new germplasm that meets market demands in collaboration with ***IARCs*** or ***public breeding programs***	***Private sector*** directs the breeding of new inbred lines to meet requirements for brewing, possibly by providing funding and guidelines to breeders from IARCs, NARS, or universities
Variety Selection & Breeding	• ***Private companies or industry consortia*** select germplasm based on local adaptability and desirability and breed first generation of localized breeder seed	***Private companies*** select best inbred lines for their needs and either breed or fund the breeding of the first generations of localized breeder seed
Breeder Seed Production & Maintenance	• ***Private companies or industry consortia*** maintain parent lines and produce subsequent generations of breeder seed	***Private foundation seed enterprise (FSE)*** maintains inbred parent lines and produces breeder seed for companies on an ongoing basis under exclusive licenses
Foundation Seed Production	• ***Private companies or industry consortia*** produce foundation seed from breeder seed that they either maintain in-house or license from another private entity	***Private foundation seed enterprise (FSE)*** produces and markets foundation seed for distribution to private companies under exclusive licenses
Quality Seed Production	• ***Domestic seed companies*** manage production of certified seed from foundation seed through contractual arrangements with outgrowers	***Private, large domestic companies*** produce quality seed through a narrow network of contract growers and repurchase seed for central processing until throughput is reached
Marketing & Distribution	• ***Domestic seed companies*** enter into contractual arrangements with farmers to purchase seed and other inputs and sell produce back to the company for sale	***Private, large domestic companies*** market seed along with other inputs to farmers under contractual repurchase agreements before ultimately marketing produce to breweries

Legend: Type of actor investing in each value chain stage

Private Sector ***Public Sector*** ***Public-Private*** ***IARC***

Draft

We selected five examples of a country and crop for which to build detailed business models to understand the economics of the value chain, barriers to the ideal state, and potential solutions

The business model examples are intended to illustrate the ideal state of each market archetype based on real crop and country conditions, including key enabling factors and specific recommendations for different actors to overcome barriers in the value chain. The examples illustrate the economics of breeder, foundation, and quality seed production with the intention to serve as an analytical tool to identify barriers to scaling production and delivery of early generation seed.

Examples were chosen based on the following criteria:

- **Alignment with the market archetypes:** Country / crop example reflects the seed characteristics and crop demand that is described in each of the market archetypes (e.g., low multiplication rate, demonstrated demand for seed)
- **Closeness to ideal state business model:** Country / crop example already incorporates several elements of the ideal state business model, even if on a small scale (e.g., private sector involved with foundation seed)
- **Donor priority:** Country / crop example represents an investment priority for BMGF and / or USAID
- **Data availability and quality:** Ability to collect high-quality data*

*Note: Zambia was selected for a market visit due to the relative lack of available secondary data as well as its seed sector's alignment with market archetypes

Private	P/P
Niche	Public

1 Maize in Zambia: High profitability of quality seed production enables backwards integration by private companies into EGS production while still earning a strong return

Breeder Seed – 100 kg		Key Observations and Insights
Variable Cost	$105,584 (13%)	Fixed costs are very high for breeder seed due to capital investment in lab space and equipment as well as salaries for highly skilled breeders and labor, while variable costs are low and are dominated by germplasm royalties paid to research centers
Fixed Cost	$688,774 (87%)	
Total Breeder Seed Cost	$794,358	Breeding and breeder seed production and maintenance are very costly activities that are not profitable on their own, due to the very low volume produced, but companies may find value investing in controlling this part of their value chain

Foundation Seed – 3 MT		
Variable Cost	$21,417 (5%)	Foundation seed has high fixed costs due to the need for skilled labor for hybridization and processing equipment, while variable costs are very low due to low volume and low transport costs due to low bulk and perishability
Fixed Cost	$422,882 (95%)	
Total Foundation Seed Cost	$444,299	Similar to breeder seed, foundation seed costs are high relative to the volume produced and would not be profitable as a standalone enterprise unless very large scale could be achieved

Quality Seed – 1,000 MT		
Variable Cost	$827,285 (67%)	Fixed costs are low for quality seed and consist mainly of equipment, while per-unit variable costs are low due to high multiplication rates and low transport costs (low bulk and perishability), so it can be profitable even at relatively small scale
Fixed Cost	$413,642 (33%)	
Total Quality Seed Cost	$1,240,927	Total costs for quality seed production are high due to large volume, so it is produced by large companies with access to credit or by contract growers to whom the company extends credit

Total Quality Seed Revenue	$3,500,000	At a price of $3,500/MT, quality seed sales are profitable enough that private companies can vertically integrate into the upstream stages of the value chain that are not profitable as standalone businesses and still earn an acceptable return
Total Cost of Production	$2,479,584	
Total Profit	$1,020,416	
Profit Margin (%)	29%	

Despite the high costs for human and physical capital required for early generation seed, quality hybrid maize seed is profitable enough that the entire value chain can be profitable for a vertically integrated company to manage end-to-end, as domestic companies like Zamseed and MNCs like Syngenta do now

Notes:
(1) Costs represent one variety since producing several varieties is only marginally more costly. Additional costs that may be incurred would come out in management, labor, and land costs.
(2) Costs represent a typical seed producer's cost to produce seed of market-standard quality at the time it is demanded, though this could pose a greater challenge for some producers versus others
(3) Additional key assumptions and detailed costs are in the appendix

2a Sweet Potato in Tanzania: Foundation and quality seed production can be profitable if demand is stable and predictable

Private	P/P
Niche	Public

Breeder Seed		Key Observations and Insights
Variable Cost	$1,800 (16%)	Fixed labor is the largest cost driver for breeder seed
Fixed Cost	$9,750 (84%)	
Total Breeder Seed Cost	$11,550	
Total Profit	($11,550)	Breeder seed production is expensive due to the technical labor and training needed. Currently no revenue is collected for breeder seed, making this stage of the value chain largely unprofitable, though the value chain could support the cost of breeder seed inputs
Profit Margin (%)	N/A	

Foundation Seed – 50 acres		
Variable Cost	$3,350 (20%)	Labor and training are the largest cost drivers for foundation seed production, but limited input costs (and no cost for breeder seed inputs) keep this stage profitable
Fixed Cost	$13,150 (80%)	
Total Foundation Seed Cost	$16,500	
Total Profit	$17,340	High disease and perishability could affect sales of foundation seed
Profit Margin (%)	51%	

Quality Seed – 1000 acres		
Variable Cost	$169,110 (69%)	Labor and irrigation equipment are the largest costs of quality seed production, though low land costs keep the value chain profitable if demand is sustainable
Fixed Cost	$75,000 (31%)	
Total Quality Seed Cost	$244,110	
Total Quality Seed Revenue	$507,600	
Total Profit	$263,490	High perishability and unstable demand add risk to an otherwise profitable value chain
Profit Margin (%)	52%	

The sweet potato value chain can be profitable, however, unstable demand and high susceptibility to disease and perishability add risk to the value chain

Notes:
(1) Costs represent one variety since producing several varieties is only marginally more costly. Additional costs that may be incurred would come out in management, labor, and land costs.
(2) Costs represent a typical seed producer's cost to produce seed of market-standard quality at the time it is demanded, though this could pose a greater challenge for some producers versus others
(3) Additional key assumptions and detailed costs are in the appendix

2a Rice in Nigeria: Given the high seeding and multiplication rates, rice production is sustainable if demand is stable and guaranteed

Private	P/P
Niche	Public

Breeder Seed – 0.2 MT		Key Observations and Insights
Variable Cost (1%)	$355 (1%)	Fixed labor is the largest cost driver for breeder seed
Fixed Cost (99%)	$62,040 (99%)	
Total Breeder Seed Cost	$62,395	
Total Profit	($54,190)	Breeder seed production is expensive because of the technical labor and training needed. Due to limited output of breeder seed, production needs to be publically supported
Profit Margin (%)	-661%	

Foundation Seed – 12.5 MT		
Variable Cost (30%)	$8,510 (30%)	Labor and planting equipment are the largest cost drivers for foundation seed production, but high seeding and multiplication rates keep this stage profitable
Fixed Cost (70%)	$19,735 (70%)	
Total Foundation Seed Cost	$28,245	
Total Profit	$505	While 2% profitability is not high enough to sustain a private business, a quality seed producer could vertically integrate profitably and manage this stage in the value chain. Public support for breeder seed inputs could also be used to make foundation seed production more profitable
Profit Margin (%)	2%	

Quality Seed – 1,000 MT		
Variable Cost (58%)	$457,800 (58%)	Consistent with the earlier pieces of the value chain, labor and planting / irrigation equipment are the largest cost drivers in production
Fixed Cost (42%)	$326,250 (42%)	
Total Quality Seed Cost	$784,050	
Total Profit	$435,950	High multiplication and seeding rates make rice production sustainably profitable if demand is high enough
Profit Margin (%)	36%	

Due to high multiplication and seeding rates, quality seed production is profitable if demand is guaranteed and stable, though low volume of breeder seed demanded necessitates public support for sustainability

Notes:
(1) Costs represent one variety since producing several varieties is only marginally more costly. Additional costs that may be incurred would come out in management, labor, and land costs.
(2) Costs represent a typical seed producer's cost to produce seed of market-standard quality at the time it is demanded, though this could pose a greater challenge for some producers versus others
(3) Additional key assumptions and detailed costs are in the appendix

2b Cowpea in Ghana: Given the demand for quality cowpea, quality seed production can be privately produced with public support for breeder and foundation seed production

Private	P/P
Niche	Public

Breeder Seed – 0.6MT		Key Observations and Insights
Variable Cost (23%)	$63,325 (23%)	Breeding efficiency is very low, takes 5-7 years to release a new variety, delaying any potential revenue and introducing risk *(numbers reflect one year of breeder activity, with two full-time breeders)*
Fixed Cost (77%)	$211,425 (77%)	
Total Breeder Seed Cost	$274,750	Because breeder seed production requires highly-skilled labor and technology with relatively low revenue, and takes many years develop a new variety, the public sector needs to support this stage of the value chain
Total Profit	($272,878)	Breeder seed is high cost with very small returns due to low multiplications rates and low volume of breeder seed demanded. While this is an extremely important step in the value chain, it will need to be publically supported to be sustainable
Profit Margin (%)	-14,554%	

Foundation Seed – 25MT		
Variable Cost (22%)	$16,450 (22%)	Salaries and land remain the highest fixed costs for foundation seed production, as breeders must allocate time to oversee the process for quality purposes; breeder seed inputs and processing and storage of foundation seed are the highest variable costs
Fixed Cost (78%)	$60,000 (78%)	
Total Foundation Seed Cost	$76,450	Although the private sector can produce foundation seed most efficiently, the public sector needs to provide support to producers to ensure profitability potentially by providing subsidized breeder seed inputs
Total Profit	($1,450)	At this scale, foundation seed production is close to break-even (or slightly profitable with breeder seed inputs subsidized), however, at current Ghana production of 70MT, foundation seed production is extremely unprofitable, similar to breeder seed production. Until scale is reached, foundation seed production will need to be publically supported
Profit Margin (%)	-2%	

Quality Seed – 1,000 MT		
Variable Cost (71%)	$800,000 (71%)	Fixed costs are limited to labor costs for quality seed production and variable costs increase with the additional need for land, distribution, and processing
Fixed Cost (29%)	$323,000 (29%)	
Total Quality Seed Cost	$1,123,000	Given the volume of demand and prices of quality cowpea, quality seed production is an economically viable model without public support
Total Quality Seed Revenue	$2,000,000	With quality seed selling at ~$2,000 per MT, quality seed production is a profitable enterprise
Total Profit	$877,125	Quality seed can be largely profitable once seed scale is achieved through breeder and foundation seed multiplication. At scale, there is an opportunity for quality seed producers to vertically integrate and support foundation seed production without significant damage to profitability
Profit Margin (%)	44%	

Given the complexity, cost, and time needed to produce cowpea breeder seed, the public sector should provide targeted support for breeder seed production. Foundation seed will also need public support until scale is reached and the private quality seed producers can vertically integrate.

Notes:
(1) Costs represent one variety since producing several varieties is only marginally more costly. Additional costs that may be incurred would come out in management, labor, and land costs.
(2) Costs represent a typical seed producer's cost to produce seed of market-standard quality at the time it is demanded, though this could pose a greater challenge for some producers versus others
(3) Additional key assumptions and detailed costs are in the appendix

Private	P/P
Niche	**Public**

3 Sorghum in Ethiopia: Sorghum seed is generally given to farmers for free now, meaning the govt. supports the value chain fully at significant cost, mainly for personnel salaries

Breeder Seed – 25kg		Key Observations and Insights
Variable Cost	$4,462 (4%)	Variable costs are very small as the land area, land prep, and inputs required to produce this much breeder seed is small due to the high multiplication rate of sorghum, but fixed costs are very high for breeding staff, equipment, facilities, etc.
Fixed Cost	$101,800 (96%)	
Total Breeder Seed Cost	$106,262	Breeder seed is very expensive to produce on a per-unit basis, and is unlikely to be profitable at any scale as a standalone business; this is even more pronounced in a market where demand for sorghum seed is extremely low like Ethiopia

Foundation Seed – 3MT		
Variable Cost	$3,203 (3%)	Foundation seed also requires high fixed costs for breeders to allocate time to overseeing the process and for overhead for facilities, staff, etc., but variable costs are moderate due to skilled labor requirement being offset by low input requirement
Fixed Cost	$51,800 (97%)	
Total Foundation Seed Cost	$55,003	Foundation seed is relatively inexpensive to produce versus some other crops (e.g., hybrid maize) due to lower labor requirement, but would require significant scale to approach commercial viability

Quality Seed – 1,000 MT		
Variable Cost	$172,667 (77%)	Fixed costs are low for quality seed as it can be grown by contract growers with little overhead; variable costs are high due to high volume despite low per-unit costs, due to sorghum's high multiplication rate, low bulk, and low input requirements
Fixed Cost	$51,800 (23%)	
Total Quality Seed Cost	$224,467	Quality seed production makes up the bulk of the cost of seed production for the government, due to the higher land requirement and attendant costs such as planting, harvesting, field preparation, and some inputs

Total Quality Seed Revenue	$220,000	Sorghum is fully publicly supported, with farmers receiving a discount off of the already-subsidized prices of $0.45-$0.65/kg, and this results in significant cost to the government to safeguard food security; this will be have a significant effect on public funds as Ethiopia tries to scale up to ~12,000 MT by 2020
Total Cost of Production	$385,732	
Total Profit	-$165,732	
Profit Margin (%)	-75%	

Quality sorghum seed is not profitable as a standalone enterprise without substantial subsidy, regardless of the price of foundation seed, due to the very low prices it can command from farmers; we estimate prices are currently discounted ~60% from the break-even price

Notes:
(1) Costs represent one variety since producing several varieties is only marginally more costly. Additional costs that may be incurred would come out in management, labor, and land costs.
(2) Costs represent a typical seed producer's cost to produce seed of market-standard quality at the time it is demanded, though this could pose a greater challenge for some producers versus others
(3) Additional key assumptions and detailed costs are in the appendix

Summary of Recommendations to Donors and Governments

Based on the examples described in the previous section of this report, we identified the challenges to public and private actors in the seed sector that constrain scale. We also provided recommendations for potential interventions that could overcome these bottlenecks for the specific country crop examples. These challenges and associated solutions generally fall into two categories:

- **Inherent Economic Constraints of a Market Archetype:** The first type of constraint is unique to a market archetype and arises from the characteristics of seed and the demand for crops the seed produces. For example, the uncertainty around demand in Market Archetype 2a necessitates support for the demand-side of production. In contrast, the high fixed costs of producing breeder and foundation seed for crops in Market Archetype 2b require government or donor support for the supply-side of production in order for the value chain to be sustainable.

- **Constraints Imposed by the Enabling Environment:** The second type of constraint may cut across several market archetypes and arises from the enabling environment in a specific country context. For example, an inefficient regulatory regime or restrictive policy that limits pluralism in the market. Until these structural barriers are overcome, it will be difficult for any seed sector to scale in that country, regardless of the market archetype.

- The dividing line between these categories is not always perfectly clean, and certain enabling factors are more important for certain archetypes than others. For example, access to financing may be more important in a market with a stronger private sector, while adjusting public research incentive structures is more important when the public sector takes a larger role in breeding.

The following recommendations illustrate options available to governments, donors, and other stakeholders for addressing specific market barriers. These recommendations assume that under the specified conditions, the entities producing the seed could meet market requirements for quality and timing, though we recognize this is a significant challenge that may present a greater obstacle for some seed producers or in some geographies than in others.

Specific recommendations based on the economic constraints of Market Archetypes are laid out on slide 77. Recommendations for different areas of the enabling environment are laid out on slides 78 and 79.

Recommendations to overcome specific Market Archetype economic constraints to scale

Private Sector Dominant	Public-Private Collaboration
Niche Private Sector	Public Sector Dominant

1 *Market Archetype 1: Remove Market Distortions*

Support and advocate for policies that enable private sector to grow sustainably

Potential Role of Government:
- Remove distortionary subsidies and restrictions where possible (e.g. public crop marketing, state-owned monopolies)
- Incentivize private sector efficiency (e.g. tendered subsidies)

Potential Role of Donors:
- Demonstrate profit potential of the market through business cases
- Alleviate high fixed cost of breeders through capacity building
- Build capacity in banking sector to increase financing availability

2a *Market Archetype 2a: Mitigate Demand Risk*

Support stable and predictable demand and linkages between producers and markets

Potential Role of Government:
- Share demand risk with the private sector by backing financing and entering into surplus purchase arrangements
- Invest in extension services to increase demand in rural markets

Potential Role of Donors:
- Improve availability and accessibility of data to enable more accurate demand forecasting and planning of production
- Demonstrate private sector potential with business cases

2b *Market Archetype 2b: Subsidize Production Costs*

Support breeder and foundation seed production by mitigating high fixed costs

Potential Role of Government:
- Directly subsidize fixed costs (e.g. breeders, certification) or back financing for capital investments, e.g. in technology
- Partly or fully fund production of breeder and foundation seed on an ongoing and stable basis (e.g., CGIAR, NARS)

Potential Role of Donors:
- Alleviate fixed costs by funding R&D and breeder training
- Ensure ROI on research by advocating for IP protections and linking breeding more closely to farmers' and market demand

3 *Market Archetype 3: Drive Public Sector Efficiency*

Support efficiency of public entities through capacity building and organizational linkages

Potential Role of Government:
- Increase responsiveness of public breeding and production efforts by increasing farmer participation
- Implement more efficient QA processes to ensure more effective use of public resources (e.g. accreditation)

Potential Role of Donors:
- Build decentralized capacity throughout a country to better leverage public resources and reduce dependence on
- Implement monitoring and evaluation for public programs to understand impact and effectiveness of public investments

Recommendations for Governments and other regulatory / policy organizations to improve the enabling environment

Funding and Incentives

Policy & Regulatory Framework

Role: Enact and implement policies that allow for pluralistic approaches to seed production, whether fully private, public-private partnership, or public investment
Applicable Market Archetype: All
Rationale: Restrictions on actors involved in production limits potential investment and may cause inefficiency

Role: Remove export restrictions, work toward quality standards harmonization, and limit distortionary demand subsidies
Applicable Market Archetype: Archetype 1, 2a, 2b
Rationale: Removing limitations on exports and minimizing government purchase of seed minimizes price distortions in the market, which may negatively impact private seed companies

Market Linkages & Data Availability

Role: Tie breeder incentives (e.g. promotion) to adoption of varieties, not simply to publications
Applicable Market Archetype: Archetypes 2a, 2b, 3
Rationale: Provides incentive for breeders to take end-user preferences into account when producing new varieties, improving the changes of higher adoption

Sufficient Demand

Role: Fully support breeder seed production and subsidize foundation seed inputs, link subsidy eligibility to productivity gains
Applicable Market Archetype: Archetypes 2b, 3
Rationale: Ensures foundation seed production is financial viable, while also holding beneficiaries of the subsidy accountable for productivity gains

Role: Guarantee consistent demand through purchase of surplus or voucher provision
Applicable Market Archetype: Archetype 2a
Rationale: Lower the risk of production by guaranteeing a minimum demand be met for key food security crops

Strengthening Capabilities

Technical & Management Capabilities

Role: Require mentorship program between senior and junior researchers to build technical capacity, empower junior practitioners, and ensure continuity
Applicable Market Archetype: Archetypes 2a, 2b, 3
Rationale: Given high cost of training and aging workforce, efforts are needed to ensure new talent is prepared to meet production demand

Role: Incentivize seed companies to train farmers in the proper use of their seed, associated agronomic practices, etc.
Applicable Market Archetype: Archetype 1, 2b
Rationale: Increase proper use of improved seeds by smallholder farmers to ensure long-term adoption of improved varieties and increased productivity

Reliable Quality Assurance Mechanism

Role: Implement sustainable QA process, e.g. licensed inspectors with annual technical refreshers, and explore intermediate policies for variety release and certification, such as quality declared seed (QDS)
Applicable Market Archetype: All
Rationale: Quality assurance is needed to establish trust in the formal seed market to encourage adoption of improved varieties

Access to Capital and Financing

Role: Channel existing government and donor financing programs to create sustainable mechanisms for financing of seed, including public loan guarantees and portfolio requirements, microfinance support, and a legal framework for public-private partnerships
Example Business Model Market: 1, 2a, 2b
Rationale: Affordable and stable financing is essential to private investment in seed production

Improving Value Chain Linkages

Sufficient Land & Infrastructure

Role: Continue national investment in improving infrastructure with potential subsidies (e.g. tax exemption) for private companies to develop infrastructure, e.g. irrigation, storage, isolation
Applicable Market Archetype: All
Rationale: Proper infrastructure and breeding/growing facilities and isolation are needed for quality varieties to be produced and multiplied

Role: Incent research institutes or companies to move processing functions to geographic locations that are underserved, potentially in a public-private partnership
Applicable Market Archetype: Archetype 3
Rationale: A more dispersed processing infrastructure will lower transportation costs to a centralized location and encourage distribution to more rural regional smallholder farmers for great adoption of improved varieties and increased productivity

Sufficient Demand

Role: Implement participatory breeding programs at regional research institutions and formalize feedback mechanism to national breeder institutions
Applicable Market Archetype: Archetypes 2a, 2b, 3
Rationale: Increase adoption of improved varieties by better matching supply with demand to ensure that varieties being produced meet unique regional needs

Recommendations to donors and NGOs to improve the enabling environment

Facilitating Stakeholder Engagement

Policy & Regulatory Framework

Role: Fund and facilitate convenings to engage legislators and stakeholders in passing IP protections
Applicable Market Archetype: Archetype 1, 2a, 2b,
Rationale: IP rights are critical for private company investment in EGS production; facilitating the legislative discussion among policy makers will help expedite the enactment of this legislation

Role: Develop business case studies as proof-of-concept for private seed companies investment in foundation and quality seed production, or govt. prioritization of a crop
Applicable Market Archetype: All
Rationale: Demonstrate profitability and feasibility to encourage private investment

Sufficient Land & Infrastructure

Role: Analysis of optimal structure for private processing facilities to help governments create incentive structures that encourage more rural distribution
Applicable Market Archetype: All
Rationale: Transportation of EGS seed to centralized processing facilities is costly due to dispersed growing plots; decentralized processing facilities would decrease initial transport costs and allow quality seed to be transported to more rural areas throughout regions

Sufficient Demand

Role: Help the government demonstrate to farmers the benefits of higher-value commercial uses of the end crop to increase price premium and margins (e.g., demonstration plots, field days, etc.)
Applicable Market Archetype: All
Rationale: Educating the market on commercial uses for crops can increase demand and profitability of seed production, especially in cases where companies are reluctant to invest in the sector due to demand risk

Strengthening Capabilities

Technical & Management Capabilities

Role: Fund start-up costs and program development for operational data collection and bookkeeping training
Applicable Market Archetype: All
Rationale: Limited knowledge in booking and data collection make efficiency and profitability at each stage of the value chain difficult to analyze and limits the ability for private and public actors to make informed investment decisions

Role: International ag. education exchange programs, fellowships, and mentorship between researchers
Applicable Market Archetype: All
Rationale: The cost of breeders and lack of capacity is prohibitive to breeder seed development and accounts for nearly all of the fixed costs at this stage of the value chain; increased access and affordability of technical knowledge will help alleviate this barrier

Reliable Quality Assurance Mechanism

Role: Help build sustainable quality assurance process by providing training for the development of a certification, accreditation, licensing of field inspectors, or truth-in-labeling program
Applicable Market Archetype: All
Rationale: Quality assurance is needed to establish trust in the formal seed market to encourage adoption of improved varieties

Sufficient Demand

Role: Deepen trend analysis capabilities for demand forecasting for breeding through training programs and analytics education
Applicable Market Archetype: 2a, 2b, 3
Rationale: Allow private market players to better understand and predict demand for more stable market investment

Improving Value Chain Linkages

Market Linkages & Data Availability

Role: Develop business case to demonstrate and evaluate profit potential of widening distribution network(i.e., agents and agro-dealers)
Applicable Market Archetype: Archetype 1, 2a, 2b
Rationale: Building a business case for increased distribution of quality seed will encourage private companies to sell to rural smallholder farmers, increasing the adoption of quality seed and the growth of private companies

Role: Test innovative solution prototypes for increasing profitability of dispersed distribution, e.g. mobile-based seed ordering to aid in distribution planning
Applicable Market Archetype: All
Rationale: Proving the effectiveness of innovative programs to reach small scale farmers and providing a business case for reaching these consumers could encourage private companies to sell to rural smallholder farmers, increasing the adoption of quality seed and the growth of private companies

Role: Aggregation service for market data on demand, prices, etc.
Applicable Market Archetype: All
Rationale: Limited data quality and availability limits the ability for private and public actors to make informed investment decisions

Access to Capital and Financing

Role: Explore options for banks or govt. to gain experience in the ag. sector and offer sustainable lending to companies and smallholder farmers, e.g. loan guarantees, portfolio requirements, microfinancing
Applicable Market Archetype: All
Rationale: Affordable and stable financing is essential to private investment in seed production