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EARLY GENERATION SEED STUDIES SYNTHESIS REPORT

RWANDA – ZAMBIA – KENYA – NIGERIA

October 2016

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RWANDA – ZAMBIA – KENYA – NIGERIA

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The United States Agency for International Development (USAID) Bureau for Food Security (BFS) Early Generation Seeds (EGS) program, acting through Development Alternatives, Inc.'s (DAI) Africa Lead II project, has utilized USAID Mission, BFS, and Bill & Melinda Gates Foundation (BMGF) partnerships to study EGS systems in Africa. Many projects fail to reach the great majority of smallholder farmers in Sub-Saharan Africa (SSA), particularly in the delivery of EGS. Other bottlenecks include poorly functioning national variety release systems; policies, regulations, and misplaced subsidies that limit access to improved varieties; and counterfeit seeds in seed markets.

The overall EGS effort, which began in 2014 and will continue through 2017, is carried out in a complex, dynamic environment involving the USAID and BMGF partnership, several international and bilateral donors, as many as 12 African governments, several African regional organizations, and a plethora of public and private stakeholders. Over the past two years, the USAID and BMGF partnership has explored, with a large number of noted US, African, and international technical experts, how to address constraints in EGS systems. This exploration led to the partnership's development of a methodology to analyze seed value chains, and to do this by specific market, crop, and economic dimensions. Applying this methodology leads to identifying actors and actions along the seed value chain that are required in order to produce an adequate supply of EGS on a sustainable basis. The methodology was vetted by technical experts from African regional organizations, research and technical agencies, and development partners.

USAID asked DAI through its Africa Lead Cooperative Agreement II to take this analytical methodology to the country level in selected Feed the Future countries, particularly in ways to change seed systems as they affect smallholders in the informal agriculture sectors. Africa Lead II selected and contracted with Context Network to execute EGS studies in Rwanda, Zambia, Kenya, and Nigeria, which were completed by August 2016, as well as a one-day EGS technical training in Addis Ababa, Ethiopia, on how to implement the study methodology, with researchers from 11 countries.

In addition to the four EGS country studies, the Context Network, with Africa Lead II's guidance, was selected to complete three other deliverables which include (1) a synthesis of the Rwanda, Zambia, Kenya, and Nigeria studies, (2) a technical review of the 10 EGS country studies performed in 2016, and (3) an EGS investment plan guide for country seed platforms with tools to transform the findings of the EGS studies into investment plans.

This Synthesis Report aims to carry the analyses of the EGS studies several steps further: presenting succinct statements on each country's agricultural landscape and the crops selected for study and analysis; drawing out lessons learned; and identifying key recommendations on both a national and four-country basis. In addition, the policy recommendations for increasing the supply of EGS and augmenting demand for it are set apart.

ACKNOWLEDGMENTS

This report was developed by a team at the Context Network led by Mark Nelson, a principal at the Context Network. The team included Mark Walton, who conducted the stakeholder consultations and led the field research work for the Rwanda EGS Study, and Dave Westphal, who had the same responsibilities for the Zambia EGS Study. These two experts co-led the technical training in Addis Ababa, Ethiopia, for agriculture researchers from 11 countries who would be implementing the same study methodology in their home countries. Finally, the experts provided distance mentoring and technical oversight for the stakeholder consultations and field research activities of the national experts for the Kenya and Nigeria EGS Studies. Robert Lowenthal was the Context Network manager for this four-country Synthesis Report.

The team is grateful for the support of DAI, including David Tardif-Douglin, Charles Johnson, and Sonja Lichtenstein, as well as guidance from BFS Senior Food Policy Advisors David Atwood and Mark Huisenga.

ACRONYMS

AATF	African Agricultural Technology Foundation
ADP	Agricultural Development Program (Nigeria)
AGRA	Alliance for a Green Revolution in Africa
AFR	Access to Finance Rwanda
ATA	Agricultural Transformation Agenda (Nigeria)
BFS	Bureau for Food Security (USAID)
BMGF	Bill & Melinda Gates Foundation
BTC	Belgium Technology Corporation
CAADP	Comprehensive African Agricultural Development Program
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
COMESA	Common Market for Eastern and Southern Africa
DAI	Development Alternatives, Inc.
DRC	Democratic Republic of Congo
EAC	East African Community
ECOWAS	Economic Community of Western States
EGS	Early Generation Seed
EGS-PPP	Early Generation Seed Public-Private Partnership
FAO	Food and Agriculture Organization of the United Nations
FGN	Federal Government of Nigeria
FISP	Farmer Input Support Program (Zambia)
FMARD	Federal Ministry of Agricultural and Rural Development (Nigeria)
FFS	Farmer Field School
FTF	Feed the Future
GDP	Gross Domestic Product
GoK	Government of Kenya
GoR	Government of Rwanda
IAR&T	Institute for Agricultural Research & Training (Nigeria)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ISSD	Integrated Seed Sector Development
KARI	Kenya Agricultural Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KSC	Kenya Seed Company
KSU	KALRO Seed Unit
KEPHIS	Kenya Plant Health Inspectorate Service
MAL	Ministry of Agriculture and Livestock (Zambia)

MARKETS II	Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites
MFI	Microfinance Institution
MINAGRI	Ministry of Agriculture (Rwanda)
NARI	National Agricultural Research Institute
NASC	National Agricultural Seeds Council (Zambia)
NCRI	National Cereals Research Institute (Nigeria)
NGO	Non-Governmental Organization
NRCRI	National Root Crops Research Institute (Nigeria)
OPV	Open Pollinated Variety
PPP	Public-Private Partnership
QDS	Quality Declared Seed
RAB	Rwanda Agriculture Board
RDB	Rwanda Development Board
SACCO	Savings and Credit Cooperative Society
SCCI	Seed Control and Certification Institute (Zambia)
SSA	Sub-Saharan Africa
TIB	Temporary Immersion Bioreactor
USAID	United States Agency for International Development
WEMA	Water Efficient Maize for Africa
YIIFSWA	Yam Improvement for Income and Food Security in West Africa
ZARI	Zambia Agriculture Research Institute

TERMINOLOGY

Breeder seed: Breeder seed is produced by or under the direction of the plant breeder who selected the variety. During breeder seed production, the breeder or an official representative of the breeder selects individual plants to harvest, based on the phenotype of the plants. Breeder seed is produced under the highest level of genetic control to ensure the seed is genetically pure and accurately represents the variety characteristics identified by the breeder during variety selection.

Pre-basic seed: Pre-basic seed is a step of seed multiplication between breeder and foundation seed that is used to produce sufficient quantities of seed for foundation seed production. It is the responsibility of the breeder to produce pre-basic seed, and production should occur under very high levels of genetic control.

Foundation seed: Foundation seed is the descendent of breeder or pre-basic seed and is produced under conditions that ensure maintaining genetic purity and identity. When foundation seed is produced by an individual or organization other than the plant breeder, there must be a detailed and accurate description of the variety the foundation seed producer can use as a guide for eliminating impurities ("off types") during production.

Certified seed: Certified seed is the descendent of breeder, pre-basic, or foundation seed produced under conditions that ensure maintaining genetic purity and identity of the variety and that meet certain minimum standards for purity defined by law and certified by the designated seed certification agency.

Quality Declared Seed: In 1993 the Food and Agriculture Organization of the United Nations (FAO) produced and published specific crop guidelines as Plant Production and Protection Paper No. 117 Quality Declared Seed – Technical guidelines on standards and procedures. The Quality Declared Seed (QDS) system is a seed-producer implemented system for the production of seed that meets at least a minimum standard of quality but does not entail a formal inspection by the official seed certification system. The intent behind the QDS system is to provide farmers with an assurance of seed quality while reducing the burden on government agencies responsible for seed certification. The QDS system is considered by FAO to be part of the informal seed system.

Quality seed: In this report, the phrase quality seed is at times used in place of certified seed or QDS to describe a quality-assured seed source without specifying certified or QDS.

Commercial seed: Any class of seed acquired through purchase and used to plant farmers' fields.

Formal seed system: The formal seed system is a deliberately constructed system that involves a chain of activities leading to genetically improved products: certified seed of verified varieties. The chain starts with a plant breeding or variety development program that includes a formal release and maintenance system. Guiding principles in the formal system are to maintain varietal identity and purity and to produce seed of optimal physical, physiological, and sanitary quality. Certified seed marketing and distribution take place through a limited number of officially

recognized seed outlets, usually for cash sale. The central premise of the formal system is that there is a clear distinction between "seed" and "grain." This distinction is less clear in the informal system.

Informal seed system: The informal system, also referred to as a local seed system, is based on farmer-saved seed or QDS. Varieties in the informal system may be variants of improved varieties originally sourced from the formal system, or they may be landrace varieties developed over time through farmer selection. There is less emphasis on variety identity, genetic purity, or quality seed. The same general steps or processes take place in the informal system as in the formal system (variety choice, variety testing, introduction, seed multiplication, selection, dissemination, and storage), but they take place as integral parts of farmers' production systems rather than as discrete activities. While some farmers treat "seed" as special, there is not always a distinction between "seed" and "grain." The steps do not flow in a linear sequence and are not always monitored or controlled by government policies and regulations. Rather, they are guided by local technical knowledge and standards and by local social structures and norms.

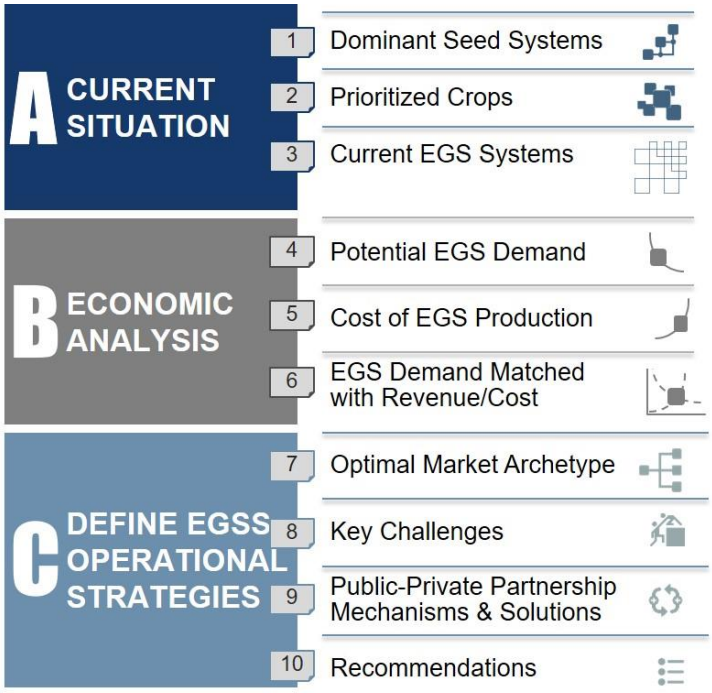
Improved versus landrace and local varieties: Improved varieties are the product of formal breeding programs that have gone through testing and a formal release process. A landrace is a local variety of a domesticated plant species which has developed over time largely through adaptation to the natural and cultural environment in which it is found. It differs from an improved variety which has been selectively bred to conform to a particular standard of characteristics.

METHODOLOGY

EGS COUNTRY STUDY METHODOLOGY

Building on previous studies and consultations with governments, private sector organizations, and partners, the USAID and BMGF partnership developed, tested, and widely vetted a methodology to identify country-specific and crop-specific options to overcome constraints in EGS supply (USAID and BMGF Early Generation Seed Study, 2015). As illustrated in Figure 1, this methodology includes ten steps to define EGS systems, perform economic analysis, and develop EGS operational strategies.

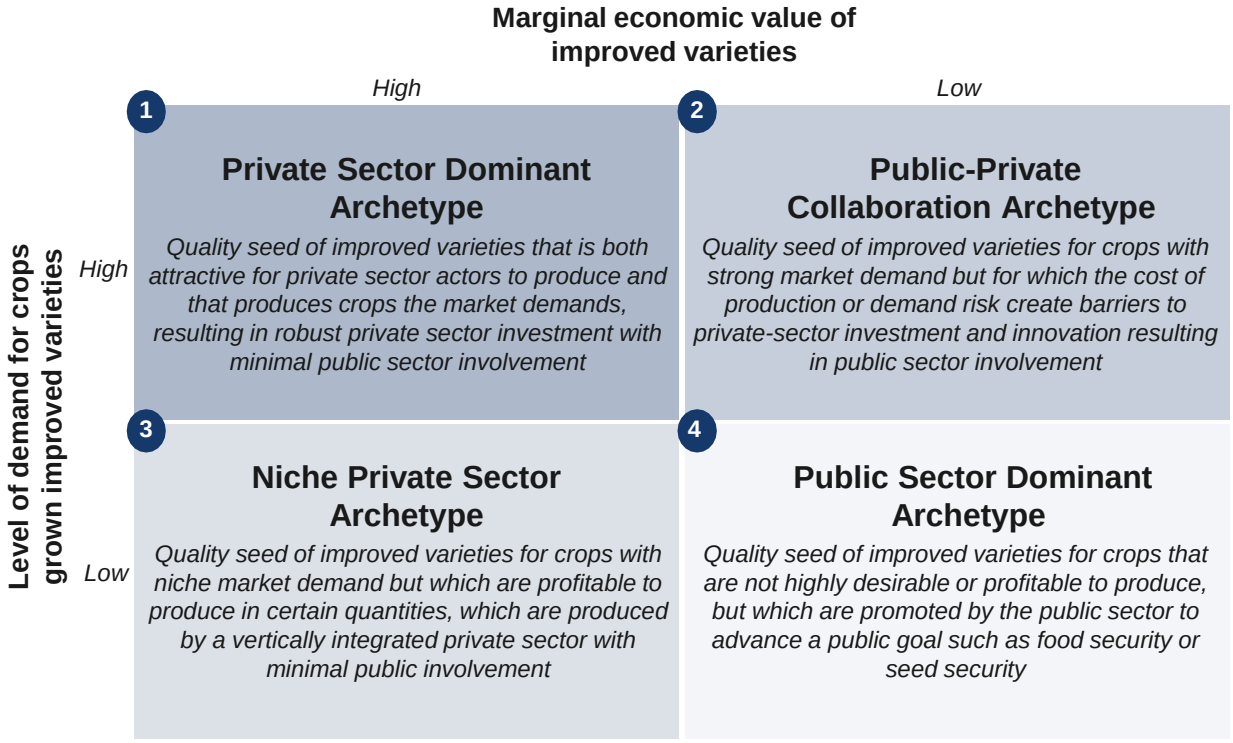
Figure 1: **EGS system ten-step process.**



Source: Ten steps based on a process developed by BMGF and USAID, under a grant from Africa Lead II to Monitor – Deloitte (2015).

The first six steps of this ten-step process were used to analyze specific crops within a given country in order to inform step seven, development of the optimal market archetype. The study commissioned by the USAID and BMFG partnership utilized a common economic framework to define public and private goods and applied it to EGS systems, as shown in Figure 2. Once the optimal market archetype for each crop was developed, steps eight through ten identified the key challenges to achieving the optimal market archetype, possible public-private partnership (PPP) mechanisms and solutions, and final recommendations.

Figure 2: **Market archetype framework.**



Source: Framework developed by the USAID and BMGF Partnership in an EGS Study under a grant from Africa Lead II to Monitor Deloitte (2015).

This framework categorizes EGS systems of crops and crop segments within a specific country, based on the marginal economic value of improved varieties and the demand for crops grown with quality seed of improved varieties.

INTRODUCTION

SYNTHESIS REPORT OBJECTIVES

This Synthesis Report has been developed utilizing the analysis and findings from four EGS country studies conducted by Context Network in 2016: Rwanda, Zambia, Kenya, and Nigeria.

The purpose of this report is to present the "landscape findings" from the four EGS country studies, identifying common themes and differences. By "landscape" we mean to compare and contrast the findings from the ten-step analysis in each country. The report then identifies the crop value chain variables and factors that account for the differences and similarities in the study findings. The report concludes with the presentation of lessons learned from the four EGS country studies, followed by policy recommendations, both country and cross-country in Chapter 5.

While the country studies are referenced throughout this report, this synthesis is not intended to be a consolidation of the four EGS country studies with the same depth of data as the individual reports. Instead, this Synthesis Report aims to carry the analyses of the EGS studies several steps further: presenting succinct statements on each country's agricultural landscape and the crops selected for study and analysis; drawing out lessons learned and identifying key recommendations on both a national and four-country basis. Together, the four-country Synthesis Report and the separate Technical Review of all 10 EGS country studies undergird the EGS Investment Plan Guide, the final report. It aims to assist country "seed platforms" grappling with improving EGS supply and augmenting demand, for the benefit of smallholder farmers.[1]

SCOPE

Each of the four EGS country studies that underpin this report focused on specific crops that were selected during a consultative process with seed platform stakeholders from the public and private sectors as well as civil society actors in the respective countries. While there is overlap among the country studies with common crops selected, no one crop was selected in all four countries, and a few crops were selected in only one country. Table 1 lists the crops studied for each country.

[1] The term "seed platform stakeholders" refers to public (government, NARs, regulatory), private (seed companies, processors, agro-dealers, traders, cooperatives, business associations), donors (CGIARs, international and bi-lateral), and civil society (NGOs, the media) actors.

Table 1: **Matrix of countries and crops included in the Synthesis Report.**

		Rwanda	Zambia	Kenya	Nigeria
Legumes	Common Bean	✓	✓	✓	
	Groundnut		✓		
	Soybean				✓
Grains	Maize	✓		✓	✓
	Rice				✓
Roots and Tubers	Irish Potato	✓		✓	
	Yam				✓

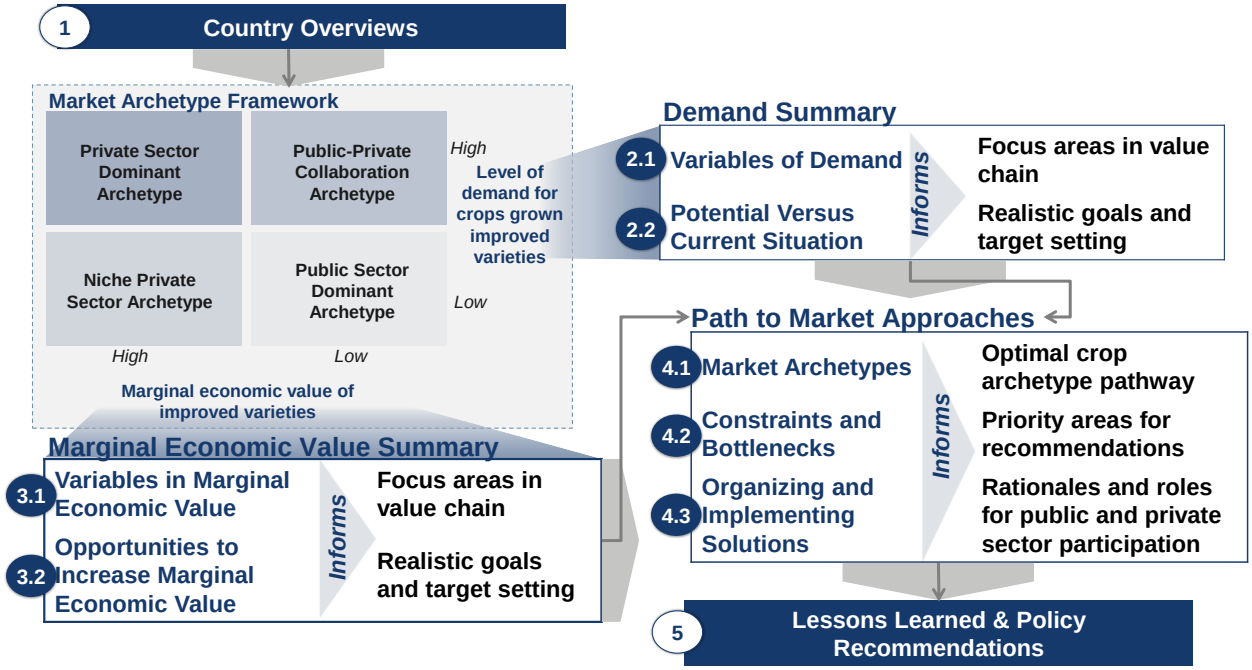
✓ **Crop selected in at least two EGS Country Studies**

Source: USAID Rwanda, Zambia, Kenya, and Nigeria EGS Country Studies, prepared by Context Network for Africa Lead, (2016).

STRUCTURE OF THE SYNTHESIS REPORT

This Synthesis Report is organized into five chapters, as outlined in Figure 3. The EGS country study methodology is rooted in an analysis that determines the crop market archetypes, which then inform the recommendations and PPPs, if applicable. Thus, at the core of the ten-step approach is the market archetype framework, and specifically the level of demand and marginal economic value of improved varieties, which are at the center of the synthesis methodology.

***Figure 3*: Synthesis Report outline.**



Source: Team analysis.

Chapter 1 summarizes data from the four EGS country studies focusing on key agricultural indicators, including agricultural GDP, important crops and growing regions, and farmer types, including gender role differentiation. Chapter 1.5 describes the dominant seed systems in each country, including the types of varieties, quality assurance systems, and seed distribution systems. Chapter 1 concludes with a summary of the process for selecting the focus crops in each country.

Chapter 2 synthesizes the elements of demand for each crop analyzed, identifying common themes. Chapter 2.1 compares and contrasts the variables of demand for the crops analyzed, looking at the crop value chains extended beyond the EGS supply chain. Understanding the variables of EGS demand for a given crop is the first step to ensuring solutions are focused in the right areas of the value chain. Chapter 2.2 analyzes the demand and supply of EGS for each crop. While demand exceeded supply for all crops, comparing the magnitudes of these imbalances and the relative level of maturity of these seed systems is critical to ensuring that future investment plans are grounded in the reality of the current context, with realistic goals and feasible targets.

Chapter 3 focuses on the other component of the market archetype framework which is the marginal economic value of improved varieties, and more specifically, the sources of economic value. Chapter 3.1 compares and contrasts the factors of EGS marginal economic value by crop to help discern the similarities and differences by crop. Chapter 3.2 identifies crop specific opportunities to increase marginal economic value based on the factors analyzed in Chapter 3.1.

Chapter 4 compares and contrasts the path to market for each crop. The EGS demand analysis from Chapter 2 and the marginal economic value analysis from Chapter 3 in each EGS country

study build the foundation for synthesizing the market archetypes of each crop in Chapter 4.1. In Chapter 4.2, the analysis focuses on the differences and similarities of supply bottlenecks and demand constraints across crops to help focus recommendations. Chapter 4.3 addresses stakeholders and how they could be organized into private or public sector led solutions, or PPPs, while also presenting the rationale for the PPP, including similarities or differences depending upon the country and/or the crop market archetype.

In the final Chapter 5, the most important lessons learned are synthesized across all four studies. Policy recommendations are then summarized for each of the four countries in sections 5.2-5.5. Section 5.6 provides a summary of common policy recommendations across all four countries.

Importantly, there are several limitations to this report that need to be explicitly stated. This report is not a comprehensive cross-crop comparison as no crop was analyzed in all four countries. The limited number of inter-country comparisons of individual crops means fewer data points, and as a result, the study authors have weak confidence that findings in this report would hold true for the same crops in other SSA countries. Thus, the application of lessons learned and recommendations from this study should proceed cautiously.

CHAPTER 1: COUNTRY OVERVIEWS – RWANDA, ZAMBIA, KENYA, AND NIGERIA

1.1 COUNTRY OVERVIEWS

Rwanda, Zambia, Kenya, and Nigeria are a diverse set of countries in SSA with respect to land mass, population, economy, and geography. Below is a summary overview of each of the four selected countries.

Figure 4: **Map of the four Synthesis Report countries.**

RWANDA

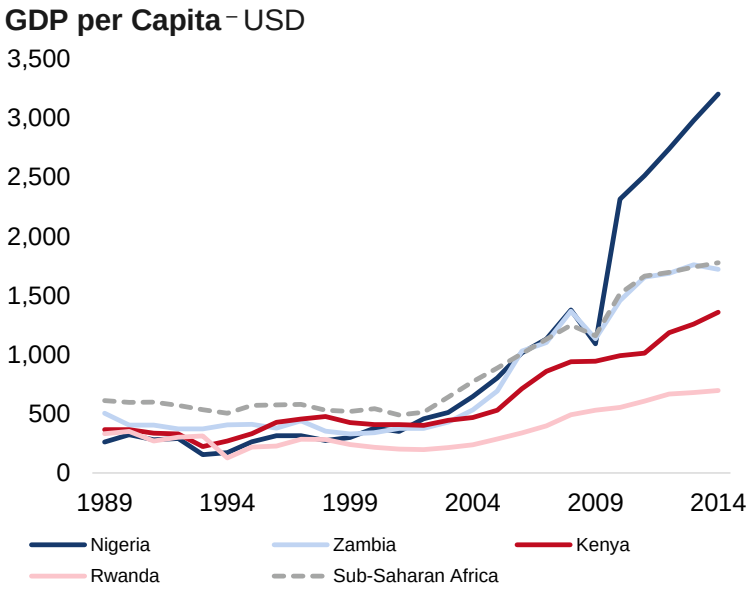
Rwanda is a small landlocked country in eastern Africa sharing boundaries with Uganda to the north, Tanzania to the east, Burundi to the south, and the Democratic Republic of Congo (DRC) to the west. It is among the ten most densely populated countries in the world, of which 52% are women, living in 26,388 square kilometers (National Institute of Statistics of Rwanda, 2012). The demographic growth rate from 2002-2012 was 2.6% and total population in 2015 was estimated at 11.3 million inhabitants (Rwanda Country Stat, 2016). In 2015, Rwanda had a fertility rate of 4.53, which ranks 27th in the world (CIA World Factbook). Rwanda's HIV/AIDS rate in 2014 was 2.8%, ranking 21st in the world (CIA World Factbook).[2]

Rwanda is divided administratively into five provinces and 30 districts. In 2012, 83% of the population was rural (National Institute of Statistics of Rwanda, 2012) despite an increasing trend for the youth (ages 15-24) to migrate to Kigali and provincial towns in search of

[2] The HIV/AIDS rate gives an estimate of the percentage of adults (aged 15-49) living with HIV/AIDS. The adult prevalence rate is calculated by dividing the estimated number of adults living with HIV/AIDS at yearend by the total adult population at yearend.

employment (The East African, 2015). In 2012, real per capita gross domestic product (GDP) was $390, well below the SSA average of $1,522 (World Bank, 2015). Between 2001 and 2014, real GDP growth averaged about 8% per year (World Bank, 2016) as illustrated in Figure 5.

Figure 5: **Per capita GDP of Rwanda, Zambia, Kenya, and Nigeria compared to Sub-Saharan Africa.**



Source: World Bank (2016).

ZAMBIA

Zambia is a landlocked country in southern Africa sharing borders with eight countries, the DRC to the north; Tanzania to the northeast; Malawi to the east; Mozambique, Zimbabwe, Botswana, and Namibia to the south; and Angola to the west. Its 15 million inhabitants live in 753,000 square kilometers (National Agriculture Investment Plan, 2013). Although there are 19 distinct ethnic groups, two groups make up roughly one-third of Zambia's population: Bemba, 21%, and Tonga, 14%.

Zambia is divided into ten provinces, with the largest populations concentrated in the Lusaka, Copperbelt, Eastern, and Southern provinces (Zambia Census, 2010). The country's growth, starting in the 1990s, has been chiefly driven by high global copper prices, as it hosts some of the world's largest copper and cobalt deposits.

Zambia's per capita GDP, which started growing in the late 1990s and has averaged 5-6% during the last decade (as shown in Figure 5), is in line with the Sub-Saharan average. Despite the high GDP growth rate, however, poverty remains high, ranking 150 of 169 in the Human Development Index, according to Zambia's National Agriculture Investment Plan 2014-2018. High fertility rates (5.72 in 2015, ranking 7th in world), a dependence on copper prices, and high AIDS/HIV rates (12.4% in 2014, ranking 7th in the world) continue as persistent and severe development problems (CIA World Factbook).

KENYA

Kenya is a regional hub in Eastern Africa with highlands that are among the most successful agricultural production regions in Africa. The country shares boundaries with Somalia, Ethiopia, and South Sudan to the north, Uganda to the west, and Tanzania to the south. Forty-five million inhabitants live in an area of 580,000 square kilometers, creating a denser population than many other East African countries. In its 2010 constitution, Kenya altered its administrative divisions, decentralizing authority from seven provinces and the Nairobi administrative area to

47 underlying counties. Much of the country's historical and trend data is still reported based on the original provinces.

According to 2009 census data, the largest share of population by county can be found in Nairobi (8%), followed by Kakamega and Bungoma from the Western province, Kiambu (Central), Nakuru (Rift Valley), and Meru (Eastern) with 4% each. Kenya is also home to 42 ethnic communities, with the two largest accounting for more than one-third of the population (Kikuyu, 22%, and Luhya, 14%). In 2015, Kenya had a fertility rate of 3.31, which ranks 46th in the world and an HIV/AIDS rate of 5.3% in 2014, which ranks 13th in the world (CIA World Factbook).

GDP has consistently grown since the 1990s, averaging 5% annually since 2006, with this growth primarily driven by the services sector, which accounted for 72% of the increase between 2006 and 2013 (World Bank, 2016). Nonetheless, despite consistent GDP growth rates, poverty remains high, ranking 145 of 188 in the Human Development Index (United Nations, 2015).

NIGERIA

Nigeria is often referred to as the "Giant of Africa" because of its large population and economy. With 177.5 million inhabitants (World Bank, 2015), of which 51% are men, Nigeria is the most populous country in Africa and hosts more than 500 ethnic groups, the three largest being Hausa, Igbo, and Yoruba. While the official language of Nigeria is English, more than 500 languages are spoken by the different ethnic groups, reflecting the wide variety of cultures.

Nigeria is divided into 36 states across six regions, namely the North East, North West, North Central, South West, South East, and South South. Approximately 70% of the Nigerian population is rural, with the populace concentrated in the North East and North West regions. Approximately 48% of Nigerians are illiterate, with the lowest literacy rates concentrated in the North East and North West. In 2015, Nigeria's fertility rate was 5.19, which ranks 13th in the world, and its HIV/AIDS rate in 2014 was 3.2%, ranking 20th in the world (CIA World Factbook).

In 2014, Nigeria overtook South Africa to become Africa's largest economy and the world's 20th largest economy. Nominal GDP is $568 billion and purchasing power parity is $1 trillion (World Bank, 2015). In 2012, real per capita GDP was $3,202, well above the SSA average of $1,522 (World Bank, 2015). Between 2005 and 2014, real GDP growth averaged about 5.3% per year (National Bureau of Statistics, 2015). Despite these recent positive trends, the International Monetary Fund downgraded Nigeria's GDP growth forecast from 3.3% to 2.3% for 2016 because of the drastic reduction in the country's foreign exchange earnings due to low oil prices and exchange rate volatility leading to rising inflation, shortfalls in non-oil revenues, and security concerns.

1.2 AGRICULTURE SECTOR

RWANDA

Currently, agriculture makes up 33% of the national GDP, more than in Kenya (30%) and in Nigeria (20%). Figure 6 shows the other two sectors contributing to GDP are services and

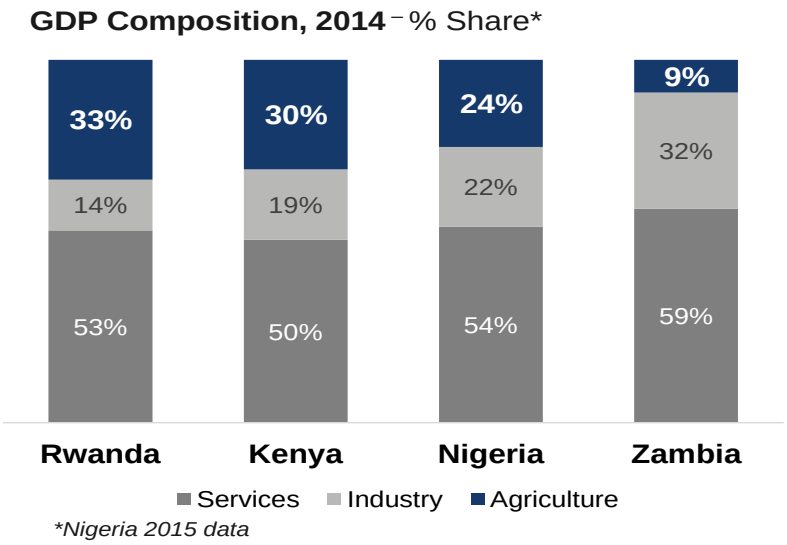
industry. Nearly 50% of all exports come from agriculture, and 90% of the total labor force works in agriculture.

Within the agriculture sector, 86% of GDP is from the production of food crops, as shown in Figure 6. Tea and coffee, highly subject to international price fluctuations, were more than 80% of agricultural exports from 2008-2010, with only small quantities of staple foods (e.g., common bean, potato) crossing the borders to neighboring countries (Uganda, DRC, Burundi) both formally and informally.

ZAMBIA

Currently, agriculture makes up approximately 9% of Zambia's national GDP, far less than in Rwanda (33%), Kenya (30%), and Nigeria (20%). Although agriculture contributes less than 10% to GDP, it accounts for at least 85% of the country's labor force. Other sectors that significantly contribute to Zambia's GDP are services and industry, as illustrated in Figure 6. While Zambia boasts the third-largest water reserves in Africa, estimates suggest that less than 20% of Zambia's arable land is currently utilized. Within the agriculture sector, 45% of GDP derives from agriculture itself, with forestry and fisheries garnering 38% and 17%. Maize is the main focus of agricultural investment, with Zambia a key hub for maize hybrid seed production and the export of seed to neighboring countries.

Figure 6: **GDP composition of Rwanda, Zambia, Kenya, and Nigeria (2014).**



Source: World Bank (2016), Nigerian Bureau of Statistics (2015).

KENYA

Agriculture contributes 30% to Kenya's GDP, as shown in Figure 6, which is comparable to Rwanda (33%) but more than Nigeria (20%). The other two sectors contributing to the national GDP are services with 50% and industry with 19%.

Additionally, agriculture is the most significant sector for employment in Kenya, with approximately 75% of the workforce engaged in an agriculture-related field (World Bank, 2016). Within the agriculture sector, 32% of GDP comes from the production of food crops, with horticulture crops representing the largest share at 33%. Industrial crops such as tea, coffee, and sugarcane account for only 17% of agriculture GDP but make up 55% of agricultural exports. Additionally, Kenya is a regional leader in the dairy industry, featuring the largest dairy herd in Eastern Africa.

NIGERIA

Currently, agriculture makes up only 24% of real GDP, despite the fact that more than 60% of the labor force is involved in this sector. Services and industry are the other two sectors significantly contributing to GDP, as shown in Figure 6. Agricultural GDP is mainly a function of crop production, with much smaller contributions by fisheries, livestock, and forestry.

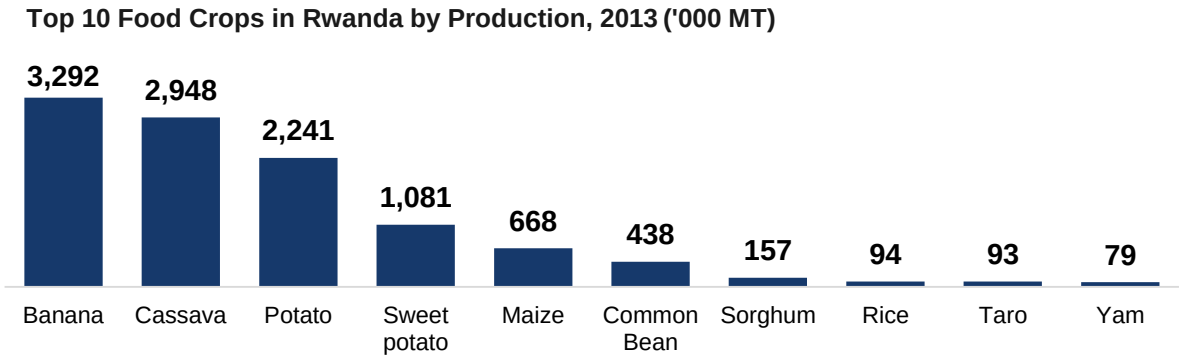
In the 1960s, agriculture contributed 60% of GDP (Omorogiuwa et al., 2014), with groundnut alone representing about 70% of export earnings. However, after the oil boom in the 1970s, petroleum exports dramatically grew (now accounting for more than 90% of export earnings), while agricultural exports plunged. Today, sesame seeds and cashew nuts are Nigeria's leading agricultural exports. Destination markets for sesame seeds are Japan, Korea, China, Turkey, and the Middle East, while cashew nuts go to Vietnam and India. A 2015 European Union ban on food crops including beans, melon seeds, dried fish and meat, peanut chips, and palm oil has prevented the already diminished agricultural export sector from developing. The ban resulted from cowpea exports that, upon analysis, had at least three times the acceptable limit of dichlorvos pesticide, which is considered dangerous to human health. The Federal Government of Nigeria (FGN) recently agreed to implement recommendations from a 17-member committee set up to address this export ban and to ensure zero rejection of food exports. Recommendations are focused on limiting the usage and concentration of this pesticide on farms, as well as the timing of usage, especially while being stored. To date the ban has not been lifted and will likely last until the FGN implements a robust food safety and traceability system.

1.3 KEY CROPS AND GROWING REGIONS

RWANDA

The top ten crops in Rwanda, based on production, are presented in Figure 7. Common bean is the largest crop based on area harvested and is grown by 92% of rural households as an important source of protein and food security. Maize represents the fastest area growth, nearly tripling area in the last ten years. Maize and rice production are growing fastest, driven by the Government of Rwanda's (GoR) Crop Intensification Program. Of the key root, tuber, and banana crops, cassava and potato production are growing fastest, while banana and sweet potato production remain relatively flat.

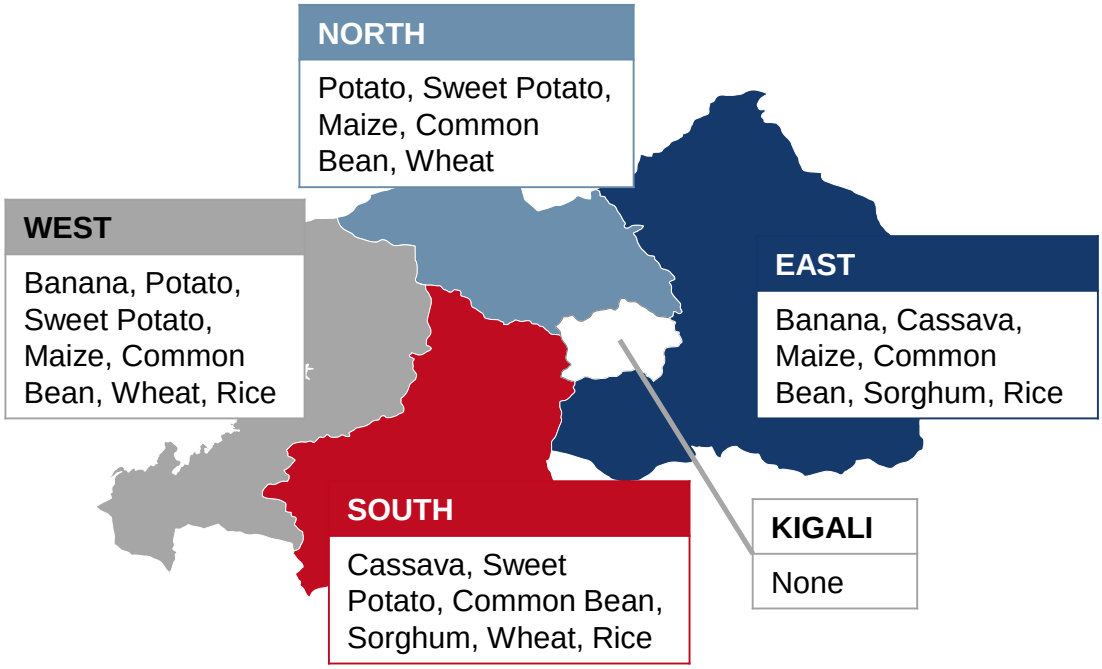
Figure 7: **Top ten crops in Rwanda by production (2013).**



Source: Rwanda Country Stat (viewed in February 2016).

Most of the staple crops are produced throughout the country, but some regions have better yields because of more favorable conditions. Figure 8 presents the key crops (defined as having more than 20% share of the national production) by province. Kigali has no key crop identified because production is limited and it has an insignificant effect on national production statistics. Common bean is grown across the country, while maize production is more focused in the north, west, and east, and potato is concentrated in the north and west.

Figure 8: **Key crops in Rwanda by province.**



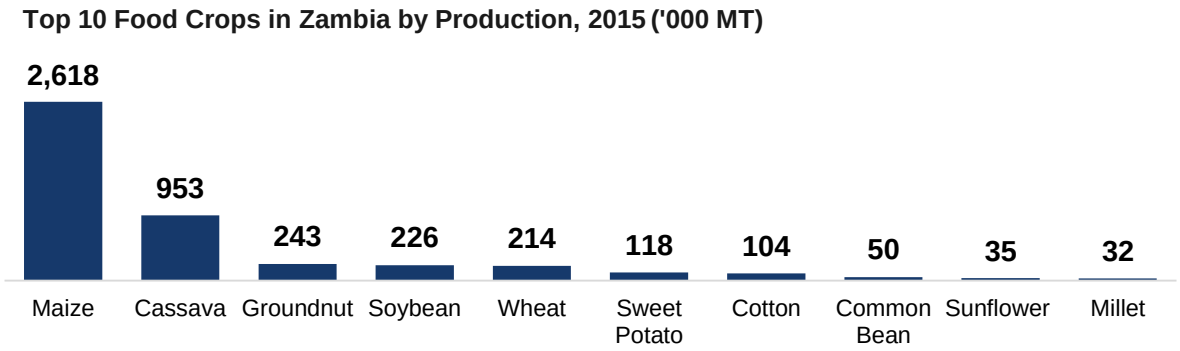
Source: MINAGRI (2011) sourced from Japanese Ministry of Agriculture (2012).

ZAMBIA

The top ten crops in Zambia in 2015, based on area harvested and production, are presented in Figure 9. Driven by the strong export market, maize far and away represents Zambia's largest crop by area, followed by cassava, groundnut, cotton, soybean, and common bean. Zambia is the second-largest exporter of maize in Africa, behind South Africa. Likewise, maize production

is nearly triple that of cassava, the next largest crop. Of the major crops, production of maize and groundnut are growing fastest, with maize driven by hybrid yield improvement. Meanwhile, cassava production remains relatively flat, and cotton production has decreased over the past ten years.

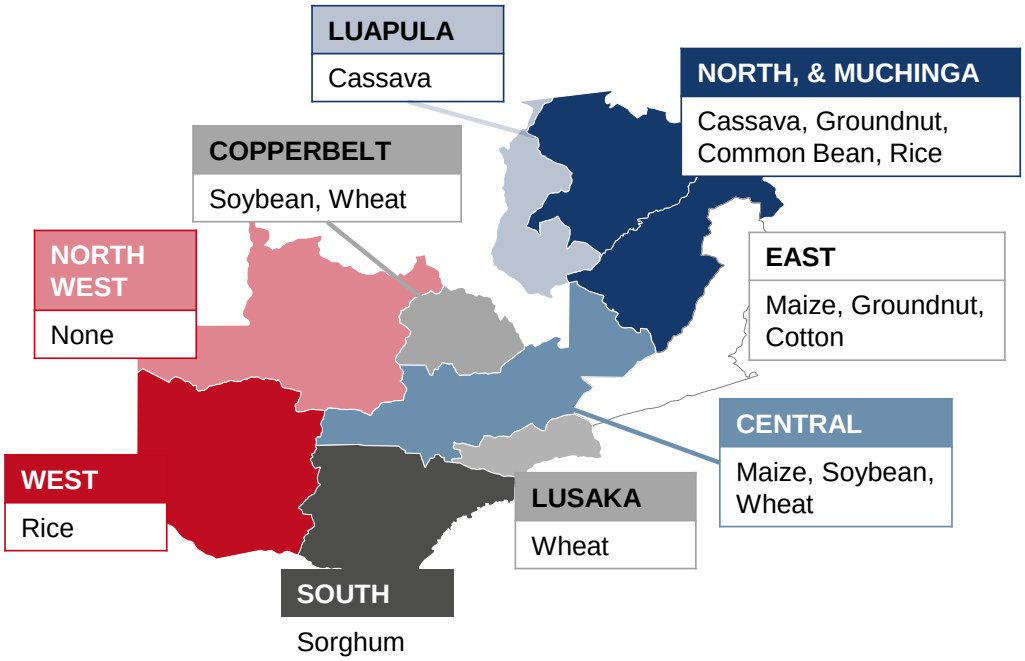
Figure 9: **Top ten crops in Zambia by production (2015).**



Source: Zambia Country Stat (viewed in February 2016).

Maize dominates production in Zambia's key regions, including the Central and Eastern provinces, with groundnut production also notable in the Northern and Eastern provinces, and common bean in the Northern province. Figure 10 presents the key crops (defined as having at least 20% share of the national production) by province.

Figure 10: **Key crops in Zambia by province.**

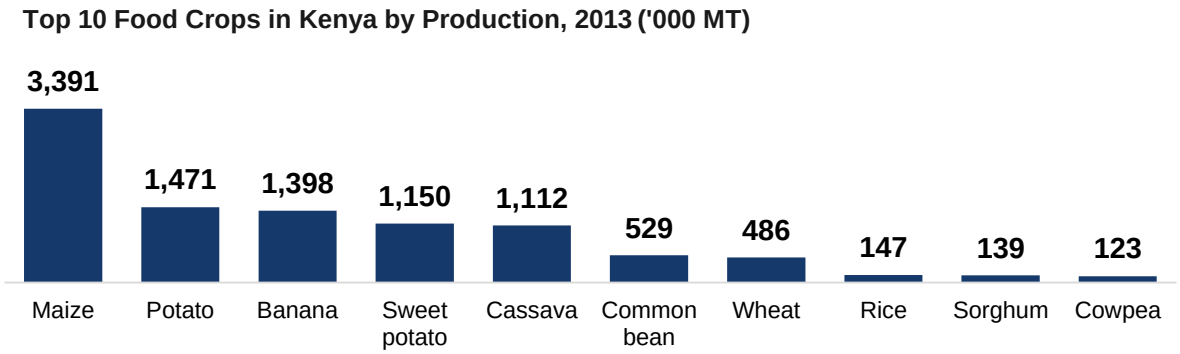


Source: Zambia Country Stat (viewed in February 2016), NAIP (2014).

KENYA

The top ten food crops in Kenya, based on production, are presented in Figure 11. Maize is the largest crop based on area harvested and production volume and is grown by 95% of rural households. It is the most significant food crop, accounting for upwards of 30% of daily caloric intake for the average Kenyan. There has been slight but consistent production growth in several of the top food crops, with cassava, rice, and cowpea growing fastest, while maize and common bean production have increased only slightly.

Figure 11: **Top ten crops in Kenya by production (2013).**



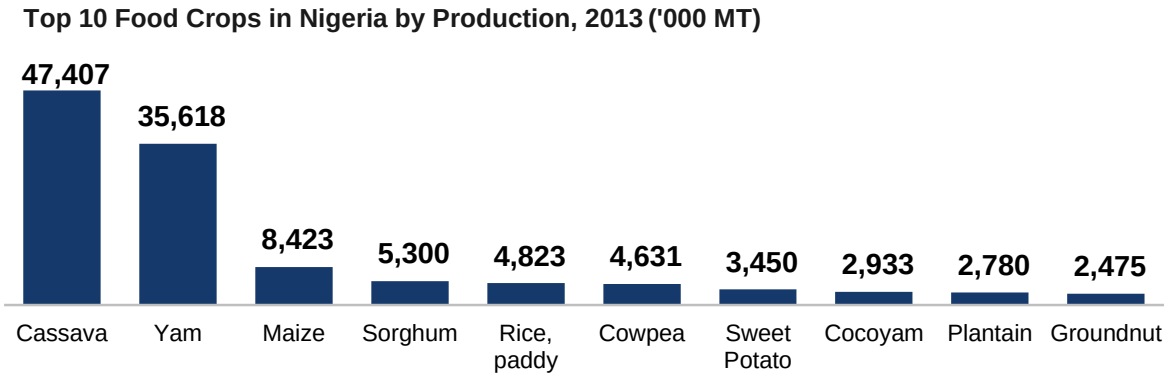
Source: Kenya Country Stat (viewed in February 2016).

Most of the staple crops are produced throughout Kenya, but yields vary by location because of agroclimatic conditions. Central and Nairobi provinces contribute very little to maize and common bean production volume, but Central province represents approximately 25% of total potato production. Additionally, Central and Nairobi provinces represent a significant end market for production of many crops. Maize production is concentrated in Rift Valley and Western provinces, while common bean is grown throughout the country.

NIGERIA

The top ten food crops in Nigeria, based on production, are shown in Figure 12. Cassava represents the largest crop by area and production, and is an important crop for smallholder farmers, with more than 90% of Nigeria's cassava production sourced from five million-plus smallholder farmers. Yam is the second largest crop in production terms and is also a key crop for smallholder farmers (~80% of production from smallholder farmers) and food security. While Nigeria is the global leader in production of both cassava and yam, cassava production has grown faster, receiving more attention from the government and private sector due to its versatile uses which include food, starch, ethanol, and animal feed. High-quality cassava flour can also serve to lessen Nigeria's reliance on wheat imports, which were more than 4.5 million MT in 2013. Maize and rice production are Nigeria's fastest-growing grain crops, partially a function of the government's efforts to decrease grain imports. With respect to legumes, groundnut and cowpea are the two largest crops in Nigeria, but soybean has emerged as a crop targeted by the government to double in production, given its nutritional importance as a source of high protein for food and animal feed.

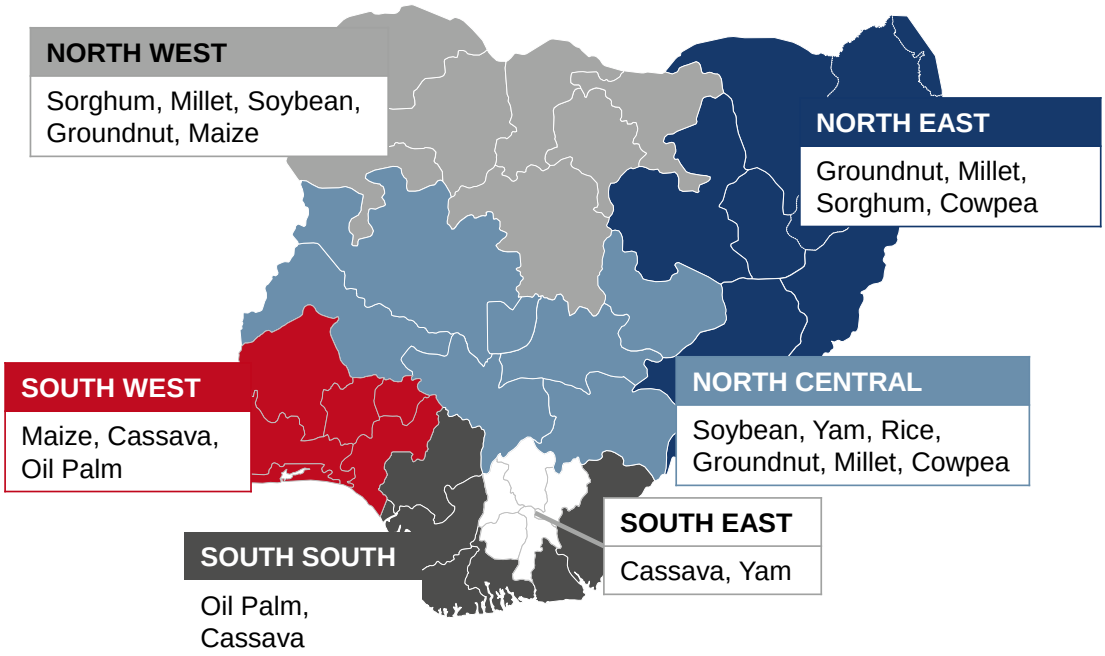
Figure 12: **Top ten crops in Nigeria by production (2013).**



Source: FAOSTAT (viewed in February 2016).

Figure 13 presents the top ten crops by region. Cassava is grown across the country, while production of other key crops such as maize, soybean, and rice is more focused in the north and middle belt. Oil palm, a top export crop, is predominantly grown in the south. Yam is grown across the country, while sorghum is produced exclusively in the north.

Figure 13: **Key crops in Nigeria by region.**



Source: Agricultural Performance Survey of 2013 Wet Season in Nigeria, NAERLS.

1.4 FARMER TYPES AND GENDER PARTICIPATION

RWANDA

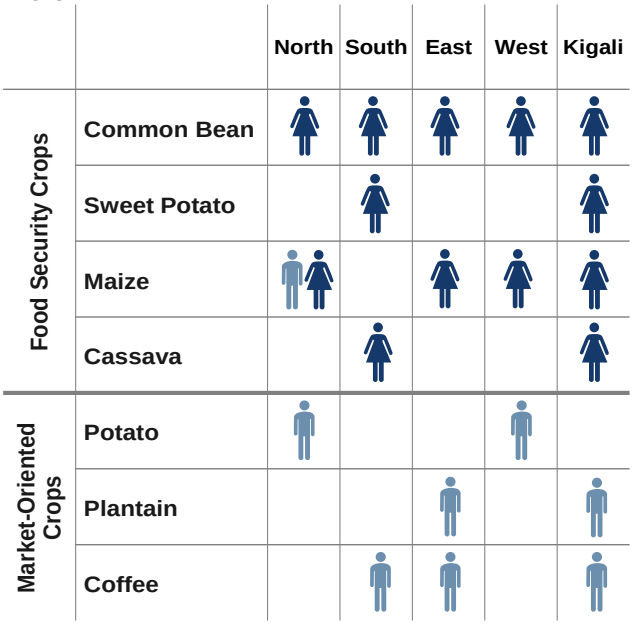
Nearly all farmers in Rwanda could be classified as smallholder farmers, as 80% of them have less than 1 Ha, 94% have less than 2 Ha, and 99% have less than 4 Ha (National Institute of Statistics of Rwanda, 2010). The East province has the largest average farm size of 1.10 Ha, well above the four other provinces, where average farm sizes are ~0.6-0.7 Ha.

As shown in Table 2, the division of labor in Rwandan agriculture is by task and by crop. Women are more active in the production of food security crops such as common bean, sweet potato, maize, and cassava at the subsistence level.

Most of women's production is consumed on-farm, with small amounts sold locally. Women receive lower prices for their products and are underrepresented in agribusiness. Female-headed households (about 30%) are often very poor, with limited access to productive resources and assets. It is reported that women, especially female heads of households, have had limited access to government initiatives in Rwanda, because the inputs (chemicals, fertilizers, seeds) are too expensive and many of the technologies are labor intensive, restricting women's participation (World Bank, 2015).

Table 2: **Gender roles in crop production by province in Rwanda.**

Rwanda gender division of crop cultivation by province



Source: MINAGRI (2010) sourced from World Bank (2015), World Bank (2015).

In general, men are more involved in the production of marketed crops such potato, plantain, and coffee. They are more open to taking risks in order to increase income.

While research suggests distinctions in gender roles by crop (World Bank 2015), field interviews reveal a more nuanced story, with both men and women often both involved in farm decisions. While women tend to manage day-to-day responsibilities because men hold additional off-farm jobs, responsibilities are highly dependent on the dynamics of specific households.

With respect to trade, women in Rwanda play a significant role in both formal and informal cross-border trade. A 2012 study by the Rwanda Ministry of Trade and Industry estimated that women represent 74% of informal cross-border traders. However, a 2013 USAID-Enabling Agriculture Trade study that conducted interviews with customs officials and National Bank data collectors contradicted this assertion and revealed "considerable variation according to the nature of the border post," with women's participation in trade being high with the DRC, but closer to 30% with respect to trade with Uganda. The study noted that women and men are both involved in cross-border trade, often working in collaboration depending on the location and the commodity being traded. Men tend to manage transport, especially with bulkier commodities such as potato, due to the physical requirements of moving bulky, heavy commodities, while women often manage the stalls in which the commodities are is sold (USAID-EAT 2013).

Gender-related issues continue to be a priority for the GoR, and while social and cultural impediments remain, the situation in Rwanda appears to be less serious of a problem compared

to many neighboring countries. According to the World Economic Forum's Gender Gap Index[3], Rwanda ranked 6th in the world in 2015, ahead of many developed countries, including Germany, France, and the U.S. While this index is not agricultural specific and doesn't capture all the specific problems for women in Rwandan agriculture, it supports the field interviews conducted in which women play critical roles in a variety of crops and functions, with specific roles varying by household.

ZAMBIA

Average farm size varies significantly across Zambian provinces, with Northern and Muchinga province farms typically the largest and with Lusaka province hosting relatively smaller farms. According to the Central Statistics Office in Zambia, there are nearly 800,000 smallholder farmers in Zambia classified as having less than 5 Ha. Roughly 20,000 farms are considered medium size (5-20 Ha), while only around 2,000 farms are considered large, having more than 20 Ha (NAP), as shown in Table 3. Despite a recent emergence of larger farms in Zambia focused on contract growing of soybean and seed maize, more than 70% of farms in Zambia are under 2 Ha, and 40% under 1 Ha.

Table 3*:* Farm sizes in Zambia.

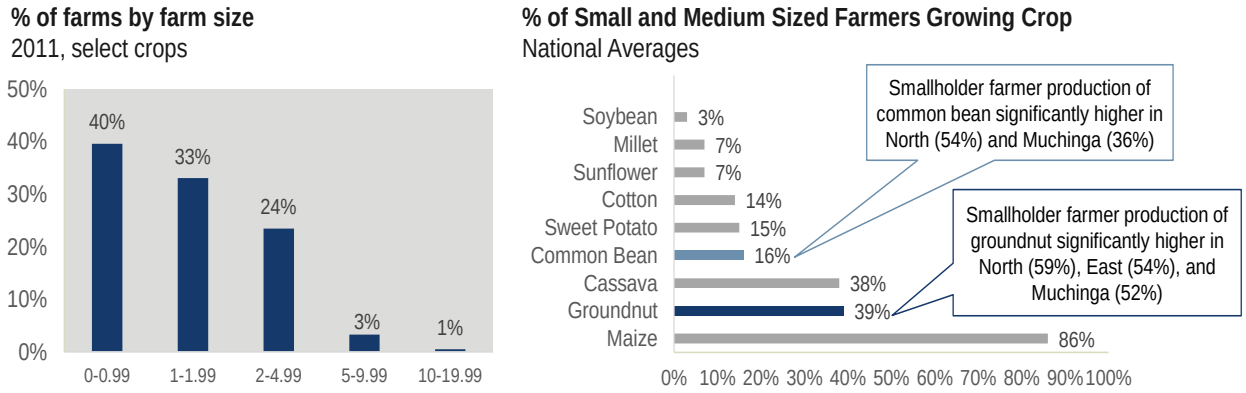
Types of Farmers	Farm Size	Number of Farmers
Small Scale	Less than 5 ha	792,212
Medium	5-20 ha	20,728
Large	Greater than 20 ha	2,052

Source: NAP sourced from CSO (2010).

Smallholder farmers in Zambia tend to grow different crops than farmers with larger farms. Among smallholder farmers in the Northern and Muchinga provinces, for instance, common bean production is two to three times higher than in other provinces, as indicated in Figure 14. Groundnut is another crop factoring significantly in smallholder farmers' production, particularly in the Northern, Eastern, and Muchinga provinces, where 52-59% of smallholder farmers grow groundnut, well above the national average of 39%.

[3]The Global Gender Gap Index was first introduced by the World Economic Forum in 2006 as a framework for capturing the magnitude of gender-based disparities and tracking their progress. The Index benchmarks national gender gaps on economic, political, education, and health criteria, and provides country rankings that allow for effective comparisons across regions and income groups.

Figure 14: **Farm sizes in Zambia by crop.**



Source: Indaba Agricultural Policy Research Institute (2013).

Gender division of labor in Zambian agriculture tends to be by task and by crop, although this varies by household. As shown in Table 4, women are on average more active in the production of food security crops, most notably groundnut.

In general, women in Zambia are more involved in crops that are consumed on-farm, while men are more involved in the production of marketed, cash crops. Accordingly, women's roles in maize depend on the role of maize in the household, as women tend to be more involved and more conservative in variety selection if the maize is for on-farm consumption. For cassava, women generally lead processing activities, while gender-specific roles in input decisions and crop production roles for cassava vary by household. Groundnut is viewed as a food security crop, and as such, input decisions and processing are generally led by women, although men are increasingly involved in groundnut production. Both women and men are involved in all common bean activities, but women tend to be more involved in variety selection in Muchinga, while men are more involved in the Northern province. Gender roles in common bean are highly dependent on specific households. Given that cotton is a high-value cash crop, men generally make input technology decisions and handle marketing, while women are usually only involved in cotton picking.

Table 4: **Gender roles in crop production in Zambia.**

	Input decision	Crop production	Processing	Marketing
Maize				
Cassava				
Groundnut				
Cotton				
Common bean				

Source: Expert analysis based on field interviews, FtF Impact Evaluation of Groundnut Value Chain in Zambia (2015), Hamazakaza et al. (2014), Mofya-Mukuka et al. (2013), and Ross et al. (2012).

With respect to accessing credit, women farmers are more disadvantaged than male farmers. Married women usually do not have property in their name, and as a result they often cannot provide the collateral required to access credit (USAID AgCLIR, 2011).

KENYA

Average farm size in Kenya ranges from 0.5-2.0 Ha, with differences by region and crop, depending on industrialization, profit potential, and agro-climatic conditions. The division of labor in Kenyan agriculture varies by task and by crop. Women are more active in the production of food security crops such as common bean, banana, potato, and cassava, as illustrated in Table 5.

Table 5: **Gender roles in crop production in Kenya.**

Kenya gender division of crop cultivation by role

Top crops	Seed selection	Land preparation	Planting	Weeding/ In-season tasks	Harvesting	Post-harvest processing	Marketing
Maize	♀ ♂	♂	♀ ♂	♀ ♂	♀ ♂	♀ ♂	♂
Common bean	♀	♀ ♂	♀	♀ ♂	♀ ♂	♀ ♂	♀ ♂
Banana	♂	♀ ♂	♀ ♂	♀	♀	♂	♀ ♂
Cassava	♀ ♂	♀	♀ ♂	♀	♀ ♂	♀	♀ ♂
Potato	♀ ♂	♀	♀ ♂	♀ ♂	♀	♀	♀
Wheat	♂	♂	♂	♂	♂	♂	♂
Tea	♂	♀ ♂	♀ ♂	♀ ♂	♀ ♂	♂	♂

Source: Context expert analysis, Katungi (2010).

Most of women's production is consumed on-farm with small amounts sold locally. Women generally receive lower prices for their products than men and are underrepresented in agribusiness. In general men are more involved in the production of cash crops such as maize, wheat, and tea. They are more open to taking risks in order to optimize payout potential.

While research suggests crop-specific distinctions in gender roles (World Bank 2015), field interviews reveal a more nuanced story, with both men and women often involved in farm decisions. While women tend to manage day-to-day responsibilities because men hold off-farm jobs, responsibilities are highly dependent on the dynamics of specific households.

Many crops see significant differences in gender roles by size and scale of farm, with the general observation being that women have a greater role in small-scale farming operations, while men play a larger role in commercial or large-scale farming and agribusiness operations.

Marketing of crops generally falls more to men than to women, especially in cash crops such as maize, wheat, and tea. This finding stays relatively consistent when looking at marketing of crops in formal cross-border trade, with men taking a leading role in the majority of crops and situations. Informal cross-border trade has a different dynamic, featuring heavier involvement by women.

NIGERIA

Although farm sizes vary across the country, the majority of farmers can be classified as smallholder farmers, as the average farm size is about 2 Ha.

As shown in Table 6, the division of labor in Nigeria varies by task and by region. Women actively participate in all aspects of production, but men own the majority of farmland and are also dominant in decision-making. A male farmer in Nigeria is five times more likely to own land than a female farmer (Africa Region Gender Practice, 2012). Across the country, women are most active in local processing of food security crops, such as rice, maize, cowpea, and vegetables, but this processing is often at a subsistence level on farm, rather than for commercial purposes. Female-headed households are very few and often very poor, with limited access to funds and suitable equipment such as tractors.

In general, men are more involved in the production of cash crops such yam, maize, soybean, cotton, and sesame seeds. They are more open to taking risks in order to optimize payouts.

In regard to trade, Nigerian women play an important role in both formal and informal cross-border trade. An estimated 52% (Adeyinka, 2014) of cross-border trade between Nigeria and Benin Republic is carried out by women.

Table 6: **Gender roles in crop production in Nigeria.**

		Maize		Rice		Soybean		Yam	
									
North	Production	**98%**	2%	**90%**	10%	**95%**	5%	*N/A*	*N/A*
	Processing	10%	**90%**	20%	80%	10%	**90%**	*N/A*	*N/A*
	Marketing	**85%**	15%	**90%**	10%	**90%**	10%	*N/A*	*N/A*
South	Production	**70%**	30%	**60%**	40%	86%	14%	**80%**	20%
	Processing	10%	**90%**	20%	**80%**	*N/A*	*N/A*	50%	50%
	Marketing	**90%**	10%	**60%**	40%	*N/A*	*N/A*	**80%**	20%

N/A=Not applicable

Source: Estimating Gender Differentials in Agricultural Production in Nigeria (2012).

1.5 DOMINANT SEED SYSTEMS

RWANDA

There are four identified dominant seed systems in Rwanda, as highlighted in Figure 15: farmer-saved, public-private, public, and private. The farmer-saved and public seed systems represent the majority of seed volume. Farmer-saved seed dominates the informal sector while public-private and private systems represent the majority of EGS volume.

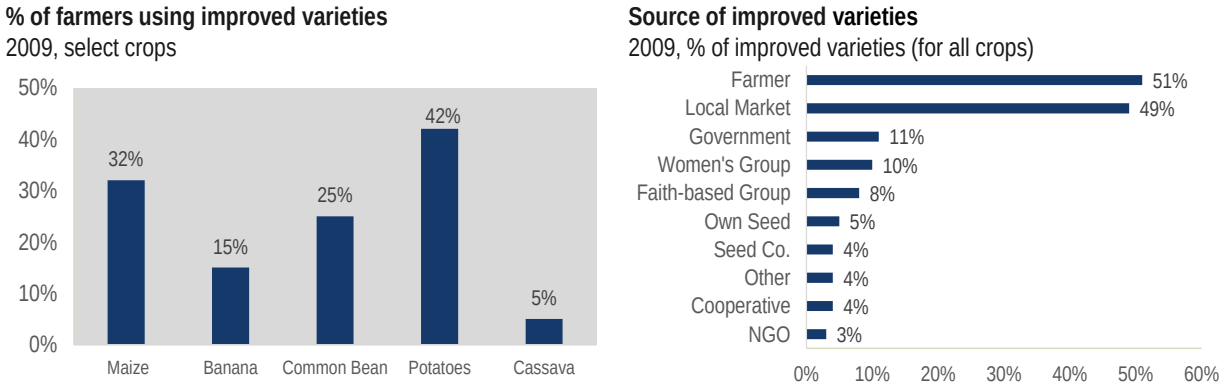
Figure 15: **Dominant seed systems in Rwanda.**

	Farmer-saved	Public	Public – Private	Private
Type of Crops	Local food crops	Major food and cash crops	Food and cash crops	High-value crops
Crops	Common bean Potato Maize (OPV) Banana Sweet potato Cassava	Maize (OPV) Potato Soybean Wheat Rice Common bean Cassava	Maize (OPV) Potato Common bean	Maize (hybrid) Soybean Vegetable
Types of Varieties	Local and improved	Improved	Improved	Improved and hybrids
Quality Assurance System	Farmer-selected	Farmer-selected, certified	Farmer-selected, certified emerging through private seed producers	Certified
Seed Distribution	Farmer-saved, farmer to farmer exchanges (trading, selling)	Agro-dealers and NGOs	Local private seed companies, agro-dealers, farmer groups, cooperatives	Regional private seed companies, NGOs, agro-dealers

Source: Broek et al. (2014), field research team interviews (2016).

Adoption of improved varieties is low across Rwanda. As depicted in Figure 16, a 2009 Agra Baseline Study Survey estimated that adoption of improved varieties in Rwanda is only 7-13%. While improved variety adoption has likely increased since the 2009 study, adoption continues to be low across all crops in Rwanda, with the exception of hybrid maize. Informal seed systems dominate most crop value chains because in many cases the formal systems cannot meet demand, often because the formal system is under-resourced and Rwanda lacks a strong private seed sector to supplement or (where appropriate) replace public sector activities. As a result, farmers predominantly rely on saved seed and informal farmer-to-farmer exchanges.

Figure 16: **Farmer use and source of improved varieties in Rwanda.[4]**



Source: Alliance for a Green Revolution (AGRA) (2010).

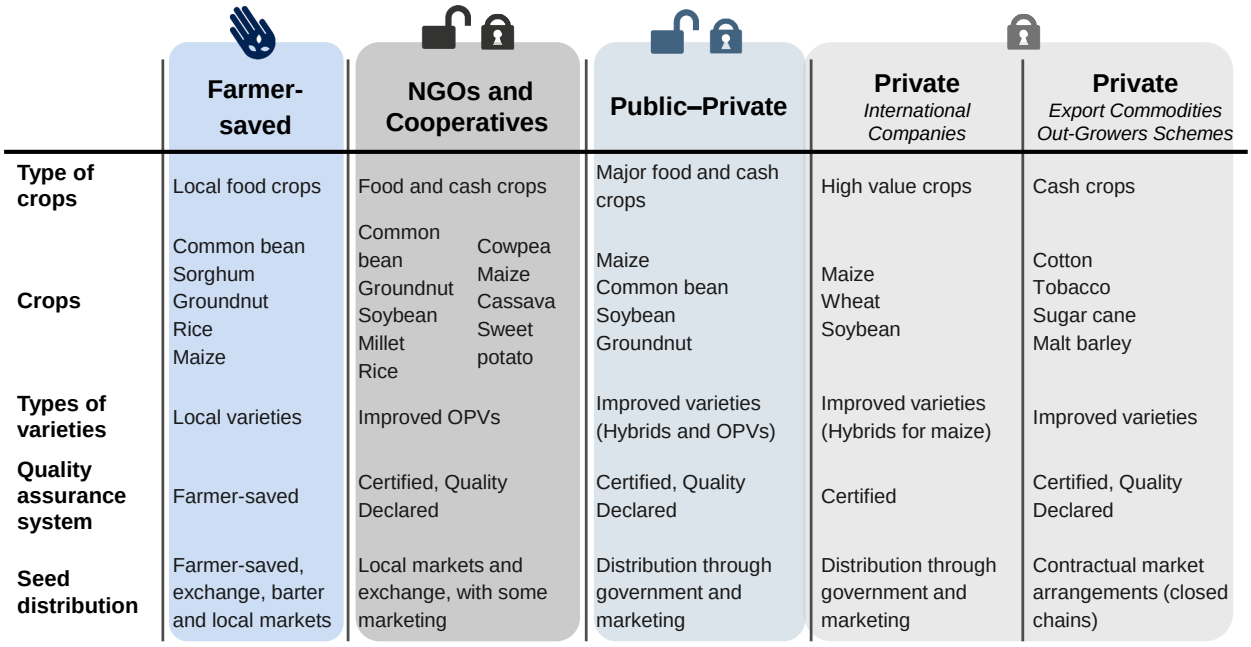
ZAMBIA

There are five identified seed systems predominant in Zambia, as highlighted in Figure 17. In the farmer-saved system, which is informal, farmers multiply seed, barter it, or sell and buy for cash. This system has no quality assurance measures for the landraces that are multiplied. In the second system, NGOs are assisting community groups or farmer cooperatives in seed multiplication and marketing. Smallholder farmers in Zambia who grow crops other than maize are nearly always acquiring seed through these two systems.

The country's agricultural focus on maize and other crops for export is similarly reflected in the three formal seed systems. These systems include: 3) public-private, supported by the Zambia Agriculture Research Institute (ZARI) and local seed companies, 4) private, supported by international seed companies, and 5) private, supported by outgrower schemes for export commodities. The privately owned local seed companies focus on seed production and marketing, often of varieties and basic seed bred from Consultative Group on International Agricultural Research (CGIAR) research institutions. International seed companies operating in Zambia are active in breeding (within and outside of Zambia), seed production, multiplication, processing, and distribution of hybrid maize and other high-value cash crops. The export commodities-driven seed system revolves around outgrower schemes for cash crops for export such as cotton, tobacco, and sugar cane.

[4] Source of improved varieties percentage does not add up to 100% because the question was based on the number of farmers that accessed improved varieties from a specific source, which could include multiple sources for a farmer.

Figure 17: **Dominant seed systems in Zambia.**

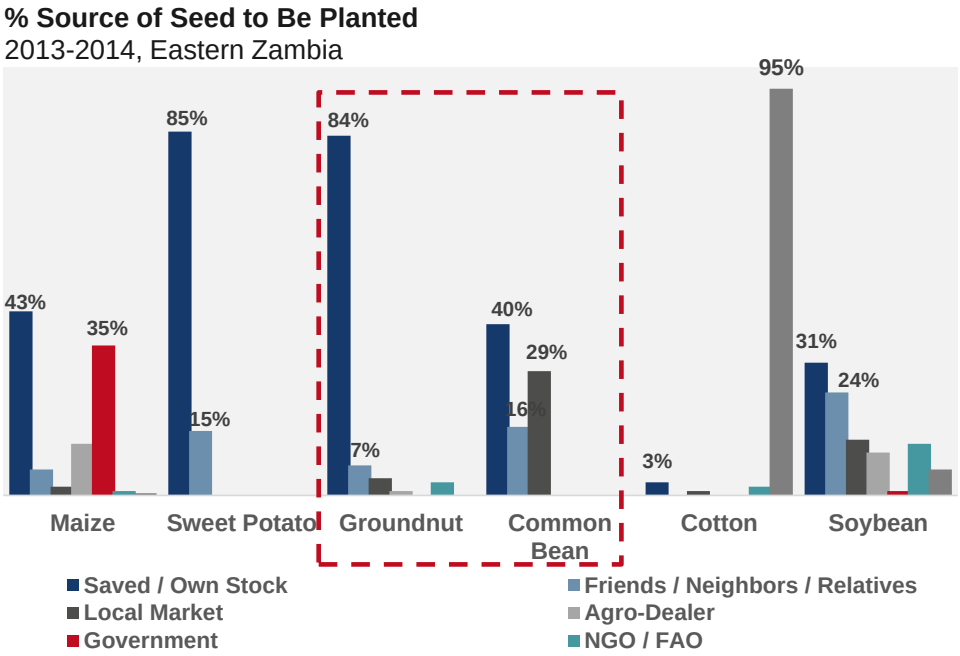


	Farmer-saved	NGOs and Cooperatives	Public–Private	Private *International Companies*	Private *Export Commodities Out-Growers Schemes*
Type of crops	Local food crops	Food and cash crops	Major food and cash crops	High value crops	Cash crops
Crops	Common bean Sorghum Groundnut Rice Maize	Common bean Groundnut Soybean Millet Rice Cowpea Maize Cassava Sweet potato	Maize Common bean Soybean Groundnut	Maize Wheat Soybean	Cotton Tobacco Sugar cane Malt barley
Types of varieties	Local varieties	Improved OPVs	Improved varieties (Hybrids and OPVs)	Improved varieties (Hybrids for maize)	Improved varieties
Quality assurance system	Farmer-saved	Certified, Quality Declared	Certified, Quality Declared	Certified	Certified, Quality Declared
Seed distribution	Farmer-saved, exchange, barter and local markets	Local markets and exchange, with some marketing	Distribution through government and marketing	Distribution through government and marketing	Contractual market arrangements (closed chains)

Source: ISSD Zambia briefing note (2012), field research team interviews (2016).

Adoption of improved varieties is low across Zambia for all crops but maize, as depicted in Figure 18. The overwhelming majority of varieties released in the country have been maize, which means the formal channel has been better established in maize than for other crops to release improved varieties. Agro-dealers mainly focus on supplying maize seed, and there are limited government and NGO programs to distribute groundnut and common bean seeds. For common bean, seed sources are typically split between farmer-saved, neighbors, and local markets. Almost all seed for groundnut is sourced from farmer-saved seed and neighbors.

Figure 18: **Farmers' sources of seed planted in Zambia.**



Source: Alliance for a Green Revolution (AGRA) (2010).

KENYA

There are five identified dominant seed systems in Kenya (Figure 19), which include farmer-saved, NGOs and cooperatives, parastatal, private international, and private local. The farmer-saved seed system accounts for the majority of seed volume in aggregate, but there are specific exceptions to this such as maize, which is sourced primarily from the formal channels (parastatal and private companies).

Figure 19: **Dominant seed systems in Kenya.**

	Farmer-Saved	NGO / Cooperatives	Parastatal	Private International Companies	Private Local Companies
Type of crops	Local food and cash crops	Food crops	Major food and cash crops	Primarily maize	Food and cash crops
Crops	Banana Common bean Cassava Cowpea Groundnut Maize Millet Pigeon pea Rice Sorghum Soybean Sweet Potato	Common bean Groundnut Pigeon pea Maize	Banana Cowpea Maize Rice	Maize	Common bean Groundnut Maize Pigeon pea Sorghum
Types of Varieties	Local varieties	Improved, open pollinated varieties (OPV)	Improved maize varieties (Hybrid and OPV)	Improved varieties (Hybrids for maize)	Improved varieties
Quality Assurance System	Farmer-selected	Certified and farmer-selected	Certified	Certified	Certified
Seed Distribution	Farmer-saved, exchange, barter, and local markets	Local markets, distribution through government, some distribution through agro-dealers	Distribution through government and agro-dealers	Distribution through agro-dealers	Distribution through agro-dealers

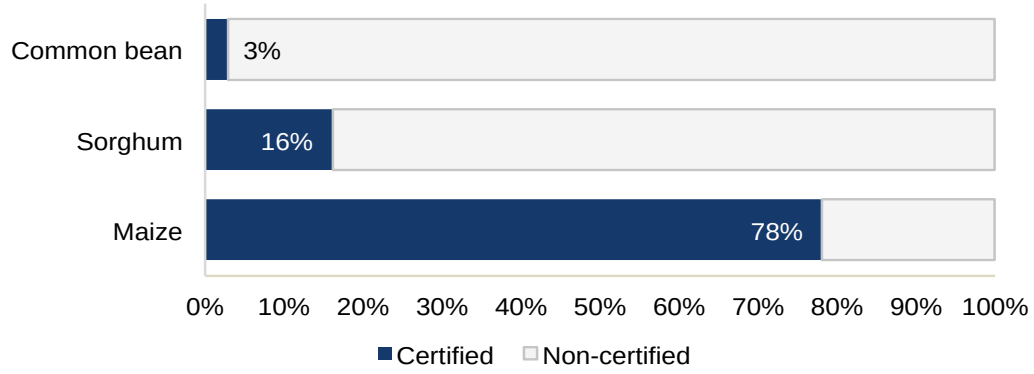
Source: Field research team interviews (2016).

As discussed earlier, the dominant source of seed varies by crop, but crops tend to be aligned with one of three primary segments:

- Primarily formal (<35% informal): Wheat and maize are the primary focus of the formal seed sector, within which seed sales are dominated by the Kenya Seed Company, a parastatal company.
- Primarily informal (35-95% informal): The majority of seeds sold in Kenya are through the informal channel, with important staple and food security crops forming a large percentage of this segment.
- Informal only (>95% informal): Cassava, soybean, and sweet potato seeds are sourced from the informal sector >95% of the time.

Overall, the informal market is estimated to be responsible for approximately 75-80% of total seed sales and barter in Kenya. Estimates of market share for certified seed by crop support these findings on informal vs. formal market share (Figure 20).

Figure 20: **Percentage of land planted with certified seed in Kenya (2013).**



Source: Kariuki (2015).

Maize is the most significant market for improved varieties, with more than one-half (258 of 482 in 2013) of registered improved varieties in Kenya being maize. The only other crops with a significant number of improved varieties are common bean, wheat, sweet potato, and sorghum.

NIGERIA

There are four identified seed systems in Nigeria, as shown in Figure 21. These include 1) farmer-saved, 2) public-private, but led by the National Agricultural Research Institutes (NARIs) with limited private seed company involvement in certified seed production, 3) public-led systems, and 4) private-led systems dominated mostly by local seed companies. The farmer-saved seed systems represent the majority of seed volume. The largest proportion of EGS volume is produced by the public and private systems, while farmer-saved seeds and farmer-to-farmer seed exchanges dominate the informal seed sector.

Figure 21: **Dominant seed systems in Nigeria.**

	Farmer-saved	Public	Public – Private	Private
Type of Crops	Local food crops	Major food and cash crops	Food and cash crops	High-value crops
Crops	Maize (OPV) Soybean Rice Cowpea Sorghum Groundnut Millet Yam Cassava Sweet potato	Maize Soybean Rice Yam Cassava Sorghum Cocoa Cotton Oil palm Wheat	Maize (OPV) Soybean Rice Cowpea Yam Cassava	Maize (OPV and Hybrid) Soybean Rice Cowpea Wheat Vegetables
Types of Varieties	Local (landraces) and Improved	Improved	Local and Improved	Improved and Hybrid
Quality Assurance System	Farmer-selected	Certified	Farmer-selected, certified	Certified
Seed Distribution	Farmer-saved, farmer-to-farmer seed exchanges, village market	ADPs, agro-dealers, NGOs	Local sales and markets	ADPs, agro-dealers, NGOs

Source: Field research team interviews (2016)[5].

While smallholder farmers in Nigeria are aware of improved varieties, the rate of adoption is low across most agro-ecological zones because most farmers recycle seeds to reduce their input costs. Adoption of improved varieties is higher for grain crops than for root and tuber crops, as root and tuber planting material is easily recyclable and there has been little demand for, or development of, improved root and tuber varieties. Among grain crops, improved varieties of maize (specifically hybrid maize) are adopted more than other grain cereals or legumes. This is because the maize value chain and seed system attracts more development initiatives from NGOs and donors than other grain value chains. While some farmers buy improved seeds, many acquire their improved seeds from donor- or NGO-funded input intervention programs.

1.6 CROP SELECTION

RWANDA

The selected crops for in-depth EGS system analysis were identified during a consultative process with BFS and USAID Rwanda. To support this endeavor, USAID Rwanda engaged key Rwandan stakeholders to participate in the selection of the crops for the study. The field research team developed a matrix of key indicators crossed with ratings definitions as the basis for discussions. These indicators created a framework to select crops that would have the largest impact on smallholder farmers and specifically women. The field research team first identified the top ten crops by area and rated them based on current production and their ten-year historical compound annual growth rate to illuminate the potential growth prospects for the

[5] The top three seeds produced by private seed companies in Nigeria include maize, soybean, and rice; only two registered seed companies produce seeds of wheat which is sold to Lake Chad Research Institute, Borno State for distribution to farmers.

crop. The team then performed desk research to categorize the importance of the crop with respect to food security based on how many households grow the top crops and the percent of production used for household consumption. Next, the team assessed the importance of the crop to women based on participation in production, as well as the importance of the crop to the GoR based on the review of the government's agricultural strategy. Smallholder farmers are not included in key indicators because all crops are considered smallholder farmer crops in Rwanda, given that 80% of farmers in Rwanda have less than 1 Ha and 94% have less than 2 Ha. Finally, the team consulted with BFS and USAID Rwanda to prioritize the crops for this EGS study based on selecting the crops that rate highest on these indicators and aligned with USAID's preference for focus crops, and input provided to USAID Rwanda from key stakeholders.

To ensure that the EGS study encompassed both the formal and informal seed systems as well as the broader crop value chain, the field research team targeted a comprehensive set of stakeholders to be interviewed. Nearly 40 stakeholders were interviewed, representing public, private, and donor actors. Public sector interviews included government officials from the Ministry of Agriculture (MINAGRI), breeders from the Rwanda Agriculture Board (RAB), and certification and inspection personnel, as well as Rwanda representatives from CGIARs. Private sector interviews included local and regional seed companies, agro-processors, and seed growers from keys regions in Rwanda. Twelve farmers were interviewed representing several farmer groups and cooperatives that play a critical role in seed production and distribution in the formal and informal seed sectors. The field team also conducted interviews with development groups and NGOs working specifically with seed growers, private seed companies, agro-dealers, smallholder farmers (specifically women), and Microfinance Institutions (MFIs).

As a result of this process (details of which are highlighted in Table 7), the field research team selected three crops for the analysis: potato, common bean, and maize. Below is a summary of the key reasons why each crop was selected for this EGS study.

Potato

- **Unmet EGS demand**: There is a significant unmet demand for EGS in potato for two key reasons. First, due to the high level of disease pressure, farmers need to access clean seed regularly to ensure their fields do not become infected with disease. Second, there is a significant gap between yield potential in Rwanda's highly fertile potato growing regions and the yield farmers are actually achieving. While there are many factors that prevent farmers from increasing yields, including poor agronomic practices and limited access to fertilizer, a lack of high-yielding improved varieties in the market is a critical issue constraining farmers from optimizing potato yields.
- **Export opportunity**: While Rwandan imports and exports are generally balanced, there's a significant opportunity to at least double potato exports, because of price premiums for high-quality market segments such as the urban demand for crisps in Uganda and Tanzania (USAID-Enabling Agricultural Trade Project, 2013). While there are many value chain-related factors such as storage limitations constraining exports, limited access to improved high-quality EGS is a critical constraint to realizing actual export gains.

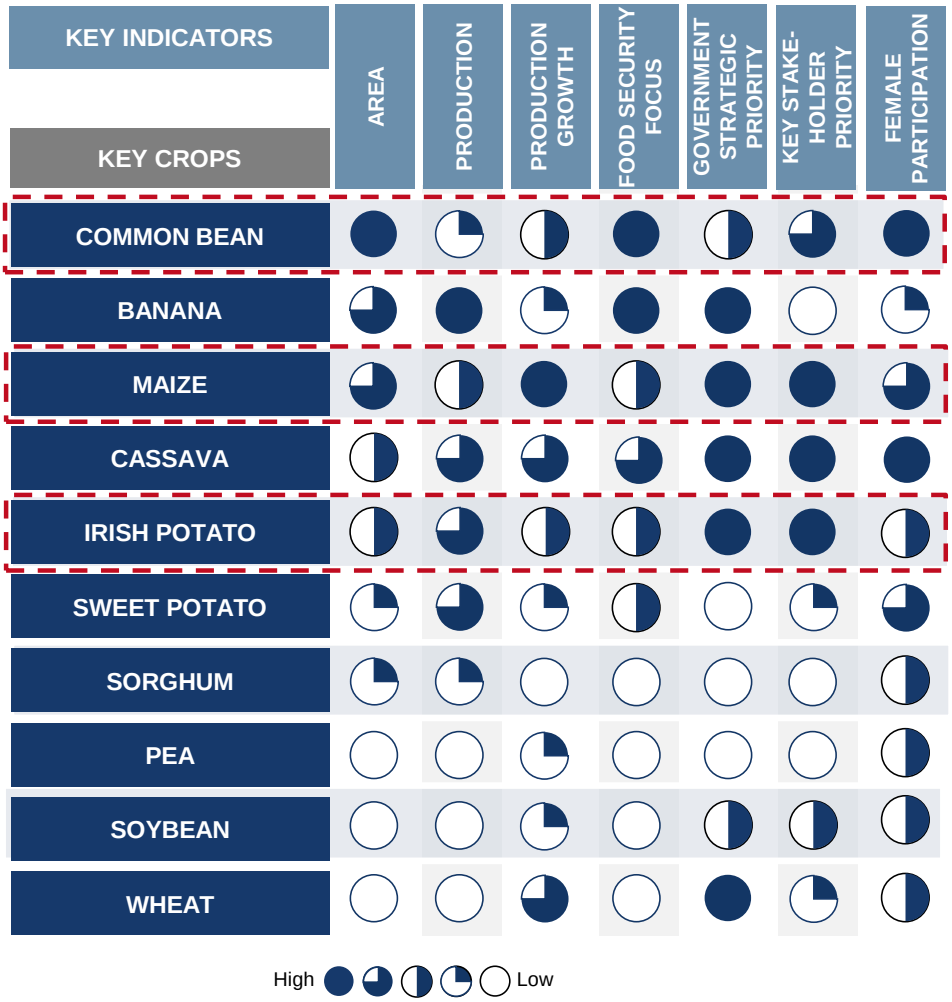
Common bean

- **Nutrition**: The critical issue of nutritional deficiency in Rwanda has led to the focus on development and dissemination of biofortified common bean varieties in Rwanda, led by HarvestPlus. However, these high-iron, improved varieties have reached farmers on a limited scale. Developing a successful EGS system is critical to improving the health of Rwanda's population and achieving HarvestPlus' goal of more than one million Rwanda farming households growing iron beans by 2018.
- **Export demand**: While Rwanda is a net exporter of common bean through informal trade to the DRC and Uganda, there is a significant opportunity to grow beans for export if smallholder farmers were able to increase productivity. Disseminating higher yielding improved varieties through a functioning EGS system is an important part of increasing productivity.
- **Increase smallholder farm family income and food security**: Increased productivity driven by improved varieties also presents an opportunity for smallholder farmers to allocate less of their land to grow the same amount of common bean, providing farmers the opportunity to use newly available land to grow higher value crops that can in turn improve their economic security.

Maize

- **Import competition:** As a net importer of maize, Rwanda cannot currently serve its growing demand for maize through local production without an increase in productivity. Continuing adoption of higher yielding hybrid maize is critical to increasing maize yields of smallholder farmers.
- **Government priority:** The government has a clear focus on increasing the adoption of hybrid maize and is advocating for private seed companies to produce hybrid seed in Rwanda, which has significant implications for how RAB allocates EGS resources in a highly resource constrained environment.

Table 7: **Priority crop selection results in Rwanda.**[6]



Source: Research team analysis based on consultation with key stakeholders (2016).

ZAMBIA

The selected crops for in-depth EGS system analysis were identified during a consultative process with BFS, USAID Zambia, and key seed system stakeholders in Zambia. Prior to kicking off field research activities, the field research team facilitated a crop selection meeting in Zambia with 15 stakeholders from the public, private, NGO, and donor sectors. In advance of the meeting, the field research team developed a matrix of key indicators crossed with ratings definitions as the basis for discussions. These indicators created a framework to select crops that would have the largest impact on smallholder farmers and specifically women. The field research team first identified the top ten crops by area and rated them based on current production and their ten-year historical compound annual growth rate to illuminate the potential growth prospects for the crop. The team then performed desk research to categorize the

[6] While desk research (World Bank 2015) identified specific distinctions in gender roles by crop, the field team (as stated in earlier sections) found that gender roles seemed to be more equal in practice. As such, the priority crop selection analysis specific to gender is a combination of both desk research and field interviews.

importance of the crop with respect to food security based on how many households grow the top crops and the percent of production used for household consumption. Next, the team assessed the importance of the crop to women based on participation in production, as well as the importance of the crop to smallholder farmers based on percentage of smallholder farmers growing the crop. During the crop selection meeting, stakeholders agreed that groundnut and common bean should be selected for study due to their smallholder farmer and food security importance.

To ensure that the EGS study encompassed both the formal and informal seed systems as well as the broader crop value chain, the field research team targeted a comprehensive set of stakeholders to be interviewed. More than 30 stakeholders were interviewed, representing public, private, NGOs, and donor actors. Public sector interviews included breeders from ZARI and certification and inspection personnel from the Seed Control and Certification Institute (SCCI). Private sector interviews included local and regional seed companies, commodity traders, associations, and agro-dealers. Seed producers including outgrowers and farmers representing farmer groups and cooperatives were interviewed who play a critical role in seed production and distribution in the formal and informal seed sectors. The field team also conducted interviews with several development groups and NGOs working specifically with seed growers, extension services, commodity traders, private seed companies, and smallholder farmers.

As a result of this process (details of which are highlighted in Table 8), two crops were selected for the analysis: groundnut and common bean. Following is a summary of the key reasons why each crop was selected for this EGS study.

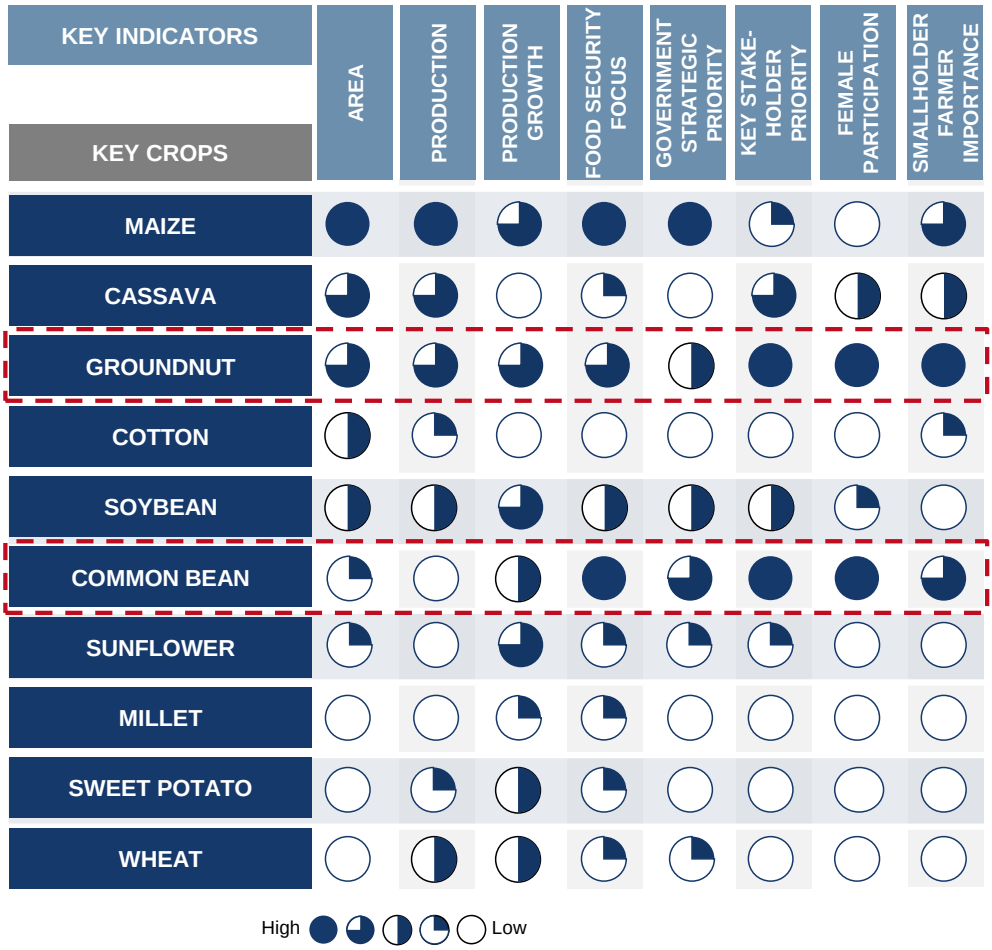
Groundnut

- Groundnut represents Zambia's largest legume crop by area and is a key crop for smallholder farmers, particularly women. However, groundnut has generally been neglected by the private sector seed industry, and as a result, there is limited availability or usage of improved seeds and yields have remained low. In order to capitalize on an opportunity to increase exports and high-value processing of groundnut, there is also a critical need to address the aflatoxin issue.

Common bean

- As a key food security and nutrition crop in Zambia, common bean is important to smallholder farmers, especially women. While soybean was considered a potential priority crop as well, common bean was selected as a higher priority due to the fact that it has been neglected by the private sector and in need of support to improve yields. In contrast, soybean already has already garnered private sector interest and is of less importance to smallholder farmers and household consumption.

Table 8: **Priority crop selection results in Zambia.**



Source: Research team analysis based on consultation with key stakeholders (2016).

KENYA

The crops selected for in-depth EGS system analysis were identified during a consultative process with key seed system and agricultural stakeholders from the public and private sectors during a roundtable meeting convened in Nairobi, Kenya, on March 16, 2016. Attendees included representatives from the Kenya Agricultural and Livestock Research Organization (KALRO), the Kenya Plant Health Inspectorate Service (KEPHIS), the Seed Trade Association of Kenya, African Agricultural Technology Foundation (AATF), National Potato Council of Kenya, public universities, CGIAR, private seed companies, and USAID.

There were subsequent meetings held with public sector stakeholders on April 29, 2016, and with public and private sector stakeholders on May 5, 2016, to share and corroborate preliminary findings. Feedback from these meetings has been incorporated into this report.

As a result of this process, three crops were selected for the analysis: maize, potato, and common bean. Below is a summary of the key reasons why each crop was selected for this EGS study.

Maize

- **Import competition:** As a net importer of maize, Kenya cannot currently serve its growing demand for maize through local production without an increase in productivity. Continued adoption of the appropriate varieties of higher yielding hybrid maize is a critical piece of increasing maize yields of smallholder farmers.
- **Nutritional and economic importance to smallholder farmers:** Maize represents ~30% of the daily caloric intake for the average Kenyan, and is even more important in the daily lives of many smallholder farmers as the primary source of food and income.

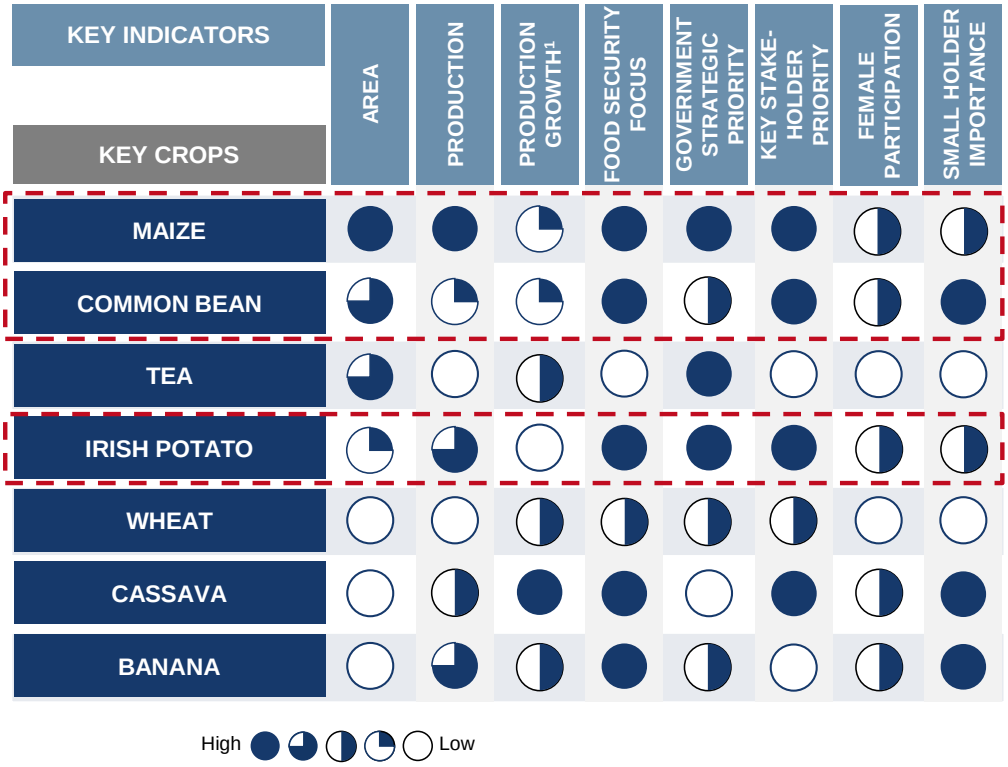
Potato

- **Unmet EGS demand**: There is a significant unmet demand for EGS in potato for two key reasons. First, high levels of disease pressure force farmers to access clean seed regularly to ensure their fields do not become infected with disease. Second, there is a significant gap between yield potential and average yields, with low-quality seed playing a large role in this shortfall. Farmers are looking for high-yielding, improved varieties to optimize their yield potential.
- **Processor demand**: Processors in Kenya routinely have to import potato to meet their demand and have recently been trying to contract with certain large-scale farmers to produce specific varieties to meet their needs. If farmers can align with processors on which varieties to grow, there will be strong demand for their produce.

Common bean

- **Unmet EGS demand:** Currently, there is not enough EGS production to meet market demand for improved seed, with farmers seeking out all available seed in the marketplace on an annual basis. This lack of quality seed negatively impacts yields for farmers and keeps Kenya's average yield significantly below comparator countries.
- **Opportunity for increasing smallholder farmer economic security**: Increased productivity driven by improved varieties would allow smallholder farmers to allocate less land to grow the same amount of common bean, thus freeing up land to grow higher value crops that can in turn boost their economic security.

***Table 9*: Priority crop selection results in Kenya.**



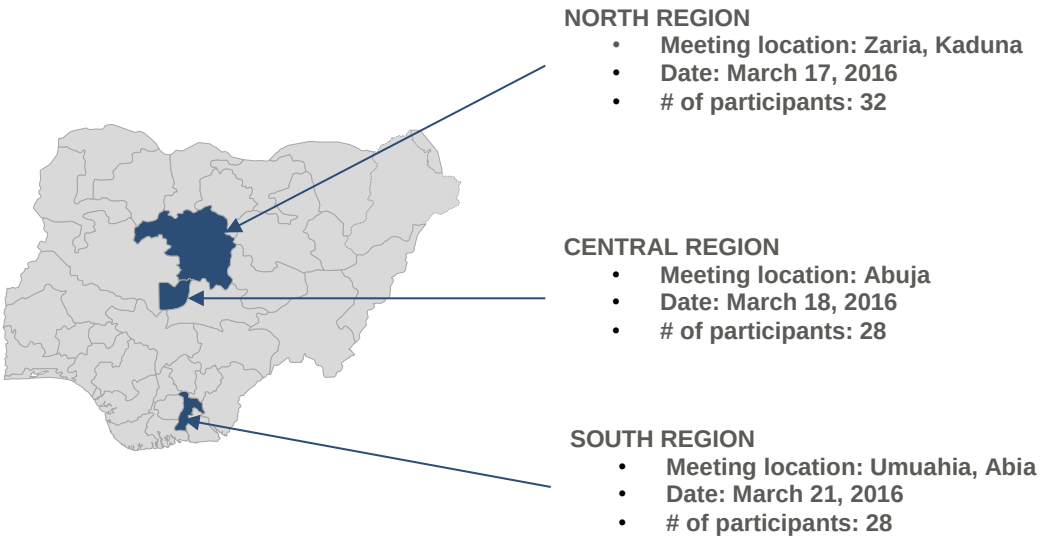
Source: Research team analysis based on consultation with key stakeholders (2016).

NIGERIA

The selected crops for in-depth EGS system study in Nigeria were identified during a consultative process with seed industry stakeholders through roundtables in three regions, including the north, middle belt, and south agro-ecological zones. Discussions at the stakeholder roundtables were based on the crop prioritization framework developed to select crops for all EGS systems study countries. A matrix of key indicators crossed with ratings and definitions was used as the basis for discussions. The framework was slightly modified based on feedback from stakeholders. Smallholder farmers are not included in key indicators because all food crops are considered important smallholder farmer crops in Nigeria, given that more than 80% of farmers are considered smallholders, having less than 2 Ha.

One of the major reasons for Nigeria's inclusion in the EGS studies is its high potential for agricultural production and processing. Each of the major agro-ecological zones is associated with specific crops and cropping systems. Given the diversity in agricultural production, the following three stakeholder roundtables were held to ensure wide geographical coverage and adequate representation of stakeholders: a north region roundtable in Zaria (Kaduna State) on March 17, 2016; a central region roundtable in Abuja on March 18, 2016; and a south region roundtable in Umuahia (Abia State) on March 21, 2016 (Figure 22). There was a total of 88 participants in the three meetings, drawn from the formal and informal seed sectors. The meeting agenda was the same at each of the meetings in order to ensure consistent results.

***Figure 22*: Stakeholder roundtable kick-off meetings in Nigeria.**



Source: Research team analysis (2016)**.**

Discussions at each of the stakeholder roundtables were based on the crop selection framework developed to select crops for in-depth analysis in all EGS study countries. The framework consists of a matrix of ten key indicators such as area, production volume, production growth, private sector engagement, gender roles, and nutritional value, with up to five ratings definitions for each indicator. The ten shortlisted crops for consideration, based on area harvested and nutritional value, were: cassava, maize, sorghum, yam, cowpea, rice, groundnut, millet, sweet potato, and soybean. At each roundtable, participants added crops to this list that were of interest to the stakeholders in the region, as well as additional key indicators such as import competition, job creation, and economic development. Participants in each region were asked to come to a consensus on the priority crops for in-depth analysis by allowing each participant to nominate three crops, including reasons for improving those crops' EGS systems. Results were tabulated after this exercise, and the stakeholders' votes determined the top three crops.

Through this process, stakeholders at the north and middle belt region roundtables selected rice, maize, and soybean, while stakeholders at the south region roundtable selected rice, maize, and yam. This resulted in the selection of four key crops: rice, yam, maize, and soybean (as presented in Table 10) for in-depth EGS analysis.

Rice: Annual rice demand in Nigeria is estimated at 5.4 million MT. However, only 3.8 million MT of milled rice is produced domestically, resulting in a significant supply gap that is met through imports (USAID MARKETS). In 2014, Nigeria was the world's second largest rice importer after China, importing 2.4 million MT of milled rice from various countries, including Thailand and India (USDA, 2014). To increase local production and processing, Nigeria's rice sector would need to increase research, promote improved varieties, and implement policies to encourage farmers to adopt improved high-yielding rice varieties.

Within the rice commodity chain, there is also a significant opportunity to improve smallholder farmers' income. Genetically impure seeds and seeds that are not true-to-type are a major

problem, which makes it difficult for farmers to sell their crop to large processors who pay the highest prices. A more organized rice seed system that provides training on production and post-harvest best practices would promote planting of true-to-type seeds among farmers and enhance their access to more profitable markets.

Yam: Currently, the yam seed system is dominated by the informal sector, with 50-70% of smallholder farmers' production costs going toward the purchase of yam seed from rural markets. The commonly used old varieties or adopted landraces are subject to high disease pressure, which reduces yields. Furthermore, yam farmers save and replant about 30% of their harvest as seed, leading to genetic degradation and low yields over time. A structured yam seed system using relatively new rapid multiplication techniques to produce disease-free, clean seed yam would significantly increase yields and improve farmers' income.

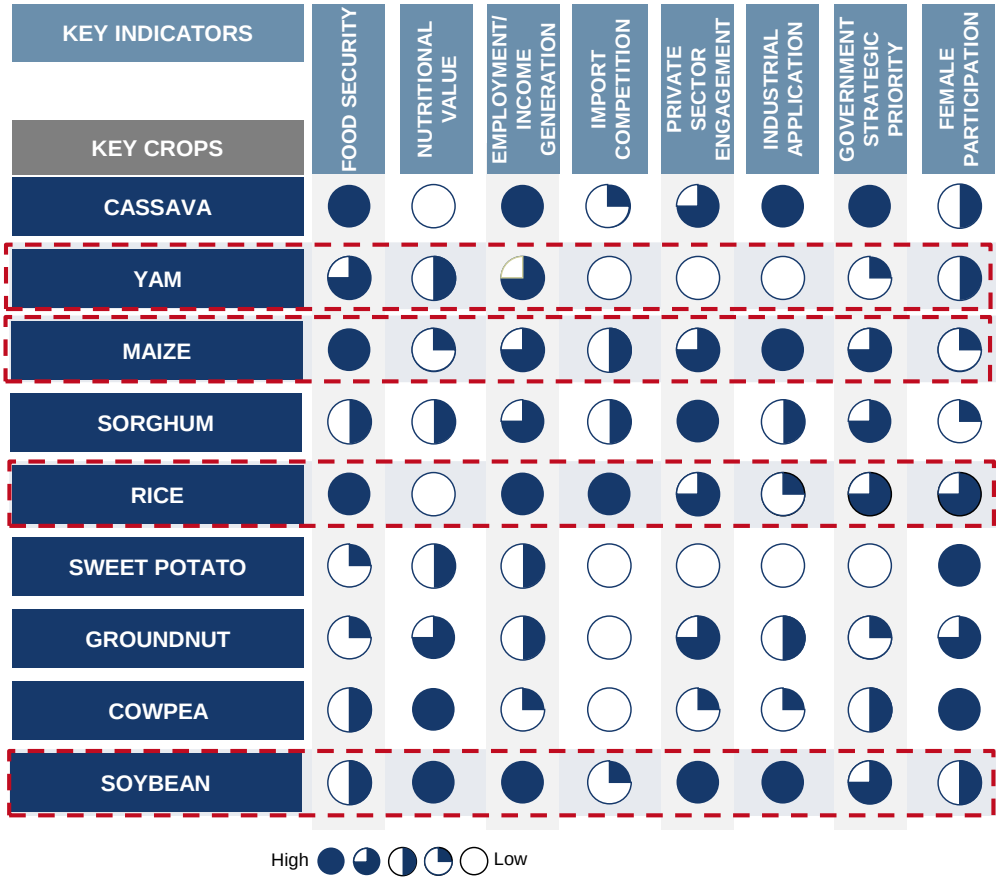
Yam is traditionally propagated by tuber, with a low multiplication rate of less than 1:10, compared to 1:200 in many cereals. This is worsened by the long growth cycle of yam. The introduction and adoption of rapid multiplication technologies, such as aeroponics and autotrophic hydroponic systems, would increase the rate of propagation and accelerate the introduction of improved varieties.

Maize: Increased production and farmer adoption of maize hybrid seeds is a priority for the FGN, as it will help ensure national food security. Due to a domestic supply gap, key producers of poultry and livestock feed, food processing companies, and breweries import large amounts of maize and maize products into Nigeria, mostly from North and South Americas, Asia, and neighboring African countries, particularly the Republic of Benin. A successful EGS system that guarantees adequate production and timely delivery of high-quality seeds, supported with the training of smallholder farmers, would increase domestic production and reduce imports.

Soybean: Given the importance of soybean as a key nutrition crop, there is a potential for increased demand for improved seeds by smallholder farmers. Malnourishment in Nigeria is among the worst 20 countries in the world. 10.2 million Nigerian children under the age of five are stunted, and about 11% of women are undernourished (DHS, 2013). The FGN and NGOs are working to boost awareness of high-energy foods and to increase household consumption of soybean. Improving awareness of the availability and affordability of processed soybean products to reduce malnutrition would generate more demand. A developed EGS system would play a key role in increasing domestic production through farmer education and the release of high-yielding varieties.

In addition, a rapidly growing animal feed sector in Nigeria has increased demand for soybean for industrial processing, which also necessitates the development and promotion of improved, more productive varieties. Currently, the most commonly grown variety is susceptible to rust disease, which reduces farmers' yield. However, other officially released varieties that are rust resistant are not adequately promoted to smallholder farmers through demonstration trials.

Table 10: **Priority crop selection results in Nigeria.**



Source: FAOSTAT (2014); Scholarly Journals of Agricultural Science (2013); Nigeria Agricultural Sector Risk Assessment, World Bank (2015).

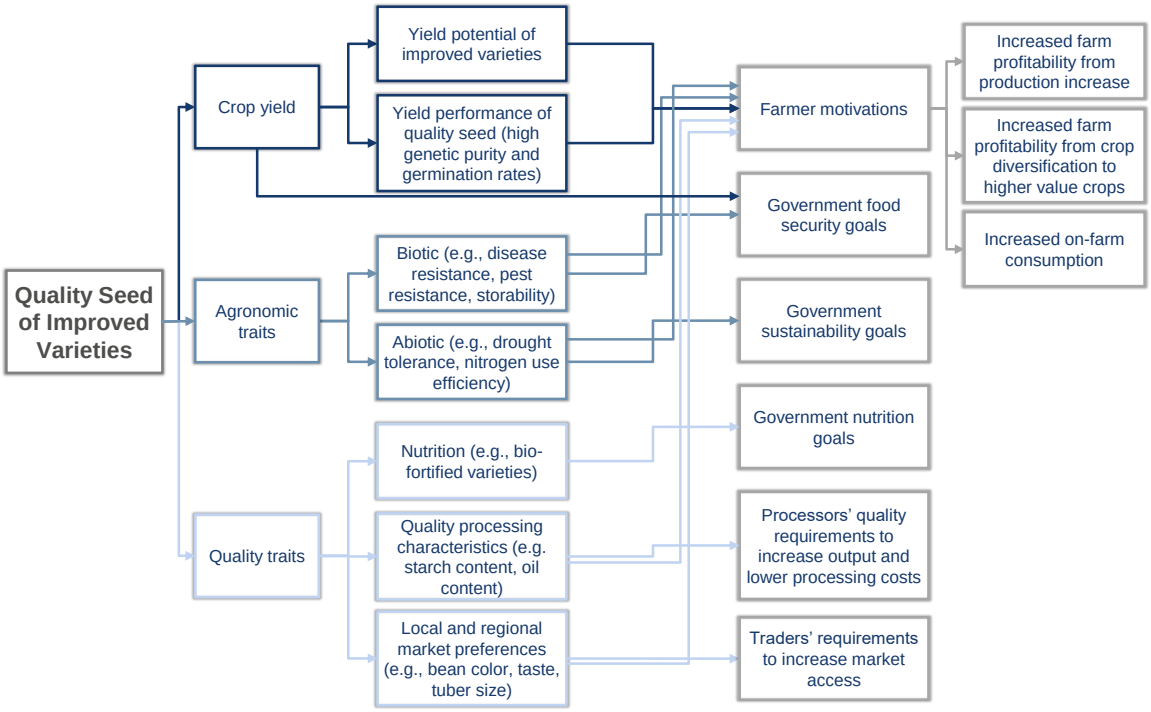
CHAPTER 2: DEMAND SUMMARY

2.1 DEMAND VARIABLES

In order to assess the potential demand for EGS, it is important to first identify the benefits and beneficiaries of quality seed of improved varieties as EGS is needed to deliver these benefits. While farmers are the most obvious beneficiaries, the findings of the EGS country studies reveal that in many cases beneficiaries extend beyond farmers to include public and private actors involved in crop value chains. Only once these demand variables and their respective beneficiaries are understood can issues constraining demand be addressed, such as lack of farmer awareness of improved varieties, lack of knowledge of agronomic best practices, and the low ability and willingness of farmers to pay the higher seed price.

Demand variables differ by crop and country, but looking across the four countries and crop value chains reveals several commonalities that help explain how EGS can address both farmer and private sector needs, as well as country level goals. Figure 23 maps these variables, starting with the potential benefits of quality seed of improved varieties, which can include crop yield, agronomic traits, and quality traits. Each of these three variables has multiple sub-benefits that are linked to the beneficiary, as elaborated in further detail below.

Figure 23: **Map of demand variables.**



Source: Team analysis.

CROP YIELD

There are many factors that influence farmer yield, including quantity, timing, and quality of inputs which include high-quality improved seed, fertilizer, and crop protection as well as best agronomic practices in crop production. While these factors are interrelated and often require a comprehensive approach to maximize yield, quality seed of improved varieties can increase yield in two key ways.

The first benefit stems from the greater yield potential of improved varieties versus older improved varieties or landraces due to advances in breeding outcomes. The other yield benefit is derived from the quality of commercial seed produced within an EGS system. A well-functioning EGS system has quality assurance systems in place that ensure that the seed produced has high levels of genetic purity and germination rates which safeguards the yield potential of improved varieties. In certain crops, saving seed leads to yield degeneration caused by disease pressure, poor production practices, or cross pollination. While it's difficult to quantify exactly how significant yield degeneration is from saving seed, some crops are more vulnerable than others. In the case of saving hybrid seed, yield drop-off is the most significant due to the inherent requirements of growing hybrid seed, which requires that male and female lines are grown in isolation.

Increasing crop yields has the potential to benefit farmers in important ways, which include increased profitability and improved food security. Profitability increases could be achieved by a farmer growing more on the same area (assuming the associated cost increases don't offset the increased revenue), which increases farmer profit. Additionally, a farmer could grow the same volume but use less land due to increased yield, allowing the farmer to grow a more profitable crop with the rest of his or her land. The other possible benefit of increased yield could be for smallholder farmers who are currently food insecure, as more production on the same land improves their food security.

TRAITS

Beyond yield, demand for EGS may also be influenced by breeding for specific traits for improved varieties. There are many types of traits specific to the agronomic challenges a farmer faces as well as the opportunities to address specific quality traits demanded by farmers, processors, and consumers.

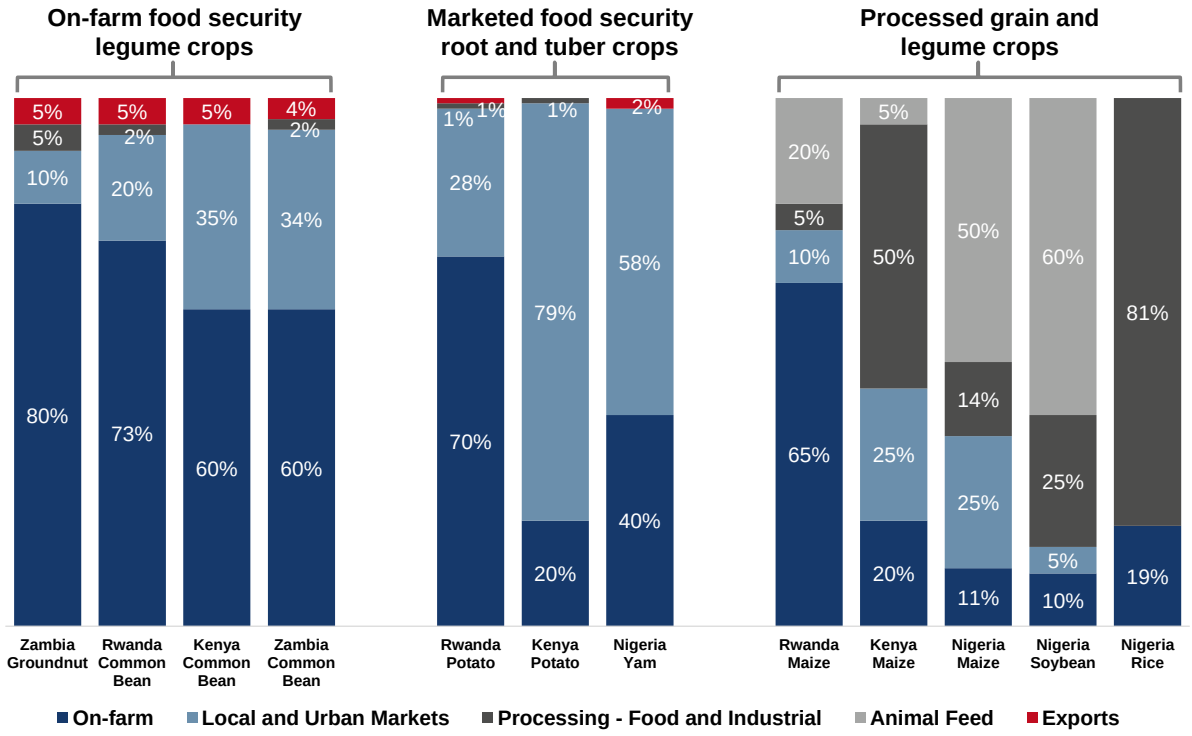
- **Agronomic traits:** Agronomic traits can come in the form of biotic traits such as disease and pest resistance and being suitable for long storage. Abiotic traits could include improved tolerance to drought or improved nitrogen use efficiency. While these traits don't increase the yield potential of an improved variety *per se*, they can protect yield from agronomic stresses as well as lower input costs (e.g., nitrogen use efficiency). Additionally, some of these traits could be aligned with government and sustainability goals. For example, if a government aims to reduce crop protection, a variety with disease or pest resistance could reduce the reliance on fungicides or insecticides.
- **Quality traits:** Improved varieties can also have quality traits for nutrition (e.g., biofortified varieties) which can help realize government nutrition goals. Quality traits can also serve processors' needs. In Nigeria, for example, starch processors demand cassava with high levels of starch content which improves the efficiency and lowers the cost of their processing operations. In some cases, processors will pay farmers higher prices for cassava that reaches their required starch levels. There are also quality traits

that meet local or regional market preferences, such as specific colors and taste preferences of common beans and tuber sizes of potato.

DEMAND SEGMENTS

Another important consideration in evaluating demand for quality seed of improved varieties is the end use demand segments in each crop country value chain. Figure 24 summarizes end use demand segments for each crop analyzed in the four country studies, which include on-farm consumption, local and urban markets, food and industrial processing, animal feed, and exports.

Figure 24: **End use demand segments of crops assessed.**



Source: Rwanda, Zambia, Kenya, and Nigeria EGS Country Studies (2016).

When analyzing the data from these studies, three groupings emerge, as described below:

- **On-farm food security legume crops:** At least 60% of crop production for common bean in Rwanda, Kenya, and Zambia, as well as groundnut in Zambia, is consumed on-farm, with the majority of the balance destined for local and urban markets, and a small volume of exports. Since smallholder farmers that grow and consume these crops are by far the largest demand segment, demand for EGS will be directly linked to how effectively quality seed of improved varieties serves these farmers' needs. A more detailed description of these farmers' motivations is described in a subsequent section of this report.
- **Marketed food security root and tuber crops:** Potato in Kenya and yam in Nigeria are also important food security crops, but rather than being mainly consumed on-farm, the majority of production is marketed in local and urban markets. This distinction is important, as farmer motivations for growing these crops is different than crops

consumed on-farm, and as such, quality seed of improved varieties should link to these motivations, which are described below. It's important to note that while Rwanda potato is an exception, as the majority of production is consumed on-farm, most crops in Rwanda have very high levels of on-farm consumption. Thus, relative to other crops in Rwanda, potato is considered a crop with high market potential (World Bank Risk Assessment 2015).

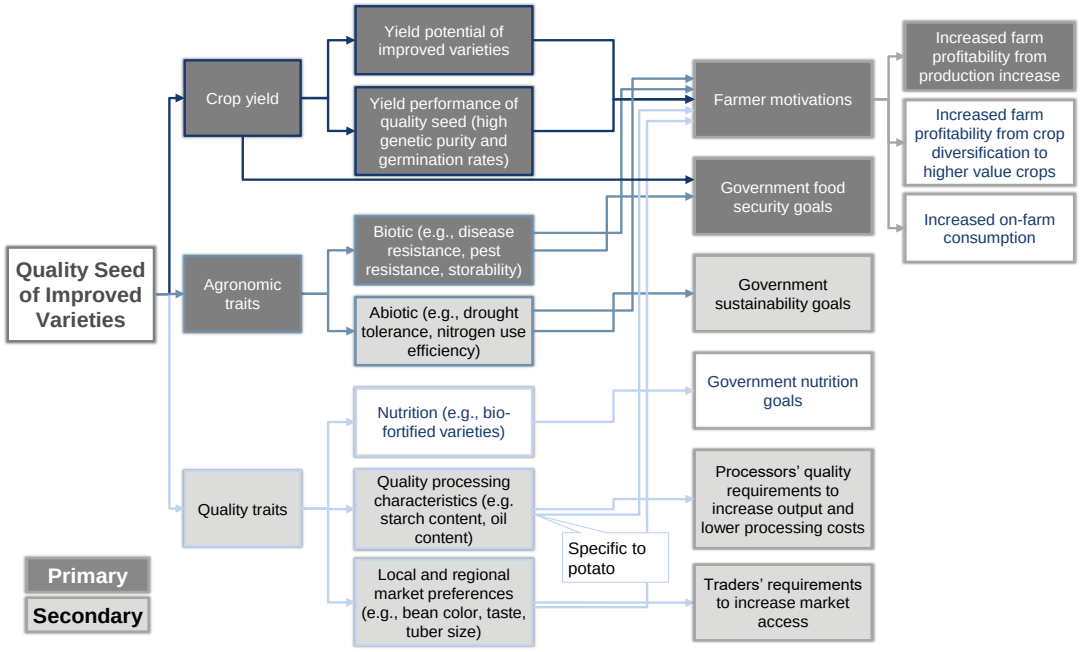
- **Processed grain and legume crops:** The third group includes maize, soybean, and rice. These crops all have high demand from food and industrial processors as well as feed animal producers. Therefore, quality of seed of improved varieties should not only benefit farmers but also address the needs of these value chain actors.

Understanding the benefits of quality seed of improved varieties as well as the beneficiaries based on examining end use demand segments and national goals is key to accurately estimating demand for EGS. Each country and crop will have variables specific to a multitude of circumstances, and therefore it is important to not overgeneralize. Nonetheless, in assessing the results of the four country studies, there are some common themes of key crops and their most important demand variables.

RWANDA AND KENYA POTATO AND NIGERIA YAM

There are similarities between the variables that drive demand for quality seed of improved varieties for the root and tuber crops assessed in the four country studies, which include potato in Rwanda and Kenya and yam in Nigeria (Figure 25). In all three instances, demand for the commodity is high and continues to grow (Nigeria EGS Study pp. 36, Kenya EGS Study pp. 33, Rwanda EGS Study pp. 23). Potato and yam are considered highly profitable crops for farmers, and therefore farmers are more likely to invest in technologies, such as quality seed of improved varieties, that would increase their yields.

Figure 25: **Map of demand variables – Rwanda and Kenya potato, Nigeria yam.**



Source: Rwanda, Kenya, and Nigeria EGS Country Studies (2016).

Demand is high for improved varieties that have agronomic traits that address a series of abiotic and biotic challenges farmers face. For example, in Kenya there are 30 listed varieties of potato for conventional management and 19 for high-input, intensive management (Table 11). Given ecological and agronomic conditions, attractive characteristics include drought tolerance, resistance to diseases such as late blight, and a short dormancy period.

***Table 11*: Key potato varieties in Kenya.**

Key potato varieties

Variety Name	Developer	Year of Release	Special Attributes
Dutch Robijn	KARI	1960's	Good storage and crisping qualities
Tigoni	KARI	1998	Good chipping, boiling and mashing quality; tolerant to late blight
Asante	KARI	1998	Good chipping, boiling and mashing quality; fairly tolerant to late blight
Kenya Sifa	CIP	2006	Medium late to late maturity, high yields with good tuber and culinary characteristics
Kenya Karibu	CIP	2006	Medium late to late maturity, high yields with good tuber and culinary characteristics
Kenya Mpya	KARI/CIP	2010	Resistant to late blight; good storability; short dormancy; good for table, chips, and mashing; wide adaptability
Sherekea	KARI/CIP	2010	High tubers per plant; highly resistant to late blight/viruses; good storability; good for table, crisp, and mashing
Shangi	KALRO	2015	Early maturity, short dormancy, highly prolific, fast cooking, versatile use

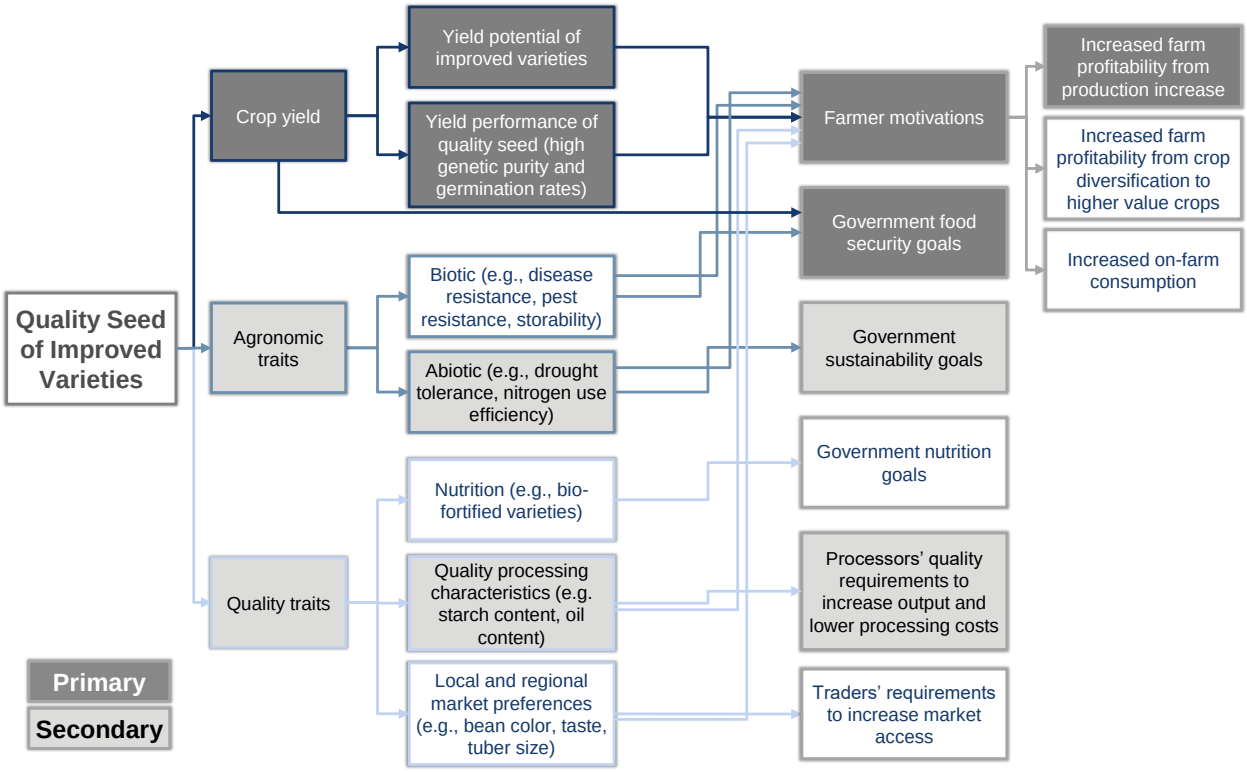
Source: KEPHIS (2016), Field research team interviews (2016).

Additionally, farmers need to replace seed often due to high levels of disease and pest pressure (in the case of potato late blight, brown rot, viruses, and potato tuber moth). Adopting quality seed lowers farmers' risk of contaminating their fields through saving seed. Improved varieties also have agronomic traits that better protect farmers' yield from these disease pressures. A small, growing segment of potato processors is emerging in both Rwanda and Kenya who are demanding potato with specific quality characteristics that meet their needs for crisps and chips. As this demand segment grows, quality traits could become an additional primary driver of EGS demand.

RWANDA, KENYA, AND NIGERIA HYBRID MAIZE

Farmer demand for hybrid maize is based primarily on its yield benefits (Figure 26). In Kenya, Nigeria, and Rwanda, adoption of hybrid maize has continued to grow, replacing OPVs despite the fact that hybrid seed is much more expensive, requires buying new seed each year, and often requires investment in other inputs such as fertilizer.

Figure 26: **Map of demand variables – Rwanda, Kenya, and Nigeria hybrid maize.**



Source: Rwanda, Kenya, and Nigeria EGS Country Studies (2016).

Farmers continue to adopt hybrid maize varieties, despite the higher investment cost, because the improved yields increase their profitability. Table 12 lists some of the key maize hybrids and OPVs in Rwanda and the significant difference in yield potential.

Table 12**: Key hybrids and OPVs in Rwanda.**

Key maize varieties

	Variety Name	Developer	Country	Potential Yield Estimates MT/Ha
Hybrids	H628	Kenya Seed Company	Kenya	3-5 MT/Ha
	H629	Kenya Seed Company	Kenya	
	PANNAR 691	PANNAR	South Africa	
	SC 719	SEEDCO	Zambia	
	SC 637	SEEDCO	Zambia	
	DH 04	Kenya Seed Company	Kenya	
	PANNAR 4M21	PANNAR	South Africa	
	PANNAR 53	PANNAR	South Africa	
	PANNAR 67	PANNAR	South Africa	
	SC 513	SEEDCO	Zambia	
	SC 403	SEEDCO	Zambia	
OPV	ZM 607	RAB	Rwanda	1-3 MT/Ha
	M101	RAB	Rwanda	
	Pool 9A	RAB	Rwanda	
	M103	RAB	Rwanda	

Source: Rwanda EGS Study (2016).

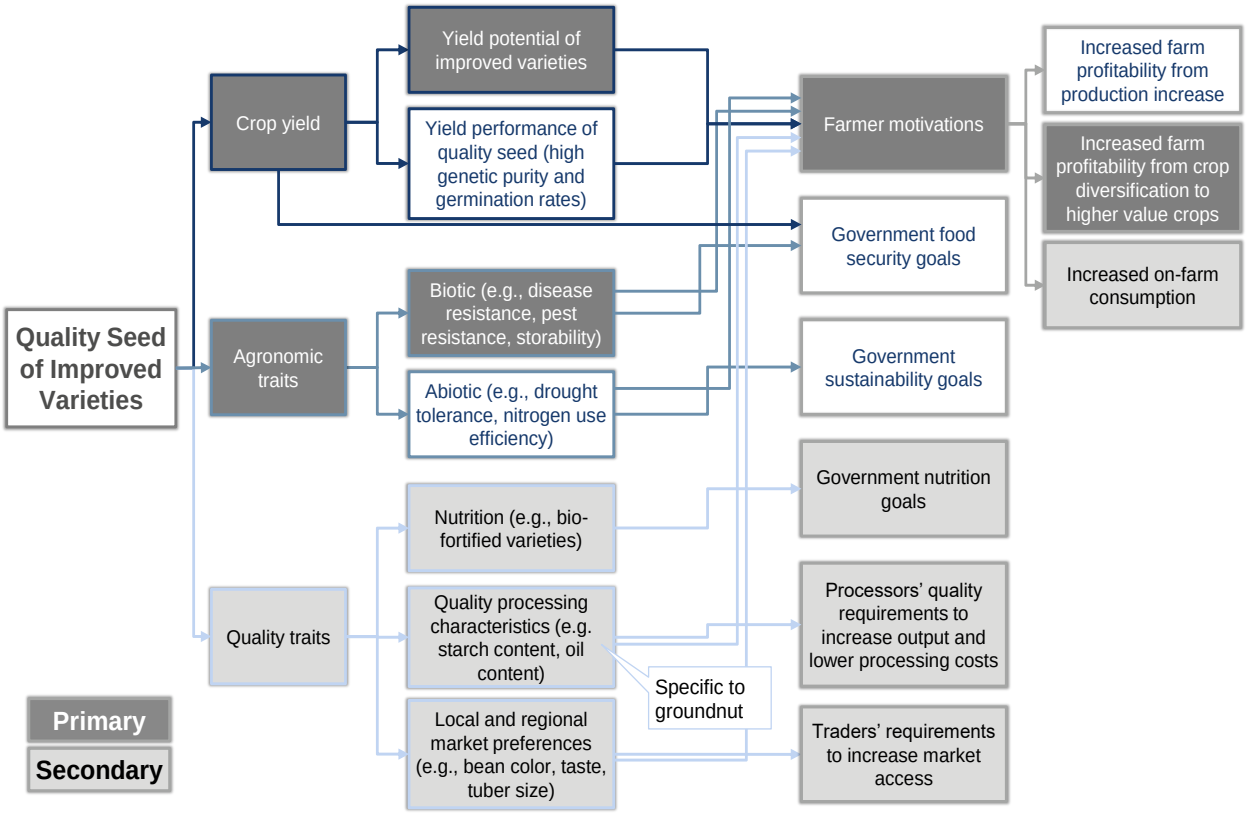
All three countries are net importers of maize, and as such, their governments have made decreasing reliance on maize imports an important component of their agricultural strategies, which could also be considered an important variable of EGS demand.

Additionally, as previously mentioned in this section, Rwanda, Kenya, and Nigeria have large and growing demand for food processing and animal feed. While the majority of these processors are less sophisticated hammer mills, there is an emerging segment of roller millers that process higher value milled grain (Rwanda EGS Study pp. 44). As these millers grow, demand for maize production that meets specific quality requirements, such as moisture level, will likely increase, resulting in higher prices for production that meets these requirements. As a result, demand for improved varieties that possess these quality traits could also increase, resulting in higher demand for EGS.

RWANDA, ZAMBIA, AND KENYA COMMON BEAN AND ZAMBIA GROUNDNUT

Both common bean and groundnut were identified as key food security crops to smallholder farmers in all the countries assessed. In Rwanda common bean is the most important crop in terms of national consumption, food security, geographical coverage, and the percentage of households producing it (92%). With 56% fiber and 25% protein content, common bean is an important nutritional complement to starchy cereal and tuber-based diets (World Bank, 2015). Common bean is Kenya's second-largest crop by area and represents a significant staple crop across the country. The Kenya Agricultural Research Institute (KARI) estimates that 1.8 million households are involved in the production of pulses in general, with common bean estimated to contribute 85% of that total, or 1.5 million households countrywide. In Zambia, common bean is the third-most important legume crop in terms of area and production but is considered the second-most important food security crop behind maize, as it is consumed by the majority of the population in many forms including the pod, the green seed, and the mature dried bean. While only 16% of smallholder farmers grow common bean nationally, Northern and Muchinga smallholder farmer share is 54% and 36%, respectively (Zambia EGS Study 2016). Groundnut is the most important legume in Zambia; with the majority of groundnut consumed on-farm. As an important nutritional component of the traditional Zambian diet, it is consumed as a snack, as peanut butter, as a powder mixed with a variety of vegetables or crops to make traditional dishes, and as an excellent source of cooking oil.

Figure 27: **Map of demand variables – Rwanda, Kenya, Zambia common bean, and Zambia groundnut.**



Source: Rwanda, Zambia, and Kenya EGS Country Studies (2016).

With relatively small demand for marketed common bean and groundnut and minimal processing and exports, demand for quality seed of improved varieties will primarily be driven by the benefits provided to smallholder farmers. These benefits are most likely to either improve their food security situation or allow smallholders farmers to diversify into higher value crops by growing the same volumes of common bean or groundnut on less land.

Common bean and groundnut yields are quite low, and saving seed doesn't have the significant yield degeneration consequences and risks associated with hybrid maize and potato, which lowers the demand for EGS. Furthermore, farmers don't see the value of adopting improved varieties over farmer-saved seed. In Zambia, for example, farmers perceive the cost of producing certified groundnut seed to be three times that of saving seed (Figure 28).

Figure 28: **Formal versus informal variable cost basis – groundnut.**[7]

Formal vs. Informal Market on Variable Cost Basis Example: Groundnut ***MGV5***

Formal Market Cost/Ha Certified Seed Production Costs		**Informal Market Cost/Ha** Informal Seed Production Costs		**Informal Market Cost/Ha** Saved Seed Production Costs	
Seed Cost (Basic)	$300	Purchase Open Market	$150	Recycled Seed	$0
Fertilizer	$250	Fertilizer	$190	Fertilizer	$130
Pesticide	$88	Pesticide	$48	Pesticide	$25
Planting & harvesting	$664	Planting & harvesting	$510	Planting & harvesting	$210
Labor general	$400	Labor general	$308	Labor general	$208
Transportation	$20	Transportation	$20	Transportation	$0
Inspection/lab/ germination fees	$45	Inspection/lab/ germination fee	$10	No Inspection	$0
Other variables	$500	Other variables	$415	Other variables	$175
Total Variable Cost	**$2,267**		**$1,651**		**$748**
Estimated Yield Kg/Ha	*1,500*		*1,350*		*1,270*
Estimated Cost USD/Kg	**$1.51**		**$1.22**		**$0.58**

Perceived Cost Difference = ~3x

Source: Research team analysis (2016).

While there are biofortified varieties being developed and marketed in Rwanda through HarvestPlus, there isn't a strong government effort to promote these varieties, which might make a difference, if there was one.

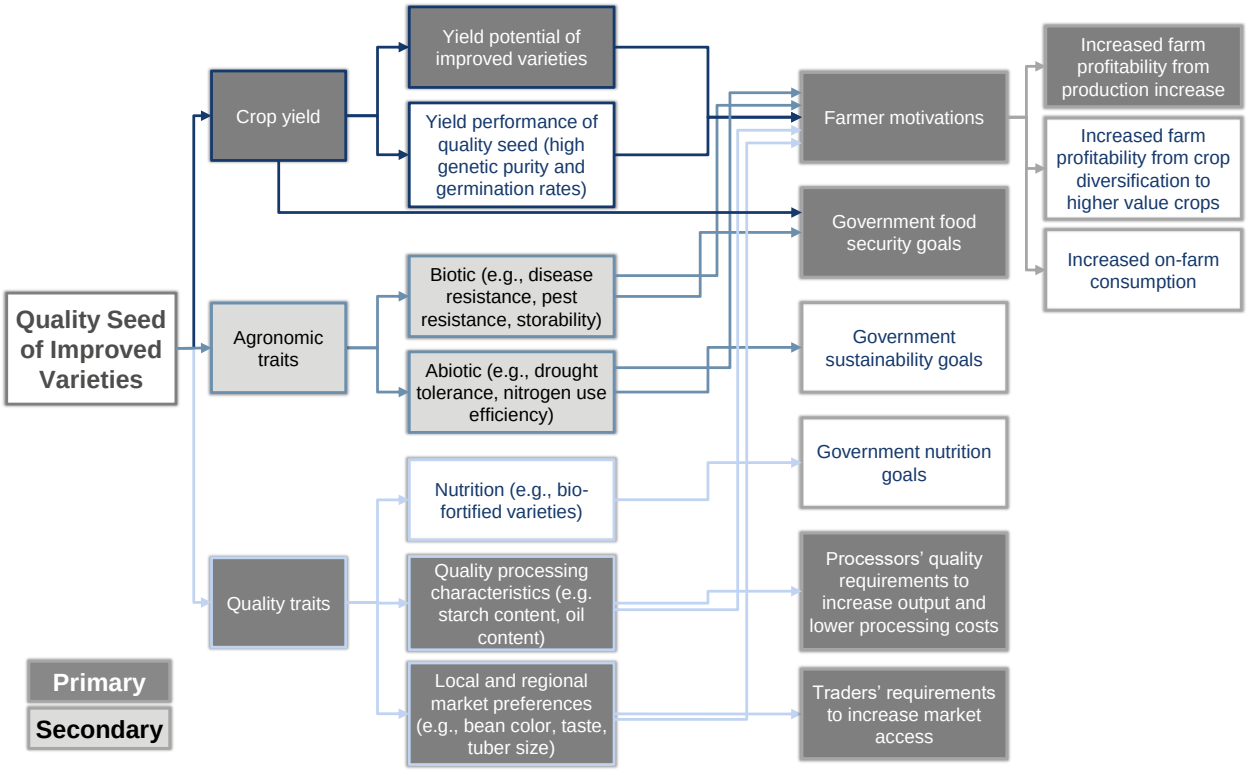
The main differentiating demand variable between common bean and groundnut is that with groundnut, there is potential for high value processing demand for a specific quality, such as oil content. Currently Zambia's processing and export sectors are small and undeveloped. Processors for both domestic and export markets are extremely sensitive to aflatoxin concerns about groundnut sourcing. The potential for reinvigorated exports is strong but only if standards can be established and enforced to ensure reliable aflatoxin control systems.

NIGERIA RICE

Rice represents the second-largest grain crop in Nigeria after maize and is a key food crop across the country, constituting more than 20% of total food expenditure among urban and rural households. While Nigeria is the leading producer of paddy rice in Africa, with 6.7 million MT in 2014, there is a significant demand-supply deficit of 1.6 million MT of milled rice that was filled by imports.

[7] Labor costs are estimated to be higher in the formal production system because labor is assumed to be hired while in the informal sector, it is assumed less labor would be hired and fewer operations conducted (e.g., one plowing rather than two). For the farmer-saved seed calculation, no labor costs were assumed because in interviews with farmers, they consistently mentioned that they do not count their own labor as a cost. While there is clearly a cost to time, the purpose of this calculation was to show how the farmer perceives the cost of seed.

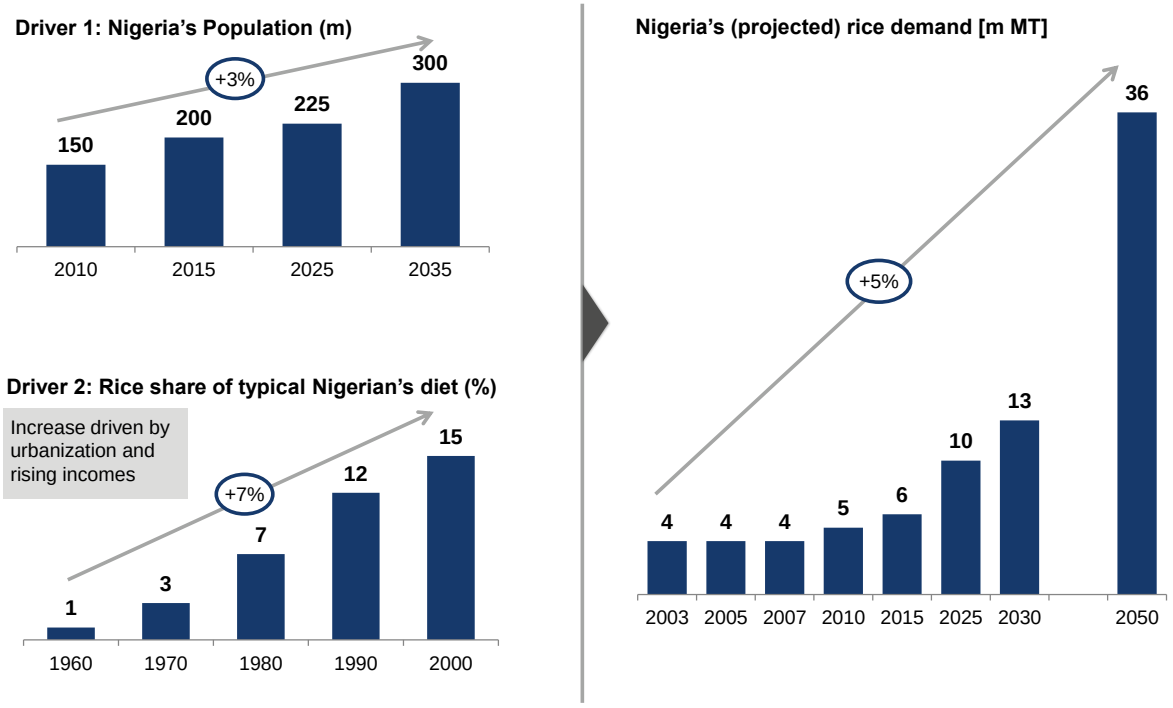
Figure 29: **Map of demand variables – Nigeria rice.**



Source: Nigeria EGS Country Study (2016).

With population growth and changing consumer preferences and dietary patterns of the growing middle class, the Federal Ministry of Agriculture and Rural Development (FMARD) estimates a six-fold increase in rice demand from 2015 to 2050 (Figure 30).

***Figure 30*: Projected rice demand in Nigeria.**



Source: Federal Ministry of Agriculture and Rural Development – ATA.

The majority of locally produced rice is sold to cottage millers and large-scale integrated millers. There are approximately 700 rice mills in Nigeria, which are mainly cottage millers. In 2014, there were 21 integrated rice mills in Nigeria, with a combined annual capacity of more than 1 million MT. However, they operate below capacity due to a shortage of rice resulting not only from poor yields but from competition with cottage millers who process most of the rice produced by smallholder farmers for rural and peri-urban markets.

An important component of the FGN's rice strategy has been an attempt to reduce Nigeria's dependency on rice imports by enacting policies that catalyze local investment and production.

There are more than 75 rice varieties in Nigeria, including 63 varieties released by the National Cereals Research Institute (NCRI) that are nitrogen- and water-efficient, pest- and disease-tolerant, and adapted to all rice-producing regions in Nigeria.

NIGERIA SOYBEAN

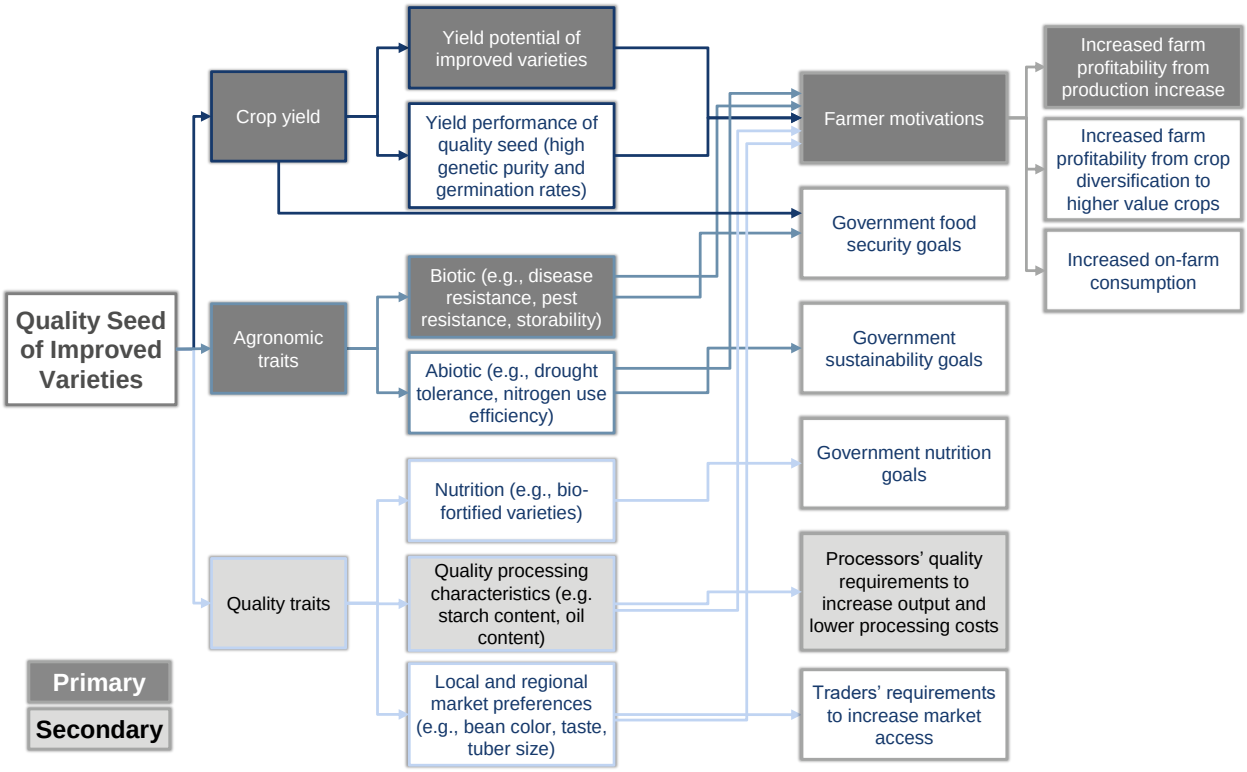
Nigeria is the second-largest soybean producer in SSA, with a production of 679,000 MT in 2014 (FAOSTAT, 2016). Soybean is an important cash crop to farmers and a good raw material for oil and cake extraction, as well as livestock and poultry feed.

During the last ten years, private sector demand for soybean has increased as a result of new processing facilities built in both northern and southern areas. Currently, the processing capacity of soybean in Nigeria exceeds the production and supply of local soybean. Demand for soy-based products in Nigeria is substantial, especially among commercial consumers in the food, paint, pharmaceutical, and confectionery industries. More than 70% of soy is processed

for industrial use. These industries utilize soybean in various forms, such as bean, meal, cake, and oil.

Local production of soybean has been increasing but continues to fall short of demand because of low yields and poor agronomic and post-harvest practices (Boateng, 2012). Currently, imports of soybean and its derived products from neighboring countries as well as the U.S. and Argentina contribute less than 6% to the total supply. However, soybean demand is projected to increase to 2.3 million MT by 2020, because of a steady increase in poultry sector consumption (Nigeria EGS Study pp. 55). These newer varieties have low shattering qualities and are resistant to rust disease, a significant issue that accounts for ~40% of soybean loss in Nigeria.

Figure 31: **Map of demand variables – Nigeria soybean.**



Source: Nigeria EGS Country Study (2016).

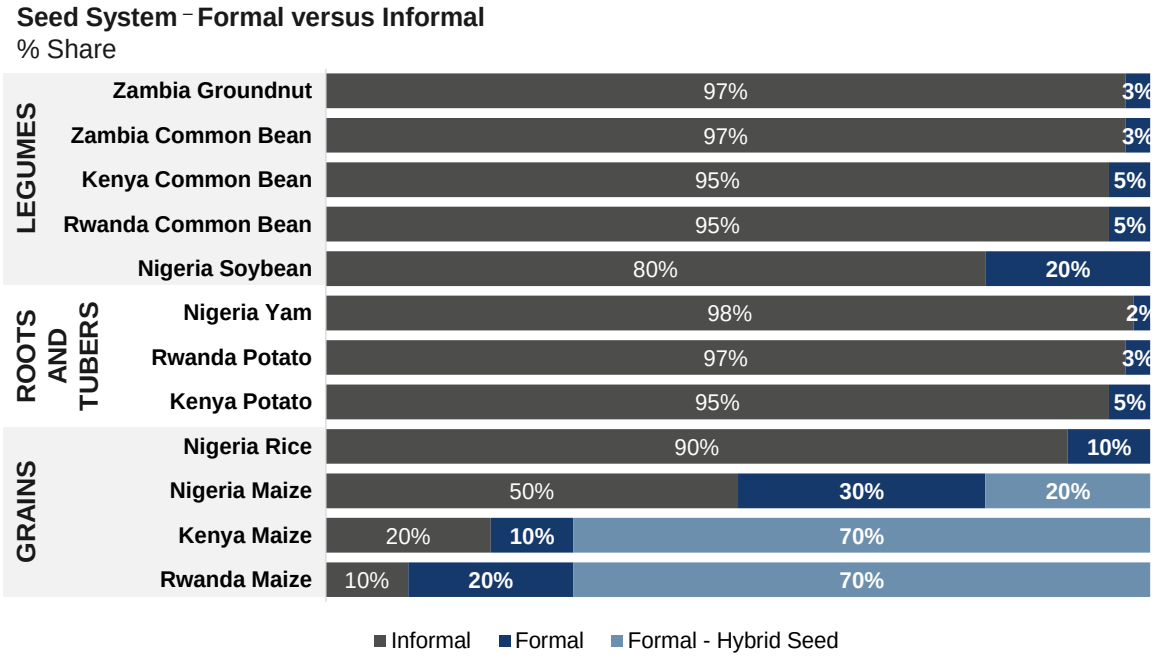
2.2 POTENTIAL EGS DEMAND VERSUS THE CURRENT BASELINE

One common finding across all crops analyzed is that demand for EGS exceeds supply. While this is an important conclusion, it is necessary to assess the magnitude of the supply and demand imbalances for each crop. In other words, while two crops assessed might both be classified as having "high" demand, the current EGS supply situation of both crops could be markedly different. One crop might have enough supply to satisfy 80% of potential EGS demand while the other crop might only have 5% of the supply necessary to satisfy potential demand. These differences help explain not only the severity of the imbalance but also the general stage of the development of each crop system.

In the 1990s both the International Food Policy Research Institute (IFPRI) and the International Maize and Wheat Improvement Center (CIMMYT) developed similar frameworks to classify the maturity levels of seed systems (Morris, 1998 and IFPRI, 1991). Both of these frameworks classified seed systems into four maturity levels which include (1) Pre-industrial, (2) Emergence, (3) Expansion, and (4) Maturity. Both of these models were based on a linear approach along a fixed pathway of seed sector development, which is limiting as it doesn't take into account the diversity of crops and seed systems even within one country (Louwaars, de Boef, Edeme). However, these approaches are useful for crops such as hybrid maize in which a formal system is required. Recent work by Integrated Seed Sector Development (ISSD) has focused on a more pluralistic, crop-specific approach to seed sector development.

Figure 32 elaborates on the ISSD approach, revealing the varying shares of the informal and formal seed systems among crops studied in the four countries.

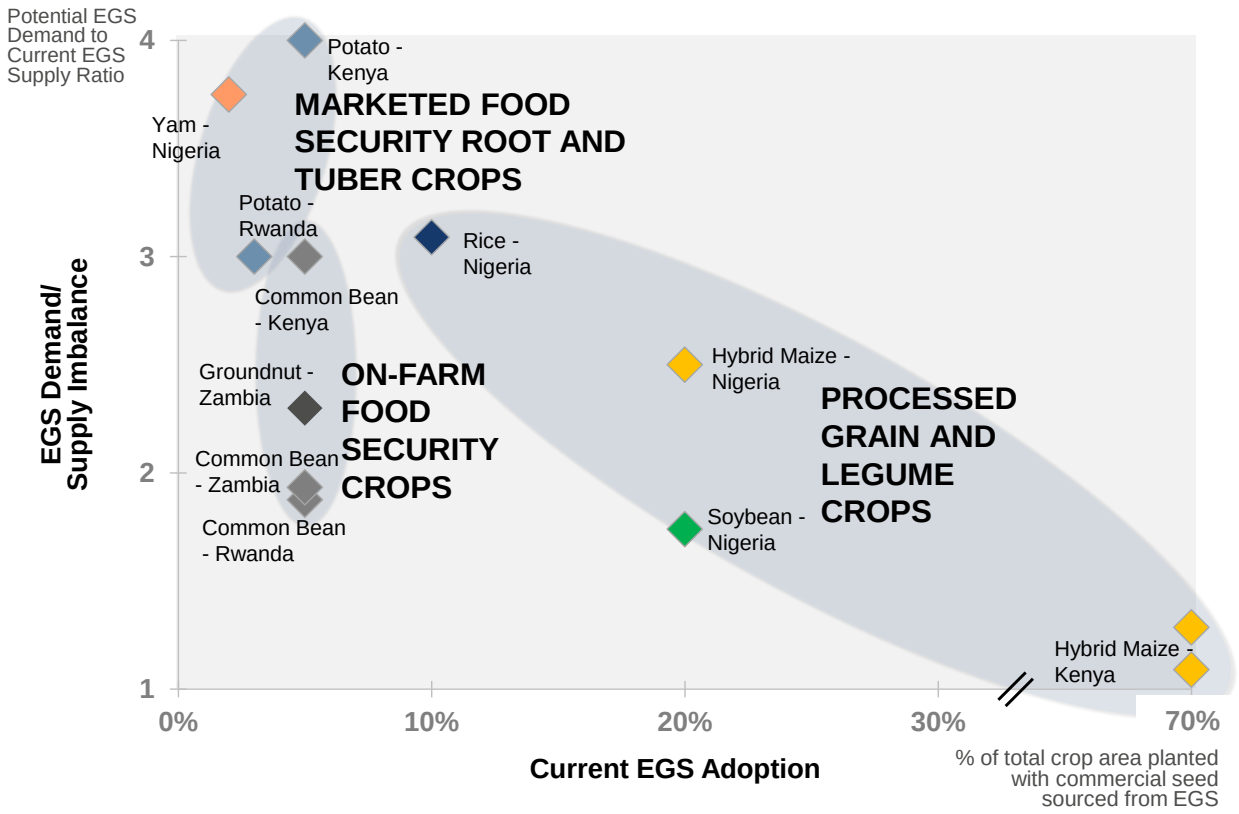
Figure 32: **Share of formal versus informal seed system by crop and country.**



Source: Rwanda, Zambia, Kenya, and Nigeria EGS Country Studies (2016).

Utilizing data from the four EGS country studies, each crop was plotted based on the current supply of EGS as the percentage necessary to supply the total planted area of the crop in that country (x-axis) versus the estimated potential EGS demand to current EGS supply ratio (y-axis). Figure 33 reveals that the crop groups (as characterized by end use demand segments in Figure 24) have distinct levels of EGS adoption and demand/supply imbalances, which supports the ISSD model. While each of the crops can be thought of as existing at a different point in EGS system development, it is not the case that all crops will develop in a similar linear fashion.

Figure 33: **EGS adoption and demand & supply imbalance by crops assessed.**



Source: Team analysis.

Crops and their respective seed systems are further elaborated below:

- **On-farm food security crops**: On-farm food security crops are characterized as having low EGS market penetration (less than 5% current EGS adoption of total planted area) and modest demand potential (less than 2.5 times current supply). Three of the twelve studied crops fall within this grouping. They are Zambia groundnut and Rwanda and Zambia common bean. These legume crops play similar roles in their respective countries as mainly food security crops with high rates of on-farm consumption (over 60%). Common bean in Kenya has a similar level of EGS adoption as these crops, but potential demand is slightly higher. While it's difficult to conclude if common bean in Kenya should or should not require a different classification, there are no significant differences from the EGS demand variables in Kenya for common bean versus Rwanda and Zambia that would justify a different classification.
- **Marketed food security root and tuber crops**: Similar to the on-farm food security crop cluster, marketed food security root and tuber crops have very low market penetration. The main difference, however, is that potential demand far exceeds EGS current supply, which suggests that the value of improved varieties is better understood by farmers. Key crops in this cluster include potato in Rwanda and Kenya, and yam in Nigeria.

- **Processed grain and legume crops**: Crops that already have a high percentage of EGS supply relative to the total planted area could be considered more mature with respect to EGS and are likely to have a lower potential demand versus supply imbalance. This is logical because the opportunity for growth would be lower relative to crops that don't have high levels of EGS supply. Hybrid maize in Rwanda and Kenya are examples of maturing crops, as penetration is already 70%. We note, however, that these crops are by no means fully mature as there is still significant growth opportunity. Furthermore, this analysis only pertains to the crops in the particular country settings that we studied and not to "mature" crops in countries with more developed agricultural sectors.

Figure 34 below further explains common characteristics of the crops assessed. The informal seed system dominates the on-farm food security crops through farmer-saved seed and farmer-to-farmer exchanges, while a formal seed system producing EGS with quality assurance processes in place is very small (Figure 34). Farmers mostly plant local varieties as the EGS systems are in such early stages that improved varieties have not reached farmers in large quantities. The varieties planted are highly dependent on local preferences, and as a result, highly fragmented with hundreds of varieties in circulation. Demand for improved varieties is relatively low as farmers either are not aware of the value of improved varieties or the value is yet to proven or demonstrated on a large scale. While demand does exceed supply and addressing supply bottlenecks is essential, the clear top priority for these crops is to generate demand by demonstrating the value of improved varieties to farmers.

Figure 34: **Seed systems by crops assessed.**

	ON-FARM FOOD SECURITY CROPS	MARKETED FOOD SECURITY ROOT AND TUBER CROPS	PROCESSED GRAIN AND LEGUME CROPS
Seed System	Informal dominates: farmer-saved and farmer exchanges	Mostly informal, emerging formal: certified and/or QDS	Expanding formal: certified and/or QDS
Varieties	Almost all local varieties, highly fragmented market with hundreds of varieties	Improved varieties demanded, but often sourced informally	Improved variety adoption growing versus local
Supply/ Demand Description	Demand for EGS low, value of improved varieties not well proven or understood by farmers	Demand for EGS exists, however significant supply bottlenecks preventing growth	EGS system is satisfying some demand, supply bottlenecks and/or demand constraints impeding growth
Examples	Common bean (Rwanda, Kenya, Zambia), groundnut (Zambia),	Potato (Rwanda, Kenya), yam (Nigeria)	Hybrid maize (Rwanda, Kenya, Nigeria), soybean (Nigeria), rice (Nigeria)

Source: Team analysis.

Examples of crops studied in the marketed root and tuber surplus include potato in Rwanda and Kenya and yam in Nigeria. While similar to the on-farm food security crops with informal systems dominating, there is an emerging certified and/or QDS system driven by high demand for improved varieties. Farmers are more aware of the benefits of improved varieties, and they demand specific varieties. However, significant supply bottlenecks throughout the EGS system prevent these varieties from reaching farmers on a large scale.

The processed grain and legume crops include Rwanda, Kenya, and Nigeria hybrid maize, and Nigeria soybean and rice. These crops (especially hybrid maize) have higher levels of penetration through a formal seed system and a steady pipeline of improved varieties being developed and marketed. While supply bottlenecks and demand constraints exist, it is often policy reforms that are needed to increase private sector dominance of the market.

While the linear model of seed system development developed by CIMMYT and IFPRI referenced above is limited by its lack of a crop-oriented approach, the model could be useful when applied at a crop level. For example, in Morris' model (CIMMYT) focusing on the stages of maize seed industry development (Table 13 below), hybrid maize in Nigeria, Kenya, and Rwanda would be classified in different stages.

Table 13: **Characteristics associated with the stages of maize seed industry development.**

Characteristics	Stage 1: Preindustrial	Stage 2: Emergence	Stage 3: Expansion	Stage 4: Maturity
Orientation of agriculture	Subsistence	Semisubsistence	Mostly commercial	Completely commercial
Predominant seed technology	OPVs	OPVs, some hybrids	Some OPVs, hybrids	Hybrids
Seed procurement practices	On-farm production, farmer-to-farmer exchange	On-farm production, farmer-to-farmer exchange, some purchasing	Frequent purchasing	Annual purchasing
Seed production	On-farm	On-farm, public organizations	On-farm, public organizations, private companies (national)	Private companies (global)
Seed market coverage	Local	Local, regional	Local, regional, national	Local, regional, national, global
Sources of seed information	Direct experience, other farmers	Public agencies	Private seed companies	Private seed companies
Locus of seed research and development	On-farm	Public organizations	Public and private organizations	Public and private organizations (specialized)
Supporting legal systems Intellectual property rights	Customary law None	Civil None	Commercial (domestic) Trade secrets	Commercial (global) Plant varietal protection, patents

Source: Maize Seed Industries in Developing Countries (1998), CIMMYT, Morris, M.

With only 20% hybrid penetration, Nigeria's maize seed sector is approximately at Stage 2: Emergence. Rwanda and Kenya, with 70% hybrid penetration are farther advanced in Stage 3: Expansion. However, Rwanda is less advanced due to the high share of on-farm consumption of maize (65%) compared to Kenya (20%) as the Expansion stage classifies the orientation of agriculture as "mostly commercial."

Unfortunately, there is no established framework of variables or criteria to measure the maturity of crop seed systems beyond maize. However, a few observations may be in order.

Among the root and tuber crops assessed in the country studies, potato in Kenya, with a 5% formal share is relatively, albeit slightly, more developed than potato in Rwanda, with only a 3% formal system. In both countries, the adoption of improved varieties is relatively high, especially when compared to yam in Nigeria, the most immature system with only a 1-2% formal share.

With respect to legume crops, both common bean in the three countries assessed (Rwanda, Kenya, and Zambia) and Zambia groundnut are dominated by the informal system, with very low levels of adoption of improved varieties. One important differentiating factor for comparing

levels of maturity is whether a QDS system exists in a country for crops with lower marginal economic value such as common bean and groundnut. Zambia is the only country of the three that uses a QDS system, where it is estimated to account for ~10% of the market for groundnut and common bean.

CHAPTER 3: SOURCES OF ECONOMIC VALUE

3.1 THE VARIABLES OF EGS MARGINAL ECONOMIC VALUE

Assessing the marginal economic value of EGS is an assessment of profitability and is a proxy for the commercial attractiveness of the sector. For seed production, which is done at three different levels (breeder, basic, and commercial), the marginal economic value can be evaluated at each level. If an EGS system is found to have positive marginal economic value, it is less likely to require public support than if the opposite is true. There are many factors that influence the marginal economic value of a given crop, including cost and revenue.

Cost factors include the fixed and variable costs of seed production, the potential seed production yield of a given crop, and the ease of transporting a crop. Seed production costs are highly dependent upon the land, labor, and machinery needed to produce a given crop, and they vary significantly by crop type. For example, soybean production requires significant labor costs due to the many field activities (e.g., weeding) required to grow the crop. Hybrid maize also has very high seed production costs due to the specific requirements associated with producing isolated male and female lines, which necessitates higher qualified and costly technicians. Seed production yields are also highly variable by crop with legume crops being very low yielding, while grain and root and tuber crops are higher yielding. Higher seed production yields bring average costs of production down (all other things being equal), as costs can be spread across the larger volumes produced. Transportability is also an important factor when calculating marginal economic value. If a crop is bulky (meaning higher planting rates are required to plant a given area), then logistical and storage costs will also be higher due to the larger volumes.

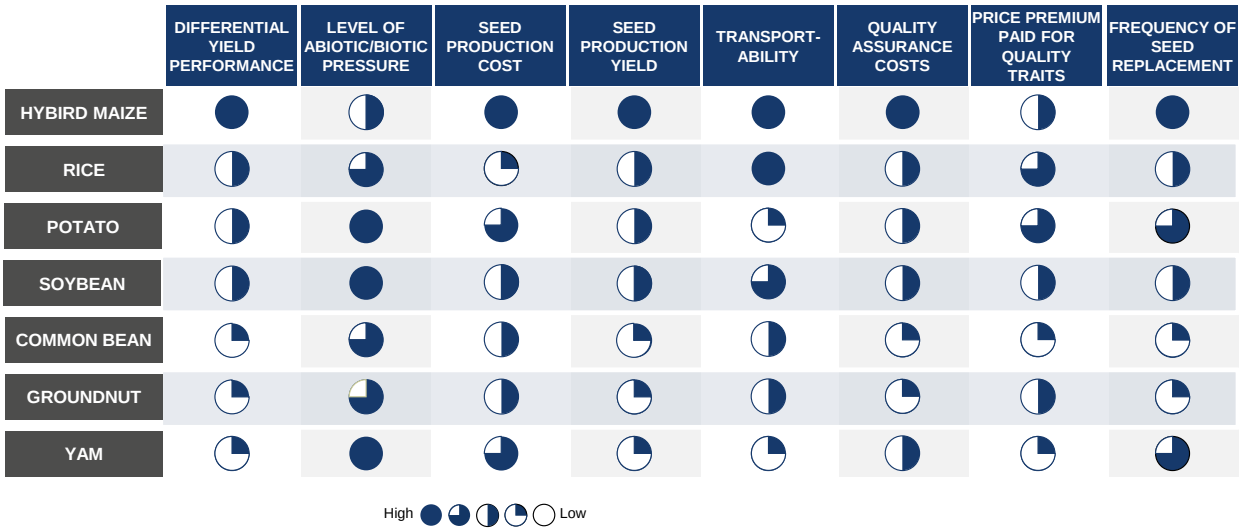
The cost of EGS production has a major impact on the optimal archetype for each crop, on the ability to scale EGS supply, and on the sustainability of the system. Understanding the cost is critical to developing a realistic and achievable plan for increasing supply.

In addition to costs, there are also many revenue factors that affect marginal economic value. One of the most important revenue factors is the differential yield performance of a given variety relative to the baseline condition. In theory, the higher the differential, the higher the value generated by adopting the improved variety and, presumably, a higher willingness to pay. Hybrid maize varieties typically have the highest differential yield while other crops are more dependent on the success of breeding programs that are developing improved varieties. Similarly, the levels of abiotic and/or biotic pressure, along with the agronomic traits to counter these pressures, affect the value of improved varieties. As mentioned earlier, soybean rust can negatively impact farmer yields in Nigeria by up to 40%, so improved varieties with rust resistance (if demonstrated correctly) could increase a farmers' willingness to purchase EGS seed. Quality traits also affect marginal economic value, as farmers could sell their production at a higher price by achieving quality specifications required by processors.

3.2 OPPORTUNITIES TO IMPROVE EGS MARGINAL ECONOMIC VALUE

Identifying the variables of marginal economic value is an important first step in understanding how to improve a crop's profitability. While profitability of all crops analyzed could be improved, there were differences with respect to which factors were most important for each crop. Figure 35 provides a high-level comparison of the variables of marginal economic value in each crop, which helps focus recommendations on crop-specific opportunities to improve profitability.

Figure 35: **Potential sources of economic value of improved varieties.**



Source: Rwanda, Zambia, Kenya, and Nigeria EGS Studies (2016).

Each crop assessed is rated from low to high based on the impact of each variable that contributes to marginal economic value. Insufficient data is available to weight each variable according to its importance to marginal economic value. This study's analysis provides some insights into the opportunities for each crop as well as a qualitative assessment of the importance of each variable. Below are summaries for each crop:

- **Hybrid maize:** It has the highest marginal economic value potential of all crops due to the high differential of yield performance of improved varieties and high seed production yield which lowers cost of production on a per hectare basis. Furthermore, planting rates are the lowest of all crops assessed (~20-25 Kg/Ha), allowing for the lower cost of transportation, which enables a simplified central production system. While seed production costs are relatively high due to the technical requirements of producing hybrid seed with male and female lines, these costs are offset by the value generated through yield increases when adopting hybrid maize.
- **Rice:** It also has a high relative marginal economic value relative to many other crops due to the low production and transports costs associated with low planting rates. While the yield potential of improved varieties is not as pronounced as hybrid maize, for example, they are still relatively high. Additionally, and specific to Nigeria, demand for high-quality rice is growing, and integrated rice processors are likely to pay high prices for rice with specific quality traits, which would serve to lower processing costs.

- **Potato:** While the marginal economic value of potato varies, there are many opportunities to increase its value. In both Rwanda and Kenya, disease pressure is a significant issue for farmers, which encourages them to adopt improved varieties with disease resistance. Replacing seed more often serves the same purpose. Additionally, an emerging potato processing sector in Kenya incentivizes farmers to invest in improved varieties with specific processing characteristics that could increase the price processors pay, the so-called "price premium" for their production. There are significant costs associated with potato seed production due to the high planting rate (~2,000 Kg/ha). This suggests the need for the early adoption of rapid multiplication technology which is, however, a costly investment that requires technical know-how. Additionally, due to the bulky nature of potato, the seed is costlier to transport than grain crops. In summary, potato requires a more localized seed production system, even if less efficient than centralized systems.
- **Soybean:** While not as valuable as hybrid maize and rice, soybean in Nigeria has a higher value as compared to the other legume crops analyzed in this study (Nigeria EGS Study pp. 72, Rwanda EGS Study pp. 60, Zambia EGS Study pp. 49-50, Kenya EGS Study pp. 55). Soybean seed production yield is generally higher than common bean and groundnut, which makes up for the high field production labor costs associated with soybean production. As previously mentioned, soybean improved varieties with rust resistant traits can prevent yield loss of up to 40% which adds significant marginal economic value.
- **Common bean and groundnut:** The marginal economic values of both common bean and groundnut are lower than the other crops analyzed mainly due to the lower differential yield performance of improved varieties. There are a couple of specific differences between common bean and groundnut that are relevant to marginal economic value. Groundnut is not as transportable as common bean because of the fragility of groundnut seed, which is easily damaged in transit. On the other hand, there is an opportunity to increase the marginal economic value if improved varieties have quality traits that respond to the requirements of groundnut processors.
- **Yam:** The variables of marginal economic value of yam are very similar to potato. Both crops have low multiplication rates, which lowers profitability, and both are costly to transport due to their bulkiness. Additionally, high levels of disease pressure require frequent seed replacement, thereby presenting opportunities to increase value for varieties with disease resistant traits.

Identifying the crop-specific variables that have the greatest opportunity to improve marginal economic value is crucial to developing recommendations that address the supply and demand imbalances in Chapter 2. The crop-specific findings are detailed below:

- **Hybrid maize:** The yield differential of improved hybrid maize varieties versus OPVs, along with the requirement to replace seed each season, creates a significant opportunity to increase economic value. In order to realize this value, it is critical to develop the technical expertise and hybrid seed production specialization (which is best managed through a centralized or centrally coordinated production) within the private sector for supply and demand to balance.

- **Potato, yam, and rice:** The marginal economic value for both potato and rice can be increased by developing improved varieties that strengthen the quality of production (resulting in increased prices) and that have agronomic traits that address abiotic and biotic pressures. The key factor to closing the supply and demand imbalance is to develop a more locally appropriate supply chain to balance production costs and transportation limitations.
- **Common bean and groundnut:** These legume crops present the greatest challenge. While there is some marginal economic value potential of seed that addresses abiotic pressures, the difficulty of transportation further diminishes opportunities to improve marginal economic value. Localized seed production is needed because the economics do not substantiate centralized production economics for any improvement in production costs.

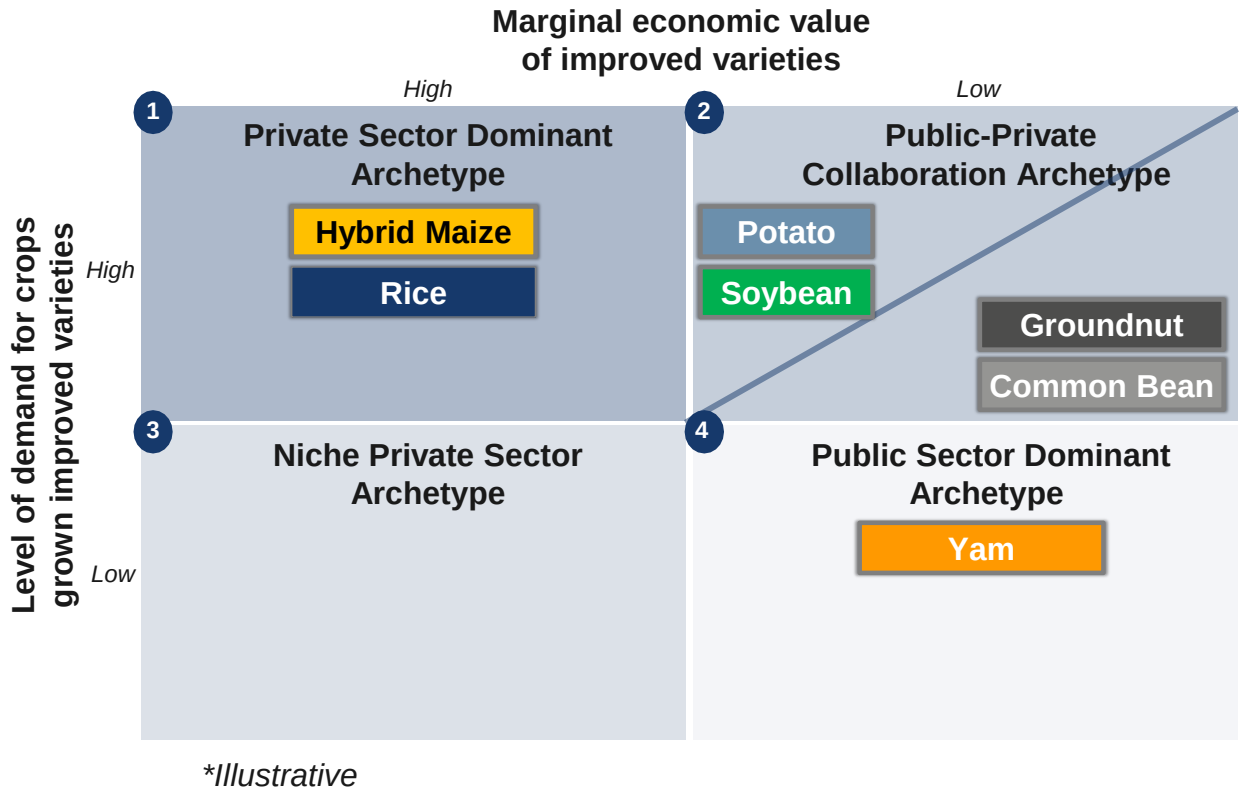
CHAPTER 4: PATH TO MARKET

4.1 MARKET ARCHETYPES

The previous two chapters described the similarities and differences identified with respect to the demand for, and the marginal economic value of, the improved varieties in each crop analyzed. The findings of these two components for each crop provides the data necessary to classify each crop market archetype as summarized in Figure 36.

As mentioned in Chapter 2, demand for EGS exceeds supply for all crops analyzed. Even for those crops with the smallest imbalance (common bean and groundnut), demand is estimated to be twice that of supply. Moreover, the improved varieties of all crops are generally in high demand. Yam is the exception because no functioning EGS system exists, and therefore, the demand for improved varieties is unclear. The grain crops analyzed (i.e., hybrid maize and rice) have the highest relative demand and marginal economic value. Potato and soybean also have high demand, but for reasons explained in Chapter 3, their marginal economic values are lower than the grain crops. Common bean and groundnut have lower levels of demand and marginal economic value.

Figure 36: **Summary of crop market archetypes. ***

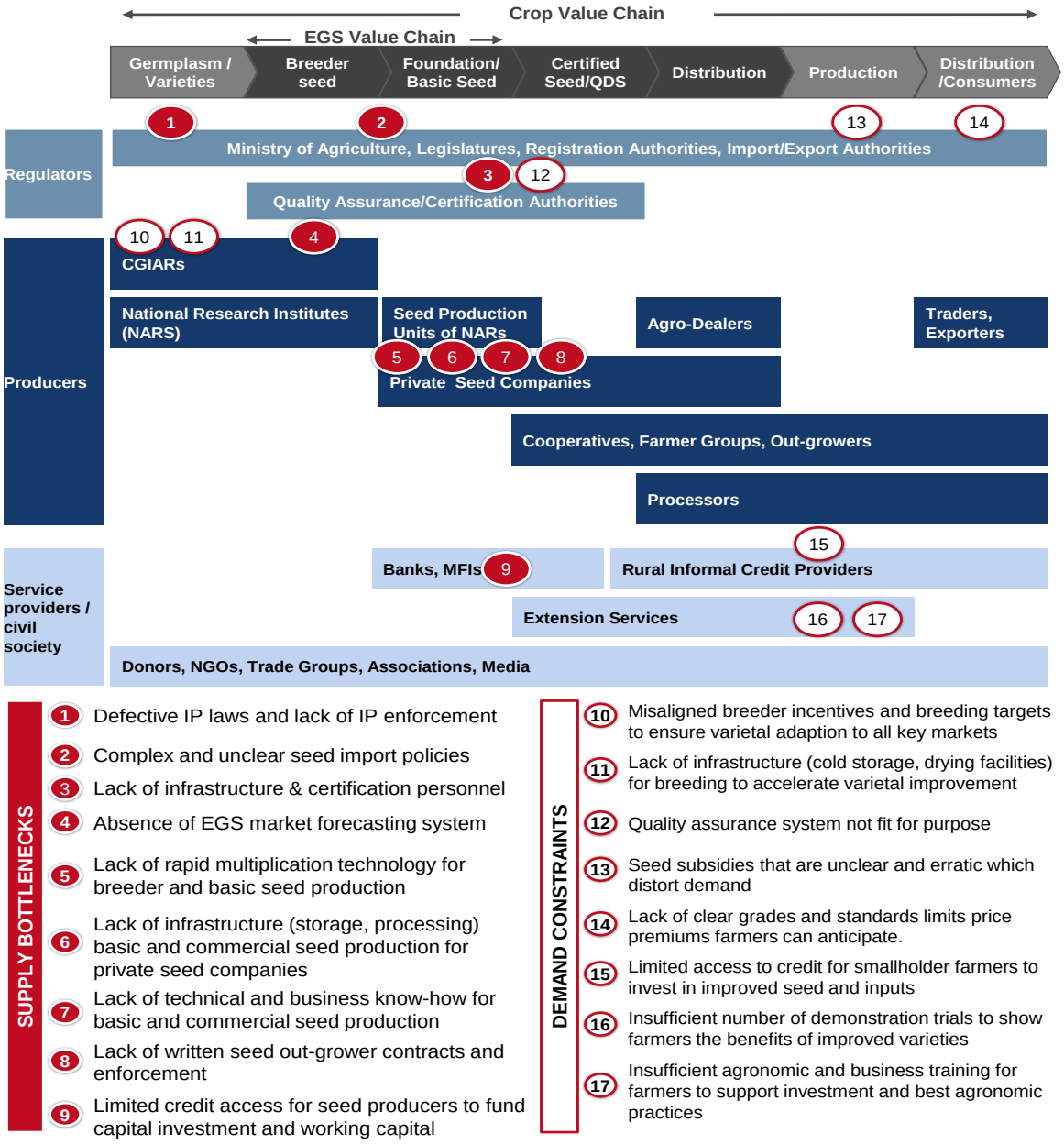


Source: Rwanda, Zambia, Kenya, and Nigeria EGS Studies (2016).

4.2 CONSTRAINTS AND BOTTLENECKS

There are many supply bottlenecks and demand constraints that prevent the value chain from performing in a commercial and sustainable manner. In order to effectively address these bottlenecks and constraints, it is necessary to map the extended crop value chain, which includes not only EGS production, but also varietal development, crop production, distribution, and end use (i.e., processing, trade, or consumption). Figure 37 is a high-level, cross-crop summary of the extended value chain stages and the key actors directly and indirectly involved in each stage. The exact stages, roles, and responsibilities vary by crop and country, as defined in each country study.

Figure 37: **Common supply bottlenecks and demand constraints.**



Source: Rwanda, Zambia, Kenya, and Nigeria EGS Studies (2016).

There are common supply bottlenecks and demand constraints that impede the development of EGS systems. Figure 37 also highlights the most common obstacles identified in the four country studies across all crops and indicates where on the crop chain they occur. It is important to note that the supply bottlenecks tend to occur at the EGS production stages, while the demand constraints occur before and after the EGS production stages and often with regulators, extension services, credit providers, and traders.

4.3 ORGANZING AND IMPLEMENTING SOLUTIONS

The classification of crops by market archetype, which was summarized in Chapter 4.1, is an important factor in determining which stakeholders are needed to organize and implement EGS recommendations. With high marginal economic value and demand for quality seed of improved varieties, both hybrid maize in Rwanda and rice in Nigeria were classified as crops with a private-sector dominant archetype. On the other end of the spectrum, Nigeria yam was classified in the public-sector dominant archetype but with the potential to have greater private sector participation if new seed multiplication technologies and business models, currently being tested, are successful. The remaining nine crops were classified in the public-private archetype and EGS public-private partnerships (EGS-PPPs) were recommended.

PUBLIC-PRIVATE PARTNERSHIPS

The rationale for a PPP is nearly the same in every case. The structural and demand issues identified that impact quantity, quality, and use of early generation and certified seed can be addressed and resolved, but only if adequate financial and human resources are brought into play. With decades of experience, it is clear that governments cannot solely undertake all of the necessary changes to build fully effective EGS systems, even in the absence of funding constraints. Hopefully, governments will be willing to consider alternatives that will incentivize private sector participation and reduce the need for larger government investments in the seed sector.

The primary objectives for each EGS-PPP are similar: (1) produce enough EGS to meet current and future demand, (2) produce seed at the lowest possible cost while continuing to meet quality standards, and (3) stimulate demand for quality seed at the farm level.

There were differences among the EGS-PPPs on the question of whether each PPP should include one, two, or more crops in a given country. For example, in Kenya, three separate PPPs were recommended for potato, maize, and common bean. One PPP was recommended for two crops in Zambia (common bean and groundnut), Rwanda (potato and common bean), and Nigeria (maize and soybean). The reasons for the differences in these approaches are described below:

- **Zambia**: Groundnut and common bean have many similarities that justify one PPP. The crops are both legumes and thus are very similar in terms of production practices and problems. The crops are grown in the same North and East regions of Zambia by smallholder farmers, and they have similar actors in their value chains. Most important, combining the two crops may create the scale necessary to generate private sector investment interest in smallholder farmer food security crops often overlooked in a maize-dominated country.

- **Rwanda**: While potato and common bean are quite different in terms of crop type, several factors justify one PPP for both crops. First, potato is clearly the more attractive crop to the private sector, and for this reason potato is considered the anchor crop in the PPP. While common bean would likely not warrant private sector interest as a stand-alone crop, combining common bean with potato could increase private sector interest without adding complexity. This is due to the fact that Rwanda is a very small country with a limited number of actors, each of whom is typically involved in multiple crops.
- **Nigeria**: One PPP was recommended for hybrid maize and soybean, as both crops have similar end use segments (animal feed) and similar stakeholders across each value chain.
- **Kenya**: Kenya is the exception that required separate PPPs for maize, potato, and common bean. This is due to country-specific requirements stemming from the geographical differences where the crops are grown and the actors involved in each crop's value chain.

Each country report describes in depth the roles, responsibilities, and motivations for potential stakeholders involved in each EGS-PPP. Table 14 provides a high-level summary of types of stakeholders involved in the proposed EGS-PPPs by crop. Very importantly, the political economy of each country will determine the presence of both public and private actors and the roles each will play in the solution. When PPP feasibility work is undertaken, a conventional SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis will reveal how these actors can shape solutions and the roles they can play in implementation. In addition to the important power and capacity attributes of each actor, the enabling legal and regulatory environment must be assessed, e.g., fiscal policy influencing subsidies and tariffs, laws that either stimulate or inhibit PPP formation, government procurement capacity, and many other questions that are unique to a country environment. In summary, each PPP should be considered a unique institution that reflects a country's historical evolution, present capacities, and future possibilities, as well as the particular requirements of the EGS system to be improved.

Table 14: **Summary of EGS-PPP stakeholder roles by crop.**

		Common Bean, Groundnut	Potato	Hybrid Maize, Soybean
Seed Production	**Breeder Seed**	• NARIs • CGIARs	• NARIs • CGIARs • International Seed Companies	• NARIs • CGIARs
	Basic Seed	• Seed Production Units of NARIs • Local Seed Companies	• Seed Production Units of NARIs • Local and International Seed Companies	
	Commercial Seed	• Local Seed Companies • Farmer Groups • Cooperatives		• Local and International Seed Companies contracting Outgrowers
	Marketing & Distribution	• Commercial seed producers plus agro-dealers and NGOs		
Non-seed production stakeholders		• **Public**: Ministry of Agriculture, Extension, Quality Assurance • **Private**: Agro-Processors, Supermarkets, Traders, MFIs, Rural Credit Providers, Associations • **Civil Society**: NGOs, programs, media		

Source: Rwanda, Zambia, Kenya, and Nigeria EGS Studies (2016).

PRIVATE OR PUBLIC SECTOR LED SOLUTIONS

As mentioned earlier in chapter 4.3, there were three crop country examples that did not warrant a PPP. Nigeria rice and Rwanda hybrid maize were classified in the private sector led archetype while Nigeria yam was classified in the public sector archetype. While the specifics of these crop recommendations are detailed in chapter 5, below is a summary of the justification for these crop respective private or public sector classifications.

Private Sector Led

- Rice (Nigeria): Given rice's high marginal economic value and high demand, rice should be attractive for full private sector participation. A private sector led, integrated rice processor model would produce specific, high-yielding rice varieties that would ensure increased paddy production for local processing in key rice producing states, improve livelihoods of participating outgrowers, and lower Nigeria's dependency on rice imports. The public sector would still play an important role in ensuring rice specific policies are implemented (as outlined in Chapter 5.5) and providing access to improved varieties through NARIs, but the model would be led by the private sector.
- Hybrid maize (Rwanda): The private sector is the exclusive source of maize hybrids and maize seeds. Rwanda has no established hybrid maize development or seed production programs. If the government would fully enable the maize private sector by removing all policy and regulatory barriers and by allowing market forces to dictate which hybrids are sold and at what prices, Rwandan farmers would be well served. Additionally, the government could redirect resources to support other crops.

Public Sector Led

- Yam (Nigeria): The yam EGS value chain is dominated by the informal seed system, which contributes ~98% of the total planted area, while only 2% is supported by the formal seed system. The formal system is dominated by the public sector, with very little private sector participation due to the high costs of seed production. However, a more optimized seed system is gradually evolving, thanks to positive strides made by the Yam Improvement for Income and Food Security in West Africa (YIIFSWA) project, which includes the testing and integration of new propagation technologies, quality management protocols, and the integration of a value chain approach. The potential success of the YIIFSWA project presents a strong opportunity to attract private sector interest to form a PPP. However, these technologies and business models are in their early stages and will require close monitoring to demonstrate proof of concept before a PPP is recommended.

CHAPTER 5: POLICY RECOMMENDATIONS

This chapter includes two major sections. First, lessons learned, as gleaned from the four EGS country studies, are presented and discussed. A very few lessons suggest somewhat uniform applications or adaptations that could apply across several countries. Second, the policy recommendations grow out of the experience of implementing the same EGS study scope of work in four countries in roughly the same timeframe. They are organized by country and by crop within each country. Finally, in Chapter 5.6, there is a summary of policy recommendations that could be required and implemented in more than one country. Regional projects, e.g. the Feed the Future Harmonized Seeds Regulation project could look at problems and solutions from a higher vantage point, but this would not be the right elevation for country seed platforms.

5.1 LESSONS LEARNED

In the process of analyzing four EGS country studies and synthesizing the findings, the team has identified some important lessons learned that are described below.

1.) Funding limitations require governments to make trade-offs to optimize their use of resources to achieve national goals.

In Rwanda, for example, RAB has replaced its OPV breeding program with a hybrid development program. This is not a line breeding program but a program to evaluate combinations of inbred lines obtained from CIMMYT or other sources. According to RAB, the first hybrids will begin to emerge from the program in 2019.

The hybrid combinations being evaluated by RAB are very similar if not identical to those already available through regional seed companies. It is highly unlikely that the resources RAB is using in its hybrid development program will result in hybrids that are especially well suited to Rwanda or are more competitive in farmers' fields than those already available.

Given the budget and human resource constraints that all research programs confront, careful consideration should be given to the need for a RAB hybrid maize development program. The government has expressed a desire to see the private sector play the dominant role in hybrid maize. If it acts accordingly and enables a competitive hybrid market to emerge, Rwandan farmers will be well served and have access to the best possible hybrids. In turn, RAB can redirect funds and human resources currently focused on developing maize hybrids toward other activities, e.g., potato and common bean.

2.) NARIs are generally too under-resourced to successfully achieve their main objective which is variety development and selection. Foundation seed production is not a core NARI competency and should be limited to specific situations where there is no private sector interest.

A common theme that emerged through interviews with key stakeholders is the belief that the current public system is underfunded for what it is mandated to do. The lack of capital investment and operating funds limits the public sector's ability to support private sector

activities and often creates insurmountable obstacles for private companies. Resolving the financial shortfalls in the public sector is a precondition to the development of PPPs, as there is no substitute for adequate public sector personnel, operating funds, and infrastructure. While the specific areas of resource shortfalls in NARIs vary by country, a common shortfall is the lack of personnel, including breeders and technicians. Breeding infrastructure shortfalls often include a lack of land, irrigation, rapid propagation capacity such as *in-vitro* facilities, cold storage, and drying equipment.

In Kenya, some specific areas for increased funding that surfaced during field research relate to the Kenya Agricultural and Livestock Research Organization (KALRO) technology licensing unit and the KALRO Seed Unit (KSU). The KALRO technology licensing unit will need to be expanded with additional staff in order to properly handle the volume of royalty payments that will be moving throughout the seed system. The KSU will need additional funding and likely will need to be restructured in order to implement the requirements proposed in the PPP described below. Specifically, the KSU would need to shift its focus from commercial seed production to EGS production and ensure funding is available to support production.

Additionally, during the field interviews, a number of private seed companies indicated a preference for producing their own EGS, as they believe they could produce at lower cost and at the same quality as KSU and contract growers.

In Nigeria, foundation seed production is the responsibility of private seed companies. However, the majority of domestic seed companies do not have the technical know-how and capabilities to produce foundation seeds, leaving it instead to the NARIs to produce and sell to seed companies. The current EGS system in Nigeria is hampered by high labor costs for production, including breeders' salaries. In order to make the EGS production economically viable, NARIs could partner with CGIARs to access finished hybrid lines, which the seed units within the NARIs could multiply and also use in producing single-cross females. This could be accomplished primarily by personnel trained at the MSc level, rather than PhD-level breeders, thus reducing production costs by streamlining the number of breeders required to produce inbred lines and carry out testing. In addition, domestic seed companies could partner with the NARIs to obtain breeder seed, which they would multiply into foundation seed and subsequently, certified seed.

3.) Validating the value of quality seed of improved varieties versus the status quo at the farm level is an important component of a sustainable EGS system.

A common theme from the interviews conducted with farmers and seed producers was that variety trials conducted by extension services are not seen as providing compelling evidence that improved varieties used in conjunction with good agronomic practices will provide superior returns to farmers.

In Rwanda, for example, despite repeated questioning of all stakeholders, no evidence was found of RAB or any other party conducting trials specifically designed to compare performance of quality seed with the performance of farmer-saved seed. It is essential to conduct such trials, but they must be designed to distinguish between the effects of seed quality and variety. In the absence of such visual experiences, it will not be clear to farmers that the additional cost of

certified seed is justified. Table 15 shows the significant gap between the yield potential of crops grown in optimal conditions of both bush and climbing beans and the yields obtained on farms.

Table 15: **Comparison of yield potential and on-farm productivity of common bean in Rwanda.**

Table 1. Productivity (kg/ha) of beans in Rwanda

Type	Potential (kg/ha)	On farm (kg/ha)	Mean on-farm (kg/ha)
Bush	1,500 -2,000	700 – 800	800 – 1,000
Semi-climbing	2,000 – 2,500	800 – 900	
Climbing	3,000 – 5,000	1,500 – 3,000	

Source: Musoni (2012).

4.) Increasing farmer adoption of improved varieties requires a comprehensive approach including demonstration, education, training, and credit.

Several organizations and program are successfully proving that smallholder farmers will buy nonsubsidized seed if they have access to demonstration trials, inputs, training, and credit. The One Acre Fund is an NGO that works directly with small farmers to help them improve the financial returns from of their farming operations, as outlined in Figure 38. The program was first launched in Kenya and began operations in Rwanda in 2008. The Rwandan branch of the One Acre Fund is known inside Rwanda as “Tubura,” a Kinyarwanda word that roughly translates as “multiply” or “multiplying.”

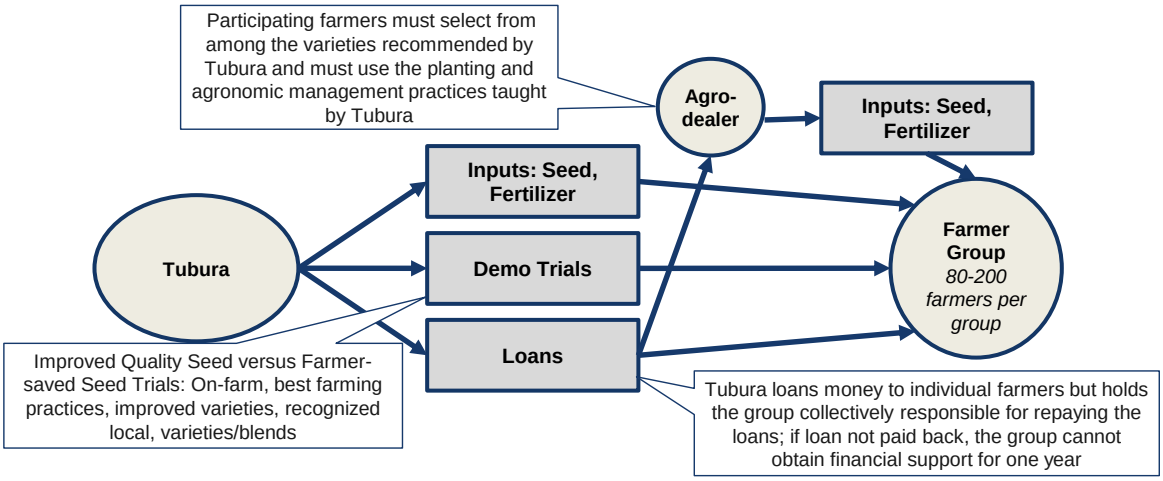
Tubura’s core program, which is focused on helping individual farmers, includes variety evaluations for the crops it has targeted (currently hybrid maize, common bean, potato, and vegetables) to identify best varieties, training farmers in best farming practices, purchasing seed of the selected varieties, and providing credit to farmers to purchase seed and fertilizer. In 2016 Tubura will work with 150,000 farmers and expects to reach 300,000 farmers by 2020. Farmers in the program have increased their profits by an average of $135 after repaying loans.

Tubura operates a second program through which it finances inventory purchases by agro-dealers enabling them to stock seed and fertilizer for resale to farmers. That program now reaches approximately 25% of the agro-dealers in the North and West provinces where Tubura is currently active.

Through this combination of programs, Tubura has become the largest single private sector seed purchaser in Rwanda. It works with RAB and the private seed sector to encourage better seed policies and to support private sector development.

The Tubura program provides very clear evidence of the impact that occurs when farmers understand the value of improved crop varieties, employ good farming practices, and have access to finance.

Figure 38: **Tubura model in Rwanda.**



Source: Field research team interviews (2016).

Another successful program is Babban Gona in Nigeria, which is a private, for-profit agricultural franchise that provides smallholder farmers access to high-quality training, financial services, agricultural inputs, and marketing services to help them increase their yields and incomes. In targeted regions of the north, Babban Gona has successfully demonstrated the benefits of using new seeds of improved varieties every planting season to smallholder farmers growing maize. The program has also proven that farmers will buy unsubsidized inputs if they know they will have guaranteed access to markets for their produce.

Using an innovative model, Babban Gona provides members of its franchised farmer groups with the following four-fold services designed to increase farmer's yields and profits, as well as their access to markets:

- **Financial services**: Using an innovative approach to mitigate risks to members of the farmer groups, Babban Gona raises capital to finance members of its franchise.
- **Agricultural input services**: Babban Gona provides agricultural inputs to help farmers achieve optimal productivity and product quality, while minimizing negative environmental impacts. According to field interviews, each farmer in the group deposits ~$45 per Ha to qualify for improved seeds and fertilizers. A minimum of 20 Kg improved maize seed and 7 bags of fertilizer (5 bags of urea and 2 bags of diammonium phosphate – DAP) is provided to each farmer.
- **Training and development**: Training on good agricultural practices helps to ensure that farmers will adhere to production standards to achieve optimal yields.
- **Marketing services**: These services include access to adequate warehousing and attractive markets. Immediately after harvest, Babban Gona buys produce from farmers at 75% the estimated off-season price. During the off-season, Babban Gona sells the produce to buyers demanding quality standards that command premium prices and pays the balance to farmers.

At the beginning of the production season, Babban Gona sets a minimum yield threshold of 2 MT for all farmers. After harvest, 2 MT is deducted from each farmer's yield and the current market price is determined. Babban Gona deducts the farmer's initial payment and pays the

balance to the farmer. In addition, when the 2 MT is sold to large-scale processors at premium prices during the off season, the farmer receives an additional payment beyond the initial market price. 90% of the increase in profit is paid to farmers, while 10% goes to Babban Gona[8].

Babban Gona, which began in 2012, is currently operating in Kaduna State, with plans to extend its activities to the south. Farmers who are members of the franchise have realized significantly improved yields. For example, one farmer attained yields of 4.6 MT/Ha in maize, about three times higher than the national average, and achieved a financial return (net of all loans) of more than $1,450 from 1.1 Ha, compared to $600 prior to joining the franchise.

5.) Producing quality seed requires different, more rigorous management practices and access to resources and facilities than those required for crop production. The corollary is that tailored training programs are also required.

Private seed producers are farmers without a deep understanding of the requirements for seed production. A common theme that emerged from our interviews is the need for more seed production expertise in the government and the private sector. The lack of knowledge about timely harvest, adequate drying, and seed storage makes it very hard to produce a high-quality seed. Public seed production units often have insufficient resources for adequate seed production and are neither have the responsibility or funding to train farmers to be seed producers. Extension services also do not appear to be meeting the needs of conventional farming and are unlikely to have seed production expertise. Consequently, governments, which are central actors in the seed sector, are poorly positioned to train private farmers in the science and art of seed production.

In the case of Rwanda, although the government has neither the resources nor the expertise to build capacity in the Rwandan seed sector, it has recognized the need for improved seed production skills and knowledge and secured support from the Belgium Technology Corporation (BTC). It is a long-time donor and partner of the Rwandan government, and will fund and operate a Seed Producer Training Program. This program uses the methods, experiences, and outcomes achieved in the Farmer Field School (FFS), a RAB-operated program which provides training to farmers and which has operated for several years, as the basis for the Seed Producer Training Program organization and operation.

The FFS provided farmers interested in seed production with training and mentoring in wheat, rice, common bean, soybean, potato, cassava, and OPV maize. The program introduced the concept of quality assurance through quality control plots where seed producers planted the seed they harvested, and which were then assessed for germination and uniformity. The FFS included four key components. First, program trainers identified and organized seed producers into producer groups. Second, they hosted regular seed producer meetings before, during, and after the season to share seed producer best practices, address issues seed producers were experiencing during the season, and develop tailored solutions to address these specific issues. Third, training sessions were conducted on seed producers' fields to ensure the hands-on training was practical and relevant. Fourth, and at harvest, the FFS facilitated distribution of seed produced by the producer groups with end users.

[8] Field interviews revealed that 10% of increase in profit belongs to the franchise.

6.) Integrating rapid multiplication technology and linking it with end users such as processors is improving the marginal economic value of crops and attracting private sector interest.

Kisima is a Kenyan-owned and operated agribusiness based in Timau, working with Deutsche Gesellschaft für Internationale Zusammenarbeit, the International Potato Center (CIP), and USAID to produce high-quality seed. Kisima has grown and developed its operation to become Kenya's leading provider of certified potato seed, utilizing 70 hectares per season to provide high-quality commercial seed to farmers. Kisima is committed to using the benefits of scale in seed production, storage, and handling and the associated lower cost per unit to benefit smallholder food production systems through the production and sale of affordable, high-quality seed.

Kisima has invested in a range of capabilities, including aeroponics and cold storage systems, which allow for higher annual yields and lower post-harvest losses. These investments, combined with the cost reductions realized through large-scale production, have allowed Kisima to become the leading provider of high-quality commercial potato seed. Kisima has worked with providers of genetics such as CIP and end-users such as industrial processors to determine appropriate varieties.

In Nigeria, the YIIFSWA project that began in 2012 is developing novel technologies, as well as the subsequent multiplication and distribution of clean foundation and certified seed yam in large quantities. Novel technologies include aeroponics and temporary immersion bioreactors (TIBs). An aeroponics system is capable of producing clean, disease-free vines and mini-tubers that can be used to produce high-quality seed yams. It has an enormous capacity to produce up to one million mini-tubers and clean vines a year. A one-node cutting from an aeroponics system produces an average seed yam of 250-300g. According to the International Institute of Tropical Agriculture (IITA), the extent of aeroponics' yield benefit over other sources of seed yam is currently being studied. TIBs is an *in-vitro* production technique that produces clean, disease-free yam vines that are fed into the aeroponics system or planted directly into the field for mini-tuber (or seed yam size tuber) production. Successfully demonstrating the efficacy of these technologies to produce clean foundation and certified seed yam at high multiplication rates and reduced cost could make seed yam production an attractive business to private seed companies.

Currently, a collaborative effort between the National Agricultural Seeds Council (NASC), the National Root Crops Research Institute (NRCRI), and IITA is promoting two improved early-maturing yam varieties and is supplying breeder seed to private seed companies to multiply into foundation seed, and subsequently, certified seed. The first set of certified seeds produced under this new arrangement was ready for sale in 2016 after a launch of the formal seed system by NASC. To date, four private seed companies have participated in multiplying yam foundation and certified seed. The aeroponics system has also been demonstrated to a total of ten private seed companies in an effort to encourage their participation in commercial seed yam production. To date the ten private seed companies have expressed interest in testing the technology and potentially investing, but no firm commitments have been made.

In addition, YIIFSWA has developed the Yam Quality Management Protocol, a standard for measuring quality across all classes of seeds including breeder, foundation, and certified seeds.

The NASC has been trained on how to use standard protocols for the inspection of seed yam fields.

Credit facilities for seed companies need to be designed for agriculture sector needs, taking into account the challenges seed companies face including lengthy cost recovery, high inventory, and agricultural specific risks.

7.) Quality assurance systems need to be tailored to crop specific requirements.

In Zambia, the quality assurance system is based on hybrid maize, a resource-intensive certification system for a higher value crop that can support a higher cost system due to the margins generated. However, it is not fit for groundnut and common bean seed producers, who cannot afford to pay certification costs for these lower margin crops. SCCI is in charge of certification which includes field inspections and seed sampling. Seed fields are inspected at four stages each season: before or just after planting, at the vegetative stage, at the flowering stage, and at crop maturity. Seed crops that don't meet standards either fail or are downgraded to lower classes, whereas crops that meet required standards are authorized to be harvested as seed for further certification processes including seed sampling, laboratory seed testing, and post-harvest control. In order to facilitate inspections of all seed crops, SCCI also trains and licenses private seed inspectors who work for seed companies, NGOs, and the crop extension service of the Ministry of Agriculture. Samples of seed produced during each growing season are selected at random and assessed for purity at one of eight seed-testing laboratories. Our field interviews suggested that this highly resource-intensive and expensive process is useful for higher value crops like hybrid maize but is not cost effective for groundnut quality assurance.

8.) Crop grades and standards are critical to improving the marginal economic value of crops, but they are non-existent.

In Zambia, the lack of crop grades and standards lowers the price premiums farmers can realize for higher quality groundnut and common bean production. For example, in the maize market, there are crop grades, such as #2 and #3 yellow corn, indicating specific quality and moisture parameters that command a price differential. #2 yellow corn would be positioned for export markets while #3 yellow corn would be designated for local feed and processing purposes with a lower price point. Such a system does not exist in groundnut and common bean in Zambia, and as a result, farmers are not incentivized to invest in improved seed as they are not rewarded for higher quality production. This example in Zambia is consistent with similar situations in Rwanda, Kenya, and Nigeria. The private sector (through trade associations for example) is widely considered the best positioned to lead the establishment and enforcement of grades and standards. The public sector also plays an important role to create the necessary policy environment that enables private sector implementation.

5.2 RWANDA POLICY

POTATO

The priority for potato is to expand and enhance EGS production capabilities to meet current and future demand. Rwanda has a robust domestic market for potato and is well positioned to become a regional supplier of potato. Demand for EGS of potato already exceeds supply by at least threefold. The primary need in early generation potato seed is a fully capable and scalable

EGS system. The overarching recommendation is to do so through a PPP as described in the previous section. In addition to building a scalable and efficient early generation potato seed system, steps should be taken to increase the availability of new, improved potato varieties and to further enhance the economic value of potato.

The following are specific policy recommendations:

Increase availability of improved varieties

In order to increase the availability of improved varieties, there are several policy changes that are recommended. Rwanda's variety registration process should be harmonized with East African Community (EAC) and Common Market for Eastern and Southern Africa (COMESA) procedures to cut the current process from four years to two years. Furthermore, the proposal in the recently passed National Legislative Framework for Seed to move variety registration out of RAB and into an independent body should be implemented. Additionally, seed import policies and procedures should be reformed and harmonized to reduce time and regulatory delays that negatively impact seed importation. Plant variety protection policies that have been embodied in the new seed law should be quickly operationalized to encourage proprietary seed developers to enter Rwanda with improved genetics.

It is also recommended that the RAB potato research unit focus its efforts on variety evaluation and release by moving all seed production activities, including *in vitro* plantlet production, out of RAB and into the potato EGS-PPP. RAB hasn't released an improved potato variety since the 1990s, and therefore it is important for RAB to refocus its efforts on variety evaluation and release rather than seed production, which the private sector is better positioned to lead in the EGS-PPP.

Finally, it is recommended that investments be made in increasing storage capacity for seed, which will allow seed producers the opportunity to store inventory from successful harvests and increase sales flexibility.

Realize the potential marginal economic value of potato

The potato industry needs to continue to work toward realizing the potential marginal economic value of potato. This can be accomplished through a variety of interrelated efforts led by the PPP covering both increasing the volume of production and decreasing costs through the utilization of macro-propagation technologies.

By introducing new, high-yielding varieties, smallholder farmers will be able to increase production and generate additional profit from the land they currently allocate to potato. Matched with this increased yield will be the need to expand storage capacity to enable smallholder farmers and traders the flexibility to store potato and to sell excess production (not required to generate operating cash) at the most ideal times, as dictated by market pricing, rather than selling any and all production immediately after harvest. The processing industry should also be engaged to determine which varieties are in demand and create an action plan for processors to source these varieties from farmers.

COMMON BEAN

The priorities for common bean are to build on-farm demand for improved varieties and quality seed and to increase the marginal economic value of common bean. As these two objectives are realized, there will be a need for a robust and capable EGS system built as a PPP. In order to make this PPP attractive to the private sector, the government should consider including soybean and wheat with common bean.

The following are specific policy recommendations:

Stimulate farmer adoption of improved varieties and quality seed of common bean

To increase farmer demand for high-quality improved seed, it is recommended that the PPP design and execute on-farm trials to compare the performance of farmer-saved seed and quality seed. Successful execution of these trials will require sufficient numbers of plots, seed, and staff to reach smallholder farmers. This will allow for direct engagement with the farmers and also help to prove the value proposition of the seed being sold by the PPP. Additionally, RAB extension service programs should be expanded to provide training and ongoing support in not only the use of best agronomic practices but also in calculating the costs and benefits of investment in inputs. Once the investment case for investing in improved varieties is demonstrated and understood by farmers, the GoR through the NGO Access to Finance Rwanda (AFR) should work with Savings and Credit Cooperative Societies (SACCO) to establish purpose-built agricultural lending products to smallholder farmers.[9] As a longer term recommendation, RAB should intensify its efforts in its bush bean breeding program, emphasizing yield and disease resistance, in order to keep pace with the number of releases in the climbing bean program.

Enhance the marginal value of common bean

There is an opportunity to reposition common bean as a higher value crop in Rwanda. As a production hub in East Africa, there is significant opportunity to increase exports through increased production. It is recommended that the Rwanda Development Board (RDB), within the common bean PPP, emphasize common bean as a key opportunity for smallholder farmers.[10] Additionally, it is recommended that HarvestPlus, within the PPP, promote the value of biofortified beans to farmers and consumers to build demand for improved varieties.

In order to enhance the marginal value of common bean, increasing yield and decreasing costs should be emphasized. As a part of the common bean PPP, there will need to be promotion of the value of improved varieties and efforts made to educate farmers through field trials and demonstrations. These efforts will help to increase demand and also can communicate and demonstrate the agronomic best practices that can result in higher yields for farmers.

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[9] Following a 2008 FinScope Survey that estimated 52% of Rwanda's population was completely excluded from financial services, the GoR launched the National Savings Mobilization Strategy which included the goal of creating at least one SACCO in every Umurenge (district) with the target of reaching 80% of Rwanda's population by 2017. As member based cooperatives, Umurenge SACCOs are considered to be better positioned to serve smallholder farmers as they are governed by members themselves, located in rural areas, and can focus on smaller sized loans.

[10] RDB is an independent body that was formed in 2008 with the mission of accelerating economic development in Rwanda by enabling private sector growth. Key agencies responsible for business registration, investment promotion, environmental clearances, privatization, and priority sectors are represented in the RDB, which reports directly to the President and is guided by a Board that includes all key Ministers (e.g., finance, commerce, infrastructure, agriculture). RDB's scope of work includes all aspects related to the development of the private sector, which includes addressing the needs of large and small companies, and both local and foreign investors (RDB official website).

Supporting these efforts to increase yields will be cost reduction efforts within the seed system, where the PPP will encourage public and private sector actors to increase the scale of their operations and focus on reducing the bringing down overall costs within the common bean seed system. The PPP itself would be a prime example of the benefits of scale as it strives to provide high-quality commercial seed at the lowest possible cost to farmers.

HYBRID MAIZE

The priority objective for hybrid maize is to stimulate sustainable private sector growth by removing barriers to participation, which will allow the public sector to exit the market.

GoR has stimulated significant growth of maize production through its support and focus on replacing OPV maize with high-performance maize hybrids. The current program, including ongoing seed price subsidies, encourages farmers to adopt hybrid maize and use good agronomic practices. The Tubura experience has proven that smallholder farmers clearly benefit from using hybrids and that the lack of agricultural credit is the key bottleneck limiting further adoption. Maintaining an OPV EGS system props up an inferior product and is detrimental to smallholder farmers' interests.

Maize is clearly a private sector crop. Around the globe, maize hybrids are developed and supplied to farmers through private sector activities motivated by profit. In Rwanda, the private sector is the exclusive source of maize hybrids and maize seeds. Rwanda has no established hybrid maize development or seed production programs. If the government would fully enable the maize private sector by removing all policy and regulatory barriers and allowing market forces to dictate which hybrids are sold and at what prices, Rwandan farmers would be well served. Additionally, the government could redirect resources into support for other crops.

The following are specific policy recommendations:

MINAGRI should work in close collaboration with local seed companies to develop and communicate a strategy to eliminate maize subsidies. This will remove market distortions, enabling private seed companies the opportunity to develop long-term seed production plans. Additionally, MINARGI should allow private maize seed companies to make seed production decisions, including what to produce and where to produce it, without government approval. In the absence of subsidies, it will be critical that MFIs and SACCOs develop purpose-built agricultural lending products tailored for smallholder farmers to ensure that they continue to adopt hybrid maize seed.

Policy changes recommended for potato also are necessary for hybrid maize. Rwanda's variety registration process should be harmonized with EAC and COMESA procedures to cut the current process from four years to two years. The proposal in the recently passed National Legislative Framework for Seed to move variety registration out of RAB and into an independent bodied should be implemented. Additionally, seed import policies and procedures should be reformed and harmonized to reduce time and regulatory delays that negatively impact seed importation. Plant variety protection policies that have been embodied in the new seed law should be quickly operationalized to encourage proprietary seed developers to enter Rwanda with improved genetics. It is also recommended that RAB focus its hybrid maize program on conducting trials to provide farmers with unbiased data to support hybrid purchase decisions rather than hybrid seed development and production.

Table 16: **Rwanda policy recommendations.**

	Rwanda Policy Recommendations	Common Bean	Potato	Hybrid Maize
Legal and Regulatory	Harmonize the variety registration process with EAC and COMESA procedures to cut the current process from four years to two years.	✓	✓	✓
	The proposal in the recently passed National Legislative Framework for Seed to move variety registration out of RAB and into an independent bodied should be implemented.	✓	✓	✓
	Reform and harmonize seed import policies and procedures to reduce time and regulatory delays that negatively impact seed importation.		✓	✓
	Operationalize plant variety protection policies that have been embodied in the new seed law to encourage proprietary seed developers to enter Rwanda with improved genetics.	✓	✓	✓
	Implement and operationalize quality declared system.	✓	✓	
	Document and communicate quality standards to growers.	✓	✓	✓
	Establish a grades and standards system for marketing of production.	✓	✓	✓
Resource Allocation	Focus national hybrid maize program on conducting trials to provide farmers with unbiased data to support hybrid purchase decisions rather than hybrid seed development and production.			✓
	Focus national potato research unit on variety evaluation and release by moving all seed production activities, including in vitro plantlet production into the potato EGS-PPP.		✓	
	Hire and train quality assurance lab and field personnel for inspection and sampling.	✓	✓	✓
	Ramp up demonstration trial capacity including seed number of plots, trained extension personnel, and seed availability.	✓	✓	✓
	Strengthen national bush bean breeding program, emphasizing yield and disease resistance.	✓		
	Increase storage capacity for seed which will allow seed producers the opportunity to store inventory from successful harvests and increase sales flexibility.		✓	
Market Development	Allow private seed companies to make seed production decisions, including what to produce and where to produce it, without government approval.			✓
	Develop and communicate a strategy to eliminate maize subsidies .			✓
	Build an seed forecasting demand system to provide real-time information on the specific varieties and quantities needed to meet market demands.	✓	✓	✓
	Develop purpose-built agricultural credit and working capital products for capital intensive EGS and commercial seed producers.	✓	✓	✓
	Develop agricultural products for smallholder farmers to invest in high quality inputs.	✓	✓	✓
	Promote the use of small seed packs tailored to smallholder farmer needs.	✓	✓	✓
	Increase farmer and seed producer educational and training programs in the use of agronomic and business best practices through successful Farmer Field School and Tubera models.	✓	✓	✓
	Develop a communications strategy focusing on educating farmers on the benefits of improved varieties using radio, television, documentary films, farmer days, market days, and national champions.	✓	✓	✓

Source: Rwanda EGS Study (2016).

5.3 ZAMBIA POLICY

The priorities for groundnut and common bean are highly aligned. The purpose is to expand and enhance EGS production capabilities to meet current and future demand through public-private collaboration that ensures profitable EGS production and a robust yet cost-effective quality assured system that increases farmer demand to purchase improved, high-quality seed. In order to achieve these objectives, here are specific policy recommendations:

Increase the marginal economic value of groundnut and common bean

There is an opportunity to reposition groundnut and common bean as higher value crops in Zambia. In order to increase the marginal economic values of groundnut and common bean, it is critical to establish a quality assurance system that is cost effective and efficient. The existing QDS system in Zambia should be scaled up and positioned as the official system for groundnut and common bean. In order to lower production costs and improve profitability, seed production yield improvement should be enhanced by introducing improved agronomic practices, which would lower costs on a $/Kg basis.

Additionally, commercial market grades and standards should be established. With a grading system in place, farmers would be rewarded for higher quality production by obtaining pricing premiums for groundnut and common bean that meet defined quality specifications. A key component of implementing a system of grades and standards is to stimulate downstream demand for higher value varieties. This would be achieved through strengthening the links between breeders, farmers, and processors to ensure that breeders are setting breeding targets to develop improved varieties (especially groundnuts) that meet both farmers' and processors' needs. The extension services should also redouble their efforts in aflatoxin management through farmer training in agronomic best practices and access to storage to stimulate demand from processors and exporters.

Stimulate farmer adoption of improved varieties and quality seed

To increase farmer adoption of improved varieties and quality seed, on-farm demonstration trials should be increased and extended in key groundnut and common bean growing regions. It is critical that these trials are designed to demonstrate the performance differences between farmer-saved seed and quality seed as well as improved varieties and local varieties. Successful execution of these trials will require greater numbers of plots, seed, and staff to reach smallholder farmers. Farmers could be directly engaged in this way and also help to prove the value proposition of the seed being sold by the PPP. Additionally, ZARI extension (in collaboration with ZARI researchers, NGOs, and private seed companies) should be expanded to train and provide ongoing support in the use of best agronomic practices, as well as how to calculate the benefits and costs of investing in improved seed, fertilizer, and crop protection. Once the investment case for investing in improved varieties is demonstrated to and understood by farmers, the Government of the Republic of Zambia (GRZ) should work with banks, MFIs, and *chilimbas* to establish purpose-built agricultural lending products to smallholder farmers.[11] As previously mentioned, the EGS-PPP should ensure that small packs of seed are sold, tailored to the volume needs of smallholder farmers, which would further increase farmer demand.

A longer term recommendation would be to accelerate varietal improvements in groundnut and common bean. While there have been recent releases of improved groundnut and common bean varieties, it appears that there has been a drop-off in varietal improvement. In any event, both the groundnut and common bean breeding programs should be reviewed and the depth of their germplasm analyzed. The corollary is that both breeding programs should be adequately

[11] A key source of credit for smallholder farmers are *chilimbas*, which are informal savings associations common in both rural and urban areas. Members of *chilimbas*, who are often women, make regular, typically weekly payments, with one member being allowed to use all the payments during one cycle. Smallholder farmers do sometimes use *chilimbas* for credit to purchase inputs, but equipment purchases are less common, as *chilimbas* are generally not large enough to support these loans (USAID AgCLIR, 2011).

resourced, including irrigation, sufficient land for breeding, mechanization, cold storage for germplasm, and drying capabilities. These necessary elements of an efficient breeding system are mostly absent or incomplete. The result is constrained breeding outcomes and high operating costs. Finally, breeder incentives should be reformed to align with market impact rather than the number of releases. Such a system has been successfully implemented for the Drought Tolerant Maize program in Africa in which breeders and breeding programs are recognized for commercial achievements such as area penetration of a specific variety rather than the number of varieties released.

Table 17: **Zambia policy recommendations.**

Zambia Policy Recommendations		Common Bean	Ground-nut
Legal and Regulatory	Operationalize plant variety protection policies and royalty collection mechanisms.	✓	✓
	Establish QDS as the official quality assurance system for groundnut and common bean and increase capacity to enforce standards.	✓	✓
	Reform breeder incentives to align with market impact rather than number of releases.	✓	✓
	Establish a grades and standards system for marketing of production.	✓	✓
Resource Allocation	Increase resourcing for national breeding programs, including irrigation, sufficient land for breeding, mechanization, cold storage for germplasm, and drying capabilities to accelerate varietal improvements.	✓	✓
	Hire and train extension services to increase capacity to train and provide ongoing support in the use of best agronomic practices.	✓	✓
	Hire and train quality assurance lab and field personnel for inspection and sampling.	✓	✓
	Ramp up demonstration trial capacity including seed number of plots, trained extension personnel, and seed availability.	✓	✓
	Increase storage capacity and training in in aflatoxin management through farmer training in agronomic best practices.	✓	✓
Market Development	Ensure Farmer Input Support Program serves crops beyond maize (as it is intended to).	✓	✓
	Build an seed forecasting demand system to provide real-time information on the specific varieties and quantities needed to meet market demands.	✓	✓
	Develop purpose-built agricultural credit and working capital products for capital intensive EGS and commercial seed producers.	✓	✓
	Develop agricultural products for smallholder farmers to invest in high quality inputs.	✓	✓
	Promote the use of small seed packs tailored to smallholder farmer needs.	✓	✓
	Increase farmer and seed producer educational and training programs in the use of agronomic and business best practices.	✓	✓
	Develop a communications strategy focusing on educating farmers on the benefits of improved varieties using radio, television, documentary films, farmer days, market days, and national champions.	✓	✓

Source: Zambia EGS Study (2016).

5.4 KENYA POLICY

HYBRID MAIZE

The priority objectives for hybrid maize are to increase private sector access to public sector varieties and to support the development of a sustainable supply of high quality EGS to satisfy market demand for hybrid seed. The combination of these objectives is intended to create additional choices for farmers. In order to accomplish these objectives, the field research team

recommends a PPP at the basic seed stage to include the principals, i.e., KALRO, private seed companies, and public universities.

Hybrid maize is a sector in which private seed companies are already active and engaged, with a long history of hybrid adoption in Kenya. Removing the current barriers to the success of these private companies would be crucial for the success of the PPP, with specific areas of improvement coming from inspection and certification and reducing the cost of production.

Revise the current inspection and certification system

KEPHIS should revise its current inspection and certification standards in order to streamline the overall process, decrease the associated costs for seed producers, and shorten certification timelines. One of the recommendations coming from a lot of stakeholders during field interviews was to utilize breeders as the primary providers of inspection and certification services for breeder seed, freeing up KEPHIS resources to focus on basic and commercial seed certification. Additionally, the field research team recommends that the Government of Kenya (GoK) increase funding for KEPHIS so that it may increase the number of inspectors in the system at times of peak demand for certification.

Allocate required resources to the national extension service

The national extension services were devolved to county control during the changes undertaken with the passage of the 2010 Constitution. While the devolution of authority and responsibility for many government functions is a welcome change, it is essential to maintain the technical expertise and depth of a national extension service for agriculture. The field research team recommends that a national level extension services be reinstated and operated in tandem with county level services to provide high-level national programming and local customization. Once this has been completed and the national extension service is operational, it could combine with county level extension services to demonstrate the value of high-yielding hybrids to farmers still using OPVs.

Once re-established, the field research team recommends that the national extension service develop comprehensive recommendations including farmer varietal needs by region and agronomic best practices to ensure the right seeds are being utilized in the best possible environments to produce yields closer to theoretical levels.

POTATO

The priority objective for potato is to expand and enhance EGS production capabilities to meet current and future demand through a PPP.

Kenya has strong demand for potato and the supply of EGS currently falls well short of current market demand. The primary need is a fully capable and scalable EGS system for potato. The overarching recommendation is to do so through a PPP anchored at the mini-tuber (breeder seed) production level between KALRO and private seed companies.

Specific policy recommendations are as follows:

Involve a diverse set of actors, including international seed companies and processors, in the creation and operations of the PPP

The potato seed PPP should include the critical actors including the Ministry of Agriculture, KALRO, KEPHIS, CIP, NGOs, Kisima and other private seed companies, agro-dealers, cooperatives, MFIs, and processors. Additional stakeholders that should be included in the potato seed PPP are international seed companies, particularly Dutch potato companies. These companies have significant experience, high-quality genetics, and experience with agronomic practices that could be offered by the PPP.

Align EGS production locations with demand centers

An important attribute of the PPP would be to remove one of the most important barriers to demand creation by moving EGS production closer to major producing regions. In addition to the proximity benefits of physical co-location of production resources with demand for seed, the field research team recommends that there be private investments made in the required storage and distribution infrastructure (based on the successful Kisima model detailed in 4.4) in order to get seed to farmers wherever needed. This would lower costs for the farmers by reducing their travel time and costs, as well as the costs for seed producers, as there would be lower levels of seed losses. Additionally, supply information could be collected and shared with farmers within a given region.

Realize the potential marginal economic value of potato

Overall, the potato industry needs to continue to work towards realizing the potential marginal economic value of potato. This could be accomplished through a variety of interrelated efforts led by the PPP covering both increasing the volume and reducing the cost of production.

By introducing new, high-yielding varieties, smallholder farmers would be able to increase production and generate additional profit from the land area they currently allocate to potato. Matched with this increased yield would be the need to expand storage capacity to enable smallholder farmers and traders the flexibility to store potato and to sell production at the most ideal time, as dictated by the market, rather than selling production immediately after harvest. The processing industry should also be engaged by the PPP to determine which varieties are in demand and to create an action plan for processors to obtain these varieties from farmers.

Beyond increasing production, costs could also be lowered within the seed system. Technology could play an important role in lowering system wide costs. The field research team recommends that the PPP encourage the utilization of technologies beyond aeroponics to lower costs and increase accessibility within the seed system. Another area of optimization could be the inspection process, wherein additional inspectors or a more streamlined process could be implemented to lower costs to farmers and decrease the risk of inspection delays.

COMMON BEAN

The priority objectives for common bean are to increase the supply of improved seed to meet current market demand, build farm demand for improved varieties and quality seed, and create a sustainable demand by increasing the marginal economic value of common bean. To meet these objectives, there is a need for a robust and capable EGS system built as a PPP. The following are specific policy recommendations:

Directly engage farmers in on-farm trials to stimulate the adoption of improved varieties and quality seed

To increase pull-based demand from farmers in the market, the field research team recommends that the PPP design and execute on-farm trials to compare the performance of farmer-saved seed and quality seed. These comparative trials would serve to prove the value of improved seed, which in turn would stimulate adoption from farmers.

In parallel with these efforts from the PPP, the field research team recommends that the GoK increase budget support for extension services, with the goal of providing education to farmers related to the costs and benefits of improved varieties as well as agronomic best practices. Combining the aforementioned field trials run by the PPP and the renewed outreach and education efforts from the extension service would allow for the largest impact with farmers. A multifaceted communication strategy would be needed to ensure these education efforts reach as many farmers as possible. Mediums including radio, television, documentary films, farmer days, market days, and national champions should all be considered to disseminate the results widely on a national level.

Enhance the marginal value of common bean for farmers

Duel priorities of increasing yield and decreasing costs should be pursued in order for the marginal value of common beans to be enhanced. As a part of the commercial seed PPP, there would need to be a promotion of the value of improved varieties, by educating farmers on higher yields and associated higher incomes through field trials and demonstrations. These two priorities would help to increase demand, as well as communicate and demonstrate the agronomic best practices that could result in higher yields for farmers. Supporting these efforts to increase yields would be cost reduction efforts within the seed system, where the PPP would encourage public and private sector actors to increase the scale of their operations and focus on cost reduction efforts in order to bring down overall costs within common bean seed system. The PPP itself would be a prime example of the benefits of scale, and it should strive to provide high-quality commercial seed at the lowest possible cost to farmers so as to support the adoption and demand stimulation efforts noted above.

Table 18: **Kenya policy recommendations.**

	Kenya Policy Recommendations	Common Bean	Potato	Hybrid Maize
Legal and Regulatory	Reinstate and operate national level extension services in tandem with county level services to provide high-level national programming and local customization.	✓	✓	✓
	Revise inspection and certification standards and streamline process in order to decrease the associated costs for seed producers and shorten certification timelines.	✓	✓	✓
	Strengthen and enforce counterfeit seed laws.			✓
	Utilize breeders as the primary source of inspection and certification for breeder seed.	✓	✓	✓
	Establish a grades and standards system for marketing of production.	✓	✓	✓
Resource Allocation	Ramp up funding for breeding and seed production activities as well as royalty collection systems at national research institutes and universities to levels that ensure they can deliver on their mandates.	✓	✓	✓
	Increase funding of national and local extension to ramp up number of trained personnel.	✓	✓	✓
	Hire and train quality assurance lab and field personnel for inspection and sampling.	✓	✓	✓
	Ramp up demonstration trial capacity including seed number of plots, trained extension personnel, and seed availability.	✓	✓	✓
	Increase storage capacity for seed which will allow seed producers the opportunity to store inventory from successful harvests and increase sales flexibility.		✓	
Market Development	Build an seed forecasting demand system to provide real-time information on the specific varieties and quantities needed to meet market demands.	✓	✓	✓
	Develop purpose-built agricultural credit and working capital products for capital intensive EGS and commercial seed producers.	✓	✓	✓
	Develop agricultural products for smallholder farmers to invest in high quality inputs.	✓	✓	✓
	Promote the use of small seed packs tailored to smallholder farmer needs.	✓	✓	✓
	Increase farmer and seed producer educational and training programs in the use of agronomic and business best practices.	✓	✓	✓
	Develop a communications strategy focusing on educating farmers on the benefits of improved varieties using radio, television, documentary films, farmer days, market days, and national champions.	✓	✓	✓

Source: Kenya EGS Study (2016).

5.5 NIGERIA POLICY

Several EGS supply bottlenecks and demand constraints were common across all four crops assessed, and as such, the following policy recommendations apply to rice, yam, maize, and soybean.

Establish a National Seed Fund

The FMARD should support the establishment of a National Seed Fund focused on enabling Nigerian seed companies to produce and distribute new varieties of foundation and certified rice, maize, and soybean seeds and to actively promote these seeds in remote areas. While there are many agriculture-related funds in Nigeria, none are seed specific (Nigeria EGS Study pp. 10-11). The fund could be structured as a public entity in the form of a loan or challenge fund or matching grant to support qualified seed companies' specific targets in foundation and certified seed production and sales to farmers. Due to the high cost of producing foundation and certified seeds, private seed companies have generally focused on already established markets with popular varieties to reduce risk and to realize quick returns. As a result, more remote agricultural areas have often been neglected because of the high costs of farmer education and the limited number agro-dealers. In order to ensure the development of sustainable private

sector seed businesses, FMARD should consider selecting a private sector fund manager to manage the National Seed Fund as a public entity working closely with the many small- to medium-sized seed companies operating in Nigeria.

Implement and enforce clear and strong IP policies

It is a common theme across all crops in Nigeria that research and EGS production is hampered by the low motivation of breeders due to the lack of strong IP policies and weak royalty sharing policies. By incentivizing breeders to develop and produce improved varieties, yields in Nigeria could improve and smallholder farmer incomes could increase.

NASC and FMARD should support the implementation of clear and strong IP policies that enable licensing agreements and support appropriate royalty sharing.[12] This would require a revision of sub-section 4.5.1 of the National Seed Policy on Control of Varieties and Varietal Ownership. In particular, a specific change to consider would be that any seed variety qualified for certification would be traced back to the institute that released it, so that royalties would be remitted before certification. The NARIs would need to work closely with NASC to share information with seed companies on licensed and released varieties to enable the enforcement of royalty payments.

Support the improvement of the quality assurance system

To ensure quality across all classes of seeds and increase the rate of adoption of improved seeds among farmers, FMARD and NASC would need to sponsor an initiative to 1) improve the quality assurance system and 2) implement a certification protocol for QDS in the informal system. A common problem in all crops is NASC's lack of sufficient personnel to certify fields. A significant increase in staff would be needed to have a minimally effective certification and QDS system, i.e., a minimum of approximately 200 NASC-recruited field officers trained in modern seed certification methods. Furthermore, FMARD should publish new standards for the certification of informal sector-produced seeds and train about 2,000 community seed producers in selected states such as Kaduna, Kano, and Kebbi on best seed production practices.

Other stakeholders could help improve the quality assurance system by conducting in-house training workshops on seed certification best practices for recruited NASC field officers. These could include NGOs such as Catholic Relief Services and AGRA, CGIARs, the UK's FERA Science Limited, and regional organizations such as West and Central Africa Council for Agricultural Research and Development (CORAF/WECARD).

Suppress counterfeit seeds through the quick enactment of the New Seed Law

FMARD should work with the National House of Assembly to complete the legislative review process, thereby accelerating the passage of the New Seed Law. According to interviews with NASC officials, there will likely be a third review, with a December 2016 target for the President to sign the new law. However, it will require the involvement of many stakeholders, including regional policy development organizations such as AGRA and CORAF/WECARD to keep the review on track.

[12] IP and plant variety protection policies should harmonize with West Africa standards from ECOWAS to include both the public and private sectors in royalty collection agreements.

The new seed law will bring credibility to the seed system by placing more stringent and punitive sanctions on seed counterfeiters in both the formal and informal systems. Currently, fraudulent community-based seed sellers are packaging grains in the brand names of established seed companies. This is criminal fraud and serves to erode farmers' confidence in authentic improved seeds and reduce the sales of registered seed companies.

FMARD and NASC could utilize tactics gleaned from other sectors that face similar kinds of fraud. For instance, the techniques used in tracking fake drugs in Nigeria could be adapted for tracking fake seeds, such as strict sanctions (e.g., more than two years' imprisonment and/or a N500,000 fine and licenses taken away from any seed company caught packaging and/or distributing uncertified seeds). NASC should also develop partnerships with media outlets to mount educational campaigns to raise public awareness about efforts to sanitize the Nigerian seed marketplace.

In addition, mobile text verification technology has been developed by mPedigree and Sproxit, both of which provide an SMS- or app-based verification service (called Mobile Product Authentication) to alert consumers they could be purchasing counterfeit products. This technology is already in use by the National Agency for Food Drug Administration and Control, which ensures the quality of manufactured food, drugs, and other regulated products. This technology could be adapted to track authentic seeds, by requiring all accredited seed companies in Nigeria to register with mPedigree and/or Sproxit and by modifying bulk seed packaging in agro-sacks to polythene bags to accommodate barcodes for checking quality.

These efforts would require partnerships between the seed companies, agro-dealers, and NASC. This recommendation could be implemented within a short time, given that the New Seed Law is under second review at the National Assembly.

MAIZE AND SOYBEAN

Establish a public-private partnership for maize and soybean

The PPP for maize and soybean is based on sharing similar objectives. These objectives include expanding and enhancing profitable EGS production capabilities to meet current and future demand, developing a cost-effective quality assurance system, and increasing farmer demand for improved, high-quality seed.

Creating the PPP will require engaging a broad set of private and public sector actors that span the maize and soybean value chains and include local and international private actors. FMARD, NASC, IITA, and NARIs will be crucial in supporting the formation the PPP and ensuring administrative hurdles are dealt with swiftly and effectively.

The participation of domestic private seed companies will be crucial to the ultimate success of the PPP to ensure the system is economically sustainable and scalable. Additionally, international seed companies, including Syngenta and Monsanto, will be important partners. Increasing the demand from processors of animal feed, breakfast cereals, and vegetable oil will help in increasing the economic value of these crops. Furthermore, agro-dealers, farmer groups and associations, MFIs, and agribusiness fund providers should play major roles in the formation and design of the PPPs' operational procedures to ensure long-term economic sustainability.

All potential stakeholders will need to reach an agreement on the structure, operational framework, the pertinent stakeholders, and roles in the PPP. This initial group of stakeholders should include the widest range of possible actors to make sure all opinions are considered.

RICE

Rice demand is expected to remain high because of growing consumption, as evidenced by rising imports. Given the crop's appreciable marginal economic value, it should be attractive for full private sector participation. The priority objective for rice should be to stimulate sustainable private sector growth by removing policy barriers to private sector participation. These include inconsistent import policies and a lack of coherent government support for increasing local rice production and milling. The FGN should introduce clear policies such as creating input financing schemes for smallholder paddy growers, removing import tariffs on rice processing equipment and machinery for millers, and ensuring a strong border control system to enforce import duties. These measures would stimulate interest in local production and processing, and create a demand for improved seed. Also, as the reforms are implemented, the public sector could withdraw from producing foundation seed.

Establish a private processor-oriented rice seed system

Building on the Anchor Borrowers' Program, the FGN should identify integrated rice processors who can partner with the NARIs and seed companies who would produce specific, high-yielding rice varieties for their outgrowers.[13] Key rice processors such as Umza Rice, Miva Rice, and Labana Rice should be supported by donors such as USAID to lead a multi-stakeholder partnership. The objective of this would be to produce specific, high-yielding rice varieties that would ensure increased paddy production for local processing in key rice producing states, improve livelihoods of participating outgrowers, and lower Nigeria's dependency on rice imports.

The processor-oriented model can be used to execute on-farm demonstrations that show the yield benefits of using best agronomic practices with improved varieties compared with farmer-saved seeds. In order to finance smallholder farmers and outgrowers under this initiative, the government (through the Bank of Agriculture) should develop a purpose-built credit scheme to provide registered farmers with loans for quality inputs. This recommendation could motivate the Anchor Borrowers' Program to enter other key rice-producing states including Benue, Taraba, and Enugu. Low paddy production for local processing contributes to increasing brown rice imports by integrated processors and negatively impacts farmer incomes. Furthermore, the low quality of locally produced paddy increases the costs and decreases the efficiency of integrated rice processors.

Success is also highly dependent upon government policy to encourage the development of local rice production and processing and strong support for input financing for participating outgrowers.

YAM

[13] Launched in late 2015, the Anchor Borrowers' Program aims at creating linkages between smallholder farmers and large scale processors of agricultural produce to increase agricultural output and significantly improve capacity utilization of integrated mills. Value chains include rice and wheat in 14 states (Kebbi, Sokoto, Niger, Kaduna, Katsina, Jigawa, Kano, Zamfara, Adamawa, Plateau, Lagos, Ogun, Cross River, and Ebonyi).

Generally, the yam value chain in Nigeria is underdeveloped, receiving less attention from the government and development organizations than other crops. While it isn't exactly clear why this is the case, the lack of industrial opportunities as compared to cassava could be the reason why the FGN has not focused more on yam to date. Furthermore, while yam is an important crop in Nigeria, it is not widely grown outside of Nigeria, as compared to cassava. This could explain why donors have focused more on cassava, as it is a key crop in many countries around the world.

Although the yam seed system currently falls under the public sector dominant archetype due to the low demand for higher yielding varieties and low economic value, it has the potential to be attractive to the private sector. The YIIFSWA program led by IITA has already formed a formal yam seed system through collaboration with private sector entities such as Biocrops Biotechnology Limited, a private laboratory committed to developing seed systems through the use of improved technologies, and other local seed companies. Once these technologies and business models are validated and demonstrate their value to the private sector, an EGS-PPP could be recommended. However, at this stage, recommendations should focus on establishing value chain linkages, demonstrating the benefits of adopting improved varieties at the farm level, and distributing improved varieties.

Establish a strong National Yam Value Chain Association

IITA and NRCRI should lead the establishment of a strong National Yam Value Chain Association, with state chapters in four key production states (Oyo, Benue, Abia, and Niger), to increase collaboration and communication among stakeholders in the yam value chain in order to improve yields and create higher demand. The association's efforts could result in much greater interest in a yam EGS system, and become a platform to advocate for government's support of the yam value chain.

Yam yields in Nigeria are very low, largely because seed yam quality in the informal system is poor, disease pressure is high, and farmers use limited amounts of fertilizer and crop protection. The development of a formal yam seed system is critical to improving yields, but it has lagged due to a lack of collaboration between the research community and processors, which has in turn discouraged farmers from investing in improved yam varieties.

The four selected state governments should establish commodity development committees under their Ministries of Agriculture that would support yam value chain actors to improve farmer access to inputs to improve yields, and to generate demand for high-quality yam from processors and exporters. Meanwhile, processors should focus on innovations in new processed yam products by gleaning ideas from YIIFSWA's yam processing trials and from other countries such as Japan. Additionally, key actors in the yam value chain should develop a contact database of members and meet periodically to promote direct linkages among the research community and farmers and processors. The proposed association would also be well positioned to comprehensively address the critical issue of post-harvest loss, which spans the yam value chain.

Support the distribution of improved seed yam

NRCRI and IITA should support the distribution of improved seed yam by identifying and training community-based seed entrepreneurs in key production states such as Oyo, Benue,

Niger, and Abia to promote farmers' adoption of new varieties of yam. Currently, seed yam distribution by public institutions such as NRCRI, the Root and Tuber Expansion Program, and Agricultural Development Programs (ADPs) has been unsuccessful on a large scale.[14] Furthermore, government interventions to improve seed yam multiplication and distribution have been poorly funded, and the low seed multiplication rates of yam contribute to the high cost of seed yam production, making it an unattractive venture for private seed companies. New technologies such as TIBs and aeroponics are costly, thus limiting their adoption by private seed companies.

However, some promising new distribution models are being developed and deployed, including the Sustainable Cassava Seed Systems project led by Catholic Relief Services and biofortified cassava stem distribution by HarvestPlus in Benue and Oyo states, both of which provide valuable experience with respect to optimizing seed production models and implementing quality assurance systems. Additionally, YIIFSWA's high-ratio propagation technology for seed yam is an important possibility for commercializing and facilitating partnerships with private seed companies.

In the short term (1-3 years), NRCRI and IITA should focus on effectively demonstrating benefits, and distribute improved seed yam to a minimum of 500 yam farmers in each of the focus states with the purpose of increasing the number of farmers growing improved varieties. Additionally, two foundation seed yam producing companies should be established (Green Gold, Romarey, and Biocrops are already engaged with IITA's YIIFSWA program) to multiply breeder seed from IITA/NRCRI using aeroponics for foundation seed production by other seed companies. In the medium term (3-5 years), a minimum of 250 improved seed yam entrepreneurs in each focus state should be trained to accelerate the distribution of improved seed yam. In the long term, the sustainable production of yam foundation seed at reduced cost should be achieved.

MAIZE

The major barriers to the further development in hybrid maize are insufficient quantities of breeder seed, breaches in hybrid seed production agreements between seed companies and outgrowers, and the limited availability of credit necessary for farmers to invest in higher cost hybrid seed and the necessary inputs to optimize yield.

A PPP focused on producing foundation seed from existing germplasm from IITA and the NARIs presents a great opportunity to develop a sustainable and economically attractive hybrid maize seed system. The PPP would supply foundation seeds to existing and emerging domestic and regional seed companies in Africa. Given the high cost of producing foundation seed of hybrid maize and soybean, as well as the complementarity of the two crops in the processing sector, the PPP would emphasize a foundation seed production system for hybrid maize, and include soybean to reduce the cost of production. This would bridge the sizeable supply-demand gap currently existing for both crops.

[14] ADPs are agricultural extension agencies under state ministries of agriculture across Nigeria. With the introduction of the Unified Agricultural Extension Services in 1989, the ADP strategy was changed from a crop-biased approach to include other sectors such as livestock, fisheries, forestry, and natural resource management.

Accelerate the production and distribution of hybrids suited to the Humid Rain Forest agro-ecology zone

Currently, only a few hybrids adapted to the Humid Rain Forest agro-ecology zone are available, and the adoption rate remains low among farmers in key states such as Oyo, Ondo, Ogun, and Abia. IITA and the Institute for Agricultural Research & Training (IAR&T), in collaboration with the respective state governments, seed companies (e.g. Samlak and Nwabudo Seeds), the National Maize Farmers Association, state-based farmer associations such as Farmers Development Union, should support the production and distribution of adaptable hybrids such as Ife Maize hyb-5, Ife Maize hyb-6, Ife Maize hyb-8, and Ife Maize hyb-9. This recommendation would require a robust farmer education program in the south on the benefits of existing hybrids. Farmers would need to work in close partnership with the maize farmers' association in order to generate the scale necessary to gain access to premium markets and processors.

SOYBEAN

The priority objective for soybean is to expand EGS production capacity to meet current and future demand through an EGS-PPP with maize. A strong EGS system would help resolve the significant local supply deficit stemming from increased demand in the poultry and aquaculture sectors, and position Nigeria to become self-sufficient in soybean production.

Increase the capability of NCRI substations

Currently, private companies that produce foundation and certified seed have difficulty in accessing soybean breeder seed material. FMARD should increase the breeder seed production capacity of established NCRI branches, which currently can only produce the seed volumes necessary to conduct on-farm adaptive trials. In order to increase capacity, these branches require modern breeder seed multiplication technology as well as improved seed distribution processes to efficiently deliver seed to local seed companies.

This would likely take 3-5 years due to the intricacies of setting up breeder seed multiplication technology and recruiting and training state-based breeders.

Increase farmer and agro-dealer knowledge about the benefits of education of improved varieties

NCRI in collaboration with seed companies, ADPs, and initiatives such as USAID's MARKETS II should target farmer and agro-dealer education, extension support, and seed distribution support in Benue, Kaduna, Kano, and Taraba to introduce rust-resistant and low-shattering varieties. This collaboration will focus on agricultural education and develop communication strategies to reach farmers about improved varieties using demonstration trials, farmer field days, and the media. It would also include training extension agents to foster the distribution of improved varieties.

Most farmers currently grow the rust-susceptible TGX 1448-2E variety because they are unaware of rust-resistant varieties such as TGX 1951-3, NCRISOY 1, and NCRISOY 2. Educating farmers on the benefits of rust-resistant varieties is a "quick win" that could be implemented in a 1-2-year timeframe and could increase soybean output by 40%. It would require identifying existing soybean farmer groups, ensuring that sufficient quantities of rust-

resistant varieties are produced, and ensuring there will be adequate resources from seed companies to advance farmer education efforts.

Table 19: **Nigeria policy recommendations.**

	Nigeria Policy Recommendations	Rice	Yam	Hybrid Maize	Soybean
Legal and Regulatory	Implement clear and strong IP policies that enable licensing agreements and support appropriate royalty sharing.	✓	✓	✓	✓
	Suppress counterfeit seeds through the quick enactment of the New Seed Law.	✓		✓	✓
	Remove import tariffs on rice processing equipment and machinery for millers, and ensuring a strong border control system to enforce import duties	✓			
	Implement contract enforcement mechanisms between seed companies and outgrowers.	✓	✓	✓	✓
	Establish a grades and standards system for marketing of production.	✓	✓	✓	✓
Resource Allocation	Increase funding for breeding activities focused on Humid Forest agro-ecology zone.			✓	
	Increase funding for NCRI substations to increase seed production and trial capacity.				✓
	Hire and train quality assurance lab and field personnel for inspection and sampling.	✓	✓	✓	✓
	Ramp up demonstration trial capacity including seed number of plots, trained extension personnel, and seed availability.	✓	✓	✓	✓
	Increase storage capacity for seed which will allow seed producers the opportunity to store inventory from successful harvests and increase sales flexibility.	✓	✓		
Market Development	Build an seed forecasting demand system to provide real-time information on the specific varieties and quantities needed to meet market demands.	✓	✓	✓	✓
	Introduce an input financing schemes for smallholder paddy growers.	✓			
	Develop purpose-built agricultural credit and working capital products for capital intensive EGS and commercial seed producers.	✓	✓	✓	✓
	Develop agricultural products for smallholder farmers to invest in high quality inputs.	✓	✓	✓	✓
	Promote the use of small seed packs tailored to smallholder farmer needs.	✓	✓	✓	✓
	Increase farmer and seed producer educational and training programs in the use of agronomic and business best practices.	✓	✓	✓	✓
	Develop a communications strategy focusing on educating farmers on the benefits of improved varieties using radio, television, documentary films, farmer days, market days, and national champions.	✓	✓	✓	✓

Source: Nigeria EGS Study (2016).

5.6 CROSS COUNTRY POLICY RECOMMENDATIONS

A review of the recommendations listed in the previous sections of Chapter 5 reveals that there are many common policy recommendations across Rwanda, Zambia, Kenya, and Nigeria. These cross-country policy recommendations are summarized in Table 20.

Table 20: **Cross-country policy recommendations.**

Cross Country Policy Recommendations

Legal and Regulatory	Implement clear and strong IP policies that enable licensing agreements and support appropriate royalty sharing.
	Implement and operationalize quality declared system.
	Reform breeder incentives to align with market impact rather than number of releases.
	Implement contract enforcement mechanisms between seed companies and outgrowers.
	Establish a grades and standards system for marketing of production.
Resource Allocation	Increase funding for breeding and seed production activities as well as royalty collection systems at national research institutes and universities to levels that ensure they can deliver on their mandates.
	Increase funding of national and local extension to ramp up number of trained personnel.
	Hire and train quality assurance lab and field personnel for inspection and sampling.
	Increase demonstration trial capacity including seed number of plots, trained extension personnel, and seed availability.
	Increase storage capacity for seed which will allow seed producers the opportunity to store inventory from successful harvests and increase sales flexibility.
Market Development	Build a seed forecasting demand system to provide real-time information on the specific varieties and quantities needed to meet market demands.
	Develop purpose-built agricultural credit and working capital products for capital intensive EGS and commercial seed producers.
	Develop agricultural products for smallholder farmers to invest in high quality inputs.
	Promote the use of small seed packs tailored to smallholder farmer needs.
	Increase farmer and seed producer educational and training programs in the use of agronomic and business best practices.
	Develop a communications strategy focusing on educating farmers on the benefits of improved varieties using radio, television, documentary films, farmer days, market days, and national champions.

Source: Rwanda, Zambia, Kenya, and Nigeria EGS Country Studies (2016).

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