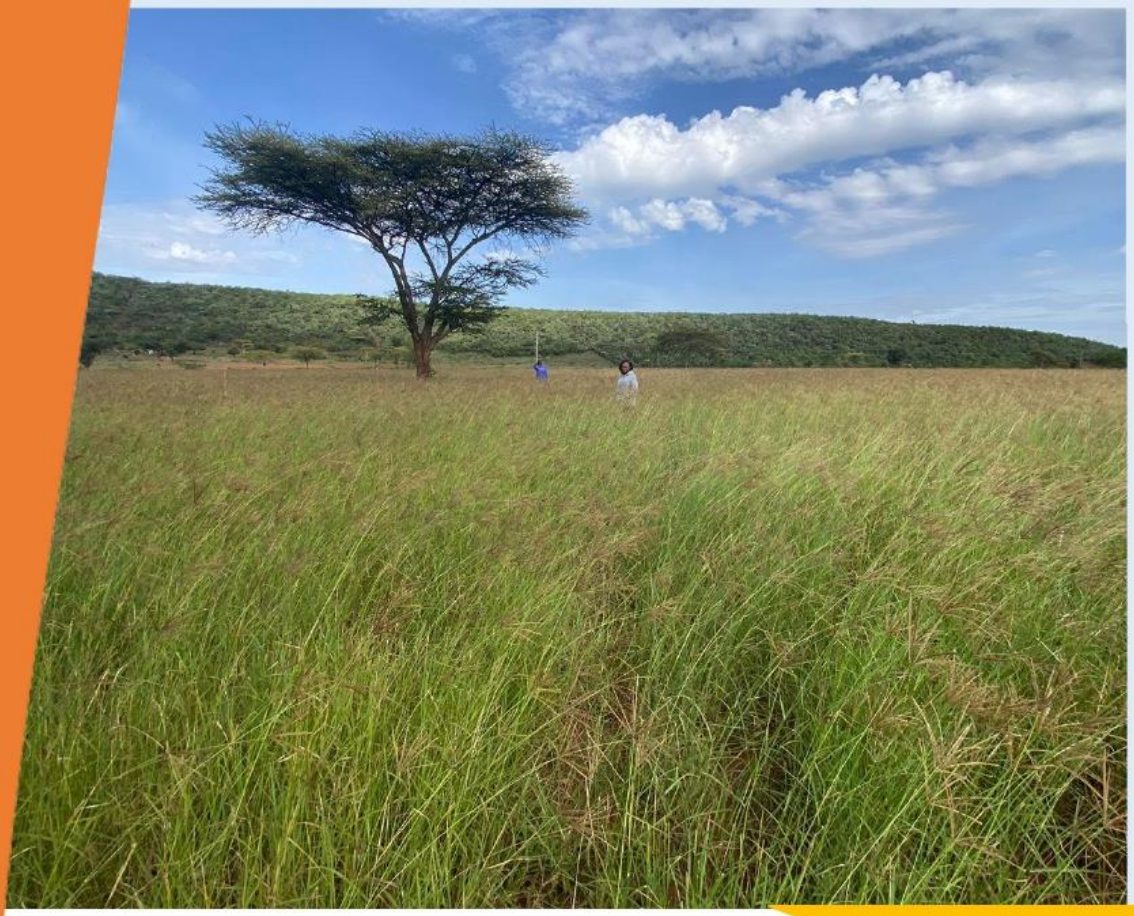

Strengthening Seed Systems in Arid and Semi-Arid Lands (ASALs) of Kenya

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Consultancy Report

FEASIBILITY STUDY FOR THE DEVELOPMENT OF PUBLIC PRIVATE SEED DELIVERY SYSTEMS IN THE ARID AND SEMI-ARID LANDS OF THE REPUBLIC KENYA.

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List of Acronyms and Abbreviations

ADC	Agricultural Development Corporation
ADSP	Agribusiness Development Support Project
AgGDP	Agricultural Gross Domestic Product
AGMARK	Agricultural Market Development Trust
AGRA	Alliance for Green Revolution in Africa
ASALs	Arid and Semi Arid Lands
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASBP	African Seed and Biotechnology Program
ASDC	Agricultural sector Development Strategy
ASTGS	Agricultural Sector Transformation and Growth Strategy
ASTI	Agricultural Science and Technology Indicators ATIRI Agricultural Technology and Information Response Initiative
AUC	Africa Union Commission
CAADP	Comprehensive Africa Agricultural Development Program
CBK	Central Bank of Kenya
CBOs	Community Based Organizations
CGD	Center for Global Development
CGIAR	Consultative Group for International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIDPs	County Integrated Development Plans.
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CNFA	Cultivating New Frontiers in Agriculture
COMESA	Common Market for Eastern and Southern Africa
CRF	Coffee Research Foundation
CSPD	Conventional Seed Pocurement and Distribution
DFRDP	Dry land Farming Research and Development Project
DUS	Distinct, Uniform and Stable Varieties
EGS	Early Generation Seed
FAO	Food and Agriculture Organization of the United Nations
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GoK	Government of Kenya
HCDA	Horticultural Crops Development Authority
IAASTD	International Assessment of Agricultural Knowledge Science and Technology for Development
IARCs	International Agricultural Research Institutes.
ICIPE	International Center of Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IGAD	Intergovernmental Authority on Development
IITA	International Institute of Tropical Agriculture
IPR	Intellectual Property Rights
ISSD	Integrated Seed Sector Development
ISTA	International Seed Testing Association
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KACE	Kenya Agricultural Commodity Exchange Limited
KALRO	Kenya Agriculture and Livestock Research Organization
KARI	Kenya Agricultural Research Institute
KASP	Kenya Agro-dealer Strengthening Program
KEFRI	Kenya Forestry Research Institute

KEMFRI	Kenya Marine and Fisheries Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KES	Kenya Shillings
KESREF	Kenya Sugar Research Foundation
KIRDI	Kenya Industrial Research and Development Institute
KLIP	Kenya Livestock Insurance Program
KNBS	Kenya National Bureau of Statistics
KSB	Kenya Sugar Board
KSC	Kenya Seed Company
KSI	Kenya Sugar Industry
KTDA	Kenya Tea Development Agency
MSCK	Monsanto Seed Company in Kenya
NAFSIPs	National Agricultural and Food Security Investment Plans
NARL	National Agricultural Research Laboratories
NERICA	New Rice for Africa
NGBK	National Gene Bank of Kenya
NGOs	Non-Governmental Organizations
NPTC	National Performance Trials Committee
NVRC	National Variety Release Committee
POC	Pioneer Overseas Corporation
PSC	Pannar Seed Company
SACCOs	Savings and Credit Cooperative Organizations
SDGs	Sustainable Development Goals
SADC	Southern African Development Community
STAK	Seed Traders Association of Kenya
SVF	Seed Vouchers and Fairs
TASAI	The African Seed Access Index
TBK	Tea Board of Kenya
TRF	Tea Research Foundation
UoN	University of Nairobi
UNDP	United Nations Development Program
UPOV	Union for the Protection of New Varieties of Plants
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VCU	Value-for-Cultivation Use
WB	World Bank
WSC	Western Seed Company

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CHAPTER ONE: INTRODUCTION AND BACKGROUND

The agricultural sector is a major driver of growth for the Kenyan economy and a dominant source of employment for roughly half of the Kenyan people. The sector is pivotal for the country to achieve the formidable goals established in the government's Vision 2030, which are to transform Kenya into a globally competitive, prosperous country with a high quality of life by 2030. It accounts for about 51 per cent of GDP (26 per cent directly and 25 per cent indirectly through its linkage with other sectors). Further, approximately nine million Kenyans (or 56 percent) of total employment (KNBS, 2018) were employed in agriculture in 2017. Agriculture is also responsible for most of the country's exports, accounting for up to 65 percent of merchandise exports in 2017. Consequently, the sector remains central to GDP growth, with years of strong agricultural sector growth reflecting in overall GDP growth. The importance of agriculture in Kenya has been highlighted in Vision 2030 and the Medium-Term Plan III, and most recently the President's Big Four priority agenda for 2017-2022, which emphasizes the importance of 100% food and nutrition security for all Kenyans.

Even though Kenya has made progress in modernizing its agriculture, the country is yet to reach its full potential. To achieve this potential, Kenya must do agriculture in a different way, from how it develops policy at the national level, to how it allocates resources in the farming households. Kenyan farms are generally small and shrinking and are becoming uneconomical to operate. Farm enterprises comprise mixed crops, pasture and livestock. Because 83 percent of Kenya's land area is in the ASAL region with an annual rainfall average of 400 mm, only 17 percent of the country is suitable for crop production (GoK, 2010). Further, increasing population in rural areas and rising urbanization means that 80 percent of the population lives on arable land, reducing per capita arable land from about 0.7 acres in the mid-1970s to 0.3 acres in 2015. Consequently, land scarcity is becoming a binding constraint to agriculture growth and is leading to unsustainable forms of agricultural production (Muyanga and Jayne, 2019). For example, about 87 percent of farmers operate less than 2 hectares, and approximately 67 percent operate less than 1 hectare. Since 20 percent of farmers with the smallest holdings generate 57 percent of their incomes from farming activities, the decline in the availability of arable land demonstrates the need and importance of improving productivity in ASALs to ensure food security.

1.1 Agricultural Production Systems

Farmers in Kenya pursue a wide range of crop and livestock enterprises that vary both across and within the major agro-ecological zones. Diversity is the norm; even at the level of the individual farm unit, farmers typically cultivate 5 or more crops in diverse mixtures that vary across soil type, topographical position and distance from the household compound. Agricultural production systems in Kenya are anchored on rain-fed and irrigated agriculture. Basically, there are two cropping seasons except in the very high-altitude areas. The performance of rain-fed agriculture varies due to the diverse agro-climatic zones. In the humid, high-altitude areas, productivity as well as predictability of a good crop is high. However, the population density in these areas has increased and land has been subdivided into such small sizes that it is becoming uneconomical for farm enterprises (Muyanga *et al*., 2017). To mitigate this problem, land subdivision should be restricted and farm enterprises intensified. In the medium altitude and moderate-rainfall areas, arable rain-fed farming is moderately suitable. However, there is a relatively high risk of crop failure due to increased frequency of dry spells and an uneven rainfall distribution. Increasing productivity in these areas will require better selection of crops, adoption of improved technologies, and better crop husbandry.

Irrigation agriculture in Kenya is carried out mainly in irrigation schemes and in large-scale irrigation of crops such as rice and maize. Individual farmers have developed their own systems of irrigation especially for export crops such as rice and horticulture. Large commercial farms account for 40 per cent of irrigated land, smallholder farmers 42 per cent and Government-managed schemes 18 per cent (GoK, 2019a). With a national average rainfall of 400 mm, the country should harvest and store adequate water for agriculture and other uses. Groundwater resources that can be exploited for agriculture need to be assessed and quantified.

More land can be reclaimed for crop cultivation by developing irrigation infrastructure in the ASALs. It is estimated that intensified irrigation can increase agricultural productivity fourfold and, depending on the crops, incomes can be multiplied to about 10 times.

1.1.1 Production Levels

Production levels can be classified based on whether the farming system is small scale, medium scale or large scale.

Small-Scale Farming

Kenya's agriculture is predominantly small-scale farming mainly in the high-potential areas. Production is carried out on farms averaging 0.2–3 ha, mostly on a commercial basis. This small-scale production accounts for 75 per cent of the total agricultural output and 70 per cent of marketed agricultural produce. Small-scale farmers produce over 70 percent of maize, 65 per cent of coffee, 50 per cent of tea, 80 per cent of milk, 85 per cent of fish, and 70 per cent of beef and related products (World Bank Country Report, 2019). However, adoption of improved inputs such as hybrid seed, concentrate feeds, fertilizer, safe use of pesticides and machinery by small-scale farmers is relatively low. There is huge potential for increasing productivity for these farmers with adoption of modern farming practices.

In the rangelands, the small-scale livestock production system features mainly pastoralists. Livestock herd sizes are considerably large because of communal grazing with low use of purchased inputs like feed, drugs and artificial insemination. Production is mainly for subsistence rather than market oriented. Disease and nutrition are major constraints to increased livestock productivity in this system.

Medium-Scale Farming

Medium-scale farms range from 3 to 49 ha. Farmers in this category are receptive to technology and practice commercial agriculture by investing in inputs, marketing produce and borrowing credit for farm development.

Large-Scale Farming

In Kenya, large-scale farming is practiced on farms averaging about 50 ha for crops and 30,000 ha for livestock ranches. The large-scale farming subsector accounts for 30 per cent of marketed agricultural produce, mainly involving growing crops such as tea, coffee, maize and wheat in addition to keeping livestock for commercial purposes. The use of improved technologies and better farm management has resulted in increased productivity per land unit in all categories of farming.

1.1.2 Livestock

Livestock plays an important economic and socio-cultural role among many Kenyan communities and especially those from the ASALs. The livestock sub-sector contributes to the food and cash needs of the farmers, and provides employment to about 10 million people, contributes 7 per cent to the GDP and 17 per cent to the AgGDP, and provides 50 per cent of the agricultural labour (GoK, 2010b). Both crop farmers and pastoralists keep livestock for food and income generation. The livestock industry has a high degree of vertical links with upstream and down-stream industries. It is a significant user of products from pasture seeds, feeds, drugs, vaccines and equipment manufacturing industries and is a major provider of raw materials for agro-processing industries. Therefore, any shock in the industry will affect the supply chain. The key livestock subsectors are beef, dairy, sheep, goats, camel, poultry, piggery and emerging livestock.

1.1.3 Aquaculture

Commercial aquaculture enterprises are increasing. This is a paradigm shift from subsistence aquaculture, which has been practiced in Kenya over the years. Due to aggressive extension, aquaculture has increased fourfold over a short time. In 2000, production was about 1000 tones; in 2006 production had risen to 4250 tones, earning the country about KES 1.0 billion (FAO, 2019). Aquaculture can be integrated with other production activities such as rice farming, poultry and dairy production to increase production efficiency per unit area.

The main constraints facing the development of aquaculture include: inadequate support to aquaculture infrastructure such as fish hatcheries, poor-quality fish seed and feed, inadequate budgetary provision, inadequate market information and marketing uncertainties, limited aquaculture research, lack of aquaculture policy, inadequate provision of extension services, poor link between production and marketing, lack of national aquaculture extension guidelines, and lack of baseline data for aquaculture investment.

1.1.4 Apiculture

Beekeeping (apiculture) is practiced in most parts of Kenya, particularly in the ASALs. In addition to contributing directly to household incomes, bees play an important role in plant pollination. The country produces an estimated 14,600 tones of honey and 140 tones of beeswax annually; all valued at KES 4.4 billion (Muma, M. 2019). Due to the low investment and variable costs involved, beekeeping is becoming increasingly popular in rural areas and especially in the ASALs.

1.1.5 Forestry

Forests are origins of water streams for hydropower. Forests and related forestry activities contribute to improved agricultural productivity through conserving soil and water and enhancing soil fertility. Kenya's national forest cover is less than 3 per cent compared with the internationally accepted level of 10 per cent. This decrease has resulted from unplanned excision of land for settlement and excessive harvesting of trees without replanting. The destruction of forestland has contributed to increased rates of flooding as the concentration time is reduced on bare ground leading to landslides and siltation of rivers. Currently, efforts in forestry development in the country focus on expanding tree cover in industrial plantations, on-farm trees, urban forestry and in local authority forests to achieve the desired 10 per cent forest cover.

Government is rehabilitating degraded water catchment areas and adoption of agroforestry has improved over the years. Promoting on-farm forestry and conservation of natural environment is ongoing. Initiatives aimed at introducing commercial tree species in the ASALs to control desertification and improve livelihoods have been undertaken (GoK, 2017). Integrated development that entails trees, wildlife, agriculture and micro-enterprises provide synergies that improve overall environmental and production needs.

1.2 Current and Recent Agricultural Development Initiatives

1.2.1 Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019-2029

Recognizing the importance of agriculture in economic development and poverty reduction, the government of Kenya has recently launched the Agricultural Sector Transformation and Growth Strategy (GoK, 2019b) that is expected to guide sector programs over the next ten years. The strategy has three main pillars: Raising the incomes of small-scale farmers, pastoralists and fisher folks; increasing agricultural output and value-addition; and boosting household food resilience. While the strategy is national, the counties will implement it in line with the Constitution's provision that agriculture is a largely devolved function. The county governments will domesticate the strategy and conduct all planning, funding and implementation in alignment with their own priorities, as outlined in sector plans and County Integrated Development Plans (CIDPs). The agricultural sector is also part of the Big 4 priority sectors, which are expected to drive the government's inclusive growth agenda over the medium term. The Big 4 agenda for agriculture is to attain 100 percent nutritional and food

security for all Kenyans by 2022 (GoK, 2018a).

Nonetheless, the sector faces formidable challenges and risks that could weaken its potential to contribute towards achievement of the Big 4 agenda. The sector's performance over the last two decades has been erratic with productivity of food crops falling rapidly relative to growing demand, leaving many poor households without adequate access to food. The flagging productivity of cereal crops such as maize, wheat and rice has resulted in rising import bills to plug the food deficit and widening of the current account deficit. Furthermore, climate change is increasingly becoming a threat to agricultural output with negative implications for food security, livelihoods, and economic growth. The Center for Global Development (CGD) ranks Kenya 13th out of 233 countries for "direct risks" arising from "extreme weather" and 71st of 233 for "overall vulnerability" to climate change (after adjusting for coping ability) (CGD, 2018). Other challenges facing the sector include scarcity of arable land, lack of access to credit, poor infrastructure, and lack of integrated markets.

1.2.2 Irrigation

Irrigation remains a key enabler for building resilience and climate proofing the sector. In recognition of this fact, the National Irrigation Board has embarked on irrigation projects in ASAL areas such as Turkana, Garissa, Hola, and Upper and Lower Eastern regions, among others. Studies have shown that returns to public spending on smallholder irrigation schemes could be significant (GoK, 2019a). For instance, returns to irrigation range anywhere from 17 percent for large-scale farmers to 43 percent for small-scale farmers, and could triple per capita farm incomes, with significant impacts on poverty reduction. As such, there is need to boost investment in smallholder irrigation schemes and to promote private sector investment in irrigation. Reforming water use policy could also allow the private sector to price and sell water to small-scale producers.

1.2.3 Liberalization of the Seed Industry

Liberalization of the seed industry through legislation has opened the market for private seed companies and NGO's to play a greater role in supporting agricultural development. Seed production and marketing in Kenya were liberalized through the Ministry of Agriculture's Seed and Plant Varieties Act Cap 326, which allowed private seed companies to cover all stages of the seed value chain. The Act regulates testing, certification and procedures relating to the introduction of improved and new varieties bred locally or imported. All crop varieties fall under Schedule II of the Act requiring mandatory inspection before official registration and varietal release. Seed laws are harmonized with the relevant international conventions. Imported seed requires phytosanitary certificates as well as International Seed Testing Association (ISTA) certificates. Local seed is considered to be over-regulated as production and distribution is subject to stringent regulations. This is coupled with long varietal release processes, which make the seed expensive, and contributes to seed shortages.

1.2.4 National Livestock Insurance Scheme

National Livestock Insurance Scheme has enabled farmers to insure their livestock against calamities like diseases, which make them incur great losses. Approximately 75 percent of livestock deaths in the Horn of Africa are caused by severe drought, repeatedly leaving herders, their families and entire communities destitute. In October of 2015, the first government livestock insurance scheme in Africa – the Kenya Livestock Insurance Program (KLIP) - was successfully piloted in two counties in the North of Kenya (KLIP, 2018). The scheme, which was launched with the support of Andrew Mude, ILRI, 2016 winner of the World Food Prize Award, and Swiss Re, will now be scaled up to benefit herders across the country.

The programme applies satellite-based index insurance to protect pastoralists in remote areas. Satellites assess the state of the grazing conditions in a certain region by measuring the colour of the ground. Green is good while yellow is very dry. Once a certain threshold is reached the insured automatically receive a lump sum payment, allowing them to provide their livestock - which includes cows, goats and camels – with feed

and water, to survive. The fact that KLIP is designed to keep livestock from dying, allows the pastoralists to hold on to their way of life and means of survival.

The KLIP pilot, which was launched in October 2015, covered the two counties of Wajir and Turkana, protecting livestock of 5,000 households. So far, 275 nomadic cattle farmers in Wajir County have received insurance payments. The scheme will now be extended across the whole country. Wholly funded by the Kenyan government, the premiums come at no charge to herders registered under the Hunger Safety Net Program, and covers five animals per household. They can also choose to insure additional animals at their own expense.

In addition to the Kenyan Government, KLIP has been implemented with the help of local insurance companies. The scheme is also supported by the World Bank, The International Livestock Research Institute and Swiss Re.

1.2.5 New Technologies to Boost Farmers' Incomes

Kenyan farmers can increase their annual profits by between 7.1 per cent and 76.3 per cent with the use of digital farming technologies that can be helpful in keeping records and monitoring crop and livestock health, according to a 2015 research conducted by UK innovation foundation Nesta. Such technologies, which include mobile applications, enhance farming activities and improve yields. Therefore, government institutions such as the Kenya Agriculture and Livestock Research Organization (KALRO) and industry experts are driving the adoption of these tools in a bid to reduce post-harvest losses through provision of timely and accurate information directly to the farmers' phones. Eska, a mobile app developed by botanist and biochemist Samuel Kamya, is used to detect crop diseases and deficiency of important nutrients such as phosphorus. It was launched in August 2017, at a time when KES150 billion worth of produce went to waste in the country due to pest infestation and inadequate market access.

Leveraging modern technology could spin-off a wide range of agricultural applications, from providing weather updates, market data and access to finance for farmers, to driving logistical efficiencies for input suppliers and buyers, as well as providing traceability opportunities across the value chain. Kenya is making a deliberate effort to be ahead of the curve on agricultural innovation. Other innovations include Safaricom's digifarm and Masoko. The former enables farmers to obtain information on soil types, markets, and credit, while the latter connects sellers to buyers overcoming search and matching costs. Thus, there is a clear will and capacity of entrepreneurs in Kenya for market-based innovation and adoption of agro-based technologies that could enhance farmer access to information and boost productivity and farmer incomes.

1.2.6 Cooperatives

The cooperative movement in Kenya has played an important role in agricultural development and in the economy. Agricultural cooperatives have helped in procurement and distribution of farm inputs, production, value addition and marketing. In the financial sector, the cooperative movement through savings and credit cooperatives (SACCOs) has helped mobilize savings and provide credit to producers. Agricultural cooperatives form 46 per cent of all cooperative societies in the country, and they have 3 million members out of a total membership of 7 million in the entire cooperative movement (Otieno, S. 2019). Whereas, the government provides the necessary legal and regulatory environment, the cooperatives are member-owned and operated organizations.

The Government recognizes the role played by cooperatives in the economy and has emphasized the need to revitalize the cooperatives sector to play a more significant role in reviving the economy through improved governance and management capacity. Consequently, the Government has reviewed the Cooperative Societies Act and formulated a new cooperative development policy in addition to the cooperative investment policy to guide the cooperative movement in the medium term. Due to the enormous growth of SACCOs in the

last few years, and to ensure that they continue to be relevant in the financial sector, the government has also developed the SACCO Regulatory Act and operationalized the SACCO Regulatory Authority.

1.3 Scope for the Development of Agriculture

In spite of the many challenges and constraints limiting agricultural growth in Kenya, the scope for agricultural development still remains wide and open. Many opportunities and advantages exist that can be exploited to build a robust and dynamic agricultural sector. These include:

1.3.1 Abundant human resources. Kenya is endowed with a massive but under-used human resource capacity. Primary, secondary and post-secondary education has expanded and produces thousands of graduates each year. This resource can be used to change the face of agriculture if young people, from primary to university level, are to be attracted to agriculture as a career. The human resource can be used in training and research to develop new and relevant technologies, and to create and expand agribusinesses.

1.3.2 New and expanding markets. Kenya is uniquely placed to take advantage of expanding domestic, regional and international markets. Due to the diverse agro-ecology, the country can produce a wide range of temperate, tropical and subtropical products. Large and expanding markets for traditional products like maize and other cereals, beef and dairy products; tea, coffee and pyrethrum exist. Global demand for horticultural products, and emerging livestock such as ostrich, guinea fowl, crocodile, frogs and butterflies, and emerging crops such as assorted resins, gum arabic, aloe and essential oils, remain under-exploited. Vast opportunities are opening up in the production of biofuels from sugar cane, maize, millet, sorghum, jatropha and other oil-bearing seeds.

1.3.3 Potential for increasing production. Not much effort has been put to increasing production of traditional commodities in Kenya. Agricultural productivity can be increased in multiples through better use of unused land in traditional farming areas, and through irrigated agriculture, and use of certified hybrid seeds. The vast livestock potential in the arid and semi-arid areas that cover 80 per cent of the country remains untapped as does the fisheries potential of the exclusive economic zone in the Indian Ocean, and of fish farming in the highlands and ASALs.

1.3.4 Vast irrigation potential. Kenya's irrigation potential is estimated at 540,000 ha of which only about 105,000 ha is exploited (Khainga, D. 2018). Compared to other countries, the rate of irrigation development in Kenya has been very low at about 0.5% p.a. There is therefore need to increase investment in irrigation development to ensure its accelerated growth and sustainable development. The potential for exploiting irrigation can be expanded by 1 million ha by developing the Tana and Athi basins. Lake Victoria has a 253-km shoreline in Kenya that is basically unused despite the huge irrigation potential.

1.3.5 Potential for increasing yields. It's a well-recognized fact that yields of most crops in Kenya are far below their optimum. Yields of maize, sugar and dairy are one-tenth of global potential. Kenya's maize yield, for example, is estimated to be approximately 2 tons/ha (Olwande, J. 2012). This is the same as the 1960 global average, more than half a century ago, and not much more than the US average of 1.5 tons/ha in the mid 1930s, before hybrids were introduced there. Yields for many other food crops are similarly low, contributing to a continuous cycle of poverty and hunger for millions of Kenya's smallholder farmers, and impedes more rapid Kenyan GDP growth.

One important factor, some believe the most important factor, contributing to the low productivity is the seed that farmers are planting. All too frequently, the seed planted by Kenyan farmers does not contain the improved germplasm available to farmers in other parts of the world, and frequently quality is wanting as well. Kenya's farmers are eager for high-quality seed of improved varieties that is suited to their agroecologies to increase their yields. Demand is undoubtedly high but the supply response however, is challenged by a myriad of factors, ranging from historically low levels of new variety releases for most crops, to under-supply of

parental seed material, to low levels of local private sector seed company financing, to the large market share held by the parastatals, namely; the Kenya Seed Company and KALRO Seed Unit.

Kenya's seed industry, while embodying strengths in many areas, does not embody many of the key working practices and levels of impact seen in mature seed industries in other parts of the world. Key among these are: a large and diverse pool of private sector participants; large degrees of self-regulation among companies; extensive private sector research efforts; rapid innovation and product release into the market; and strong mechanisms for addressing customer complaints.

Existing potential market size based on current cropping patterns is estimated to exceed US$60 million at the national level, and perhaps exceed this figure by quite a lot as more smallholders adopt higher value seeds such as vegetable hybrids. However, Kenya is not tapping even an estimated 60% of the existing potential at the national level. Furthermore, market growth is sluggish as low productivity does not drive more intensified cropping patterns. Perhaps even more important, subsequent and significant Kenyan GDP growth from agribusiness – growth that would be driven by greater use of improved varieties by smallholder farmers, larger commercial farmers, and industrial producers – is lost each year. This is a significant loss, as there is large regional and global export potential in the agribusiness sector.

Putting more and better seeds, fertilizers, and other inputs into the hands of farmers and pastoralists and finding ways to link them more directly to markets are among the key thrusts of current sector development policies. More broadly, Kenya's *Vision 2030* aims in part to transform the country's agriculture from subsistence to a more competitive and commercially oriented sector, one that can meet the country's food needs, expand exports, and become a key engine for forward growth.

1.3.6 Value addition. Value addition includes processing, branding, quality certification and accreditation, as well as farm-level quality improvements that the market values. It is estimated that 91 per cent of total agricultural exports are in raw or semi-processed form. Thus, the country loses billions in earnings by not adding value to its produce. Potential for adding value to products such as tea, coffee, pyrethrum, hides and skins, milk and beef, fruits and vegetables remains largely untapped.

CHAPTER TWO: CROP PRODUCTION SYSTEMS

The current crop production levels in Kenya are generally low, especially in the ASAL areas. There has been frequent drought occurrence, sometimes very severe. The trend for all crops is on the decline due to climatic change. Crop production is in two categories based on the use of the harvested produce: food crops and cash or industrial crops.

2.1 Food Crops

Food crops are classified into cereals (maize, wheat, sorghum, rice, millet); pulses (beans, pigeon pea, cowpea, chickpea, green grams); and, roots and tubers (sweet potato, Irish potato, cassava, arrow root and yam). The main food crops are maize, rice, wheat, sorghum, potato, cassava, vegetables and beans.

Production Trends in Kenya as collated from the ministry of agriculture and its agencies, Kenya National Bureau of Statistics, World Bank, Global Data Firm Knoema, USDA reports, FAO and other documents currently being compiled.

Table 1: Maize Trend

Year	Metric Tones	Growth rate (%)
2019	3,200,000	-20.00
2018	4,000,000	25.55
2017	3,186,000	-4.58
2016	3,339,000	-12.71
2015	3,825,000	8.88
2014	3,513,171	-2.21
2013	3,592,688	-4.19
2012	3,749,880	11.05
2011	3,376,862	-2.53
2010	3,454,541	42.05
2009	2,439,000	3.03
2008	2,367,237	-19.17
2007	2,928,793	-9.81

Table 2: Sorghum Trend

Year	Metric Tones	Growth rate (%)
2019	150,000	-16.67
2018	180,000	44.00
2017	125,000	6.84
2016	117,000	-38.10
2015	189,000	6.18
2014	178,000	5.33

2013	169,000	1.20
2012	167,000	4.38
2011	160,000	-2.44
2010	164,000	65.66
2009	99,000	83.33

Table 3: Millet Trend

Year	Metric Tones	Growth rate (%)
2017	54,000	0.00
2016	54,000	-45.45
2015	99,000	-21.43
2014	126,000	-9.24
2013	138,829	0.45
2012	138,204	88.30
2011	73,396	36.22
2010	53,881	-0.22

Table 4: Milled Rice Trend

Year	Metric Tones	Growth rate (%)
2019	80,000	1.27
2018	79,000	49.06
2017	53,000	-20.90

2016	67,000	-12.99
2015	77,000	4.05
2014	74,000	-10.84
2013	83,000	-8.79
2012	91,000	24.66
2011	73,000	28.07
2010	57,000	103.57
2009	28,000	86.67

Table 5: Wheat Trend

Year	Metric Tones	Growth rate (%)
2019	250,000	-30.56
2018	360,000	118.18
2017	165,000	-25.68
2016	222,000	-7.11
2015	239,000	4.37
2014	229,000	-49.11
2013	450,000	1.81
2012	442,000	64.93
2011	268,000	4.69
2010	256,000	-50.00
2009	512,000	133.79

Table 6: The Common Bean Trend

Year	Metric Tones	Growth rate (%)
2014	615,992	-13.79
2013	714,492	14.73
2012	622,759	7.80
2011	577,674	47.89
2010	390,598	-

Table 7: Pigeon Pea Trend

Year	Metric Tones	Growth rate (%)
2014	196,324	18.53
2013	165,636	-1.19
2012	167,623	88.74
2011	88,813	-14.04
2010	103,324	-

Table 8: Green Grams Trend

Year	Metric Tones	Growth rate (%)
2014	121,076	25.08
2013	96,799	5.42
2012	91,824	30.76
2011	70,225	14.89
2010	61,125	-

Table 9: Cow Peas Trend

Year	Metric Tones	Growth rate (%)
2014	138,673	3.68
2013	133,756	17.37
2012	113,961	39.77
2011	81,534	12.81
2010	72,274	-

Table 10: Irish Potatoes Trend

Year	Metric Tones	Growth rate (%)
2017	1,519,870	13.77
2016	1,335,883	-31.96
2015	1,963,495	20.75
2014	1,626,027	-25.85
2013	2,192,885	-24.77
2012	2,915,067	23.24
2011	2,365,263	-13.23
2010	2,725,936	18.57
2009	2,299,086	-20.72
2008	2,900,000	32.28
2007	2,192,280	-9.22

Table 11: Cassava Trend

Year	Metric Tones	Growth rate (%)
2017	1,112,000	94.46
2016	571,848	-19.45
2015	709,926	-17.30
2014	858,461	-8.19
2013	935,089	0.45
2012	930,922	37.07
2011	679,167	110.02
2010	323,389	-60.56
2009	819,967	9.19
2008	750,964	88.82
2007	397,705	-39.43

2.2 Cash or Industrial crops

Tea, coffee, sugarcane, and cut flowers are among Kenya's principal cash crops. Among these, tea is by far the most important in terms of Kenya's agricultural export earnings.

2.2.1 Tea: At roughly 370,000 tons per year, Kenya stands as the world's third largest tea producer after China and India. The highland tea-growing regions on either side of the Great Rift Valley are endowed with the ideal climate for tea production. Production goes on year-round, with two main peak seasons between March and June and October and December, coinciding with the rainy seasons. Kenyan tea is grown without the use of insecticides or herbicides because at 1,500–2,700 meters above sea level, the growing conditions act as a natural deterrent to pests.

Tea production in Kenya has grown steadily over the most recent decade mainly because of expansion in land area under cultivation. Kenyan tea is produced under two distinct production systems: smallholder production and commercial production by vertically integrated multinationals. The latter benefit from higher yields but lower-quality output due to more extensive use of machinery for harvesting. According to the Tea Board of Kenya (TBK), the smallholder sector is growing in importance and today accounts for roughly three-fifths (59 percent in 2012) of national tea production. A state corporation prior to 2000, the Kenya Tea Development

Agency (KTDA) is now a farmer-owned limited liability company that procures, processes, and markets all smallholder production in the country. It manages 67 processing factories serving over 600,000 growers organized in Savings and Credit Cooperatives (SACCOs). The plantation sub-sector operates 39 tea factories and employs about 33,000 out growers.

2.2.2 Coffee: Coffee remains important to Kenya's agricultural economy, but its importance is waning. Since production peaked in 1988 at nearly 128,000 tons, yields and output have dropped by nearly half. Among contributing factors are Kenya's aging tree stock (with high susceptibility to plant diseases) and declines in world coffee prices during 1986–1992 and 1998–2002. These trends have had a substantial impact, particularly on smallholders. Over 600,000 smallholder producers are organized into about 550 cooperatives and about 3,300 large-scale, vertically integrated coffee estates. Smallholders account for 75 percent of the land under coffee production but only slightly over half of production, according to the Coffee Board of Kenya (CBK). Average yields on the estates are nearly 1.5 times higher due to their more intensive use of fertilizers, pesticides, herbicides, and fungicides as well as irrigation.

2.2.3 Sugarcane: Kenya's sugar industry supports an estimated 2 million people and contributes an estimated $540 million to the country's GDP. It employs more than 250,000 smallholder farmers who supply over 92 percent of the sugarcane processed by nearly a dozen domestic sugar mills. The remainder is produced by factory-owned nucleus estates (KSB 2010; KSI 2009). Sugar production is concentrated in four major areas, primarily located in southern and southwestern Kenya. Increases in production during the most recent decade were largely the result of increases in total land planted while yields remained stagnant. Widespread use of poor-quality sugarcane varieties, poor agricultural and land management practices, and delayed harvesting of mature sugarcane (due to weather and/or transportation problems) contributed to poor yields over time.

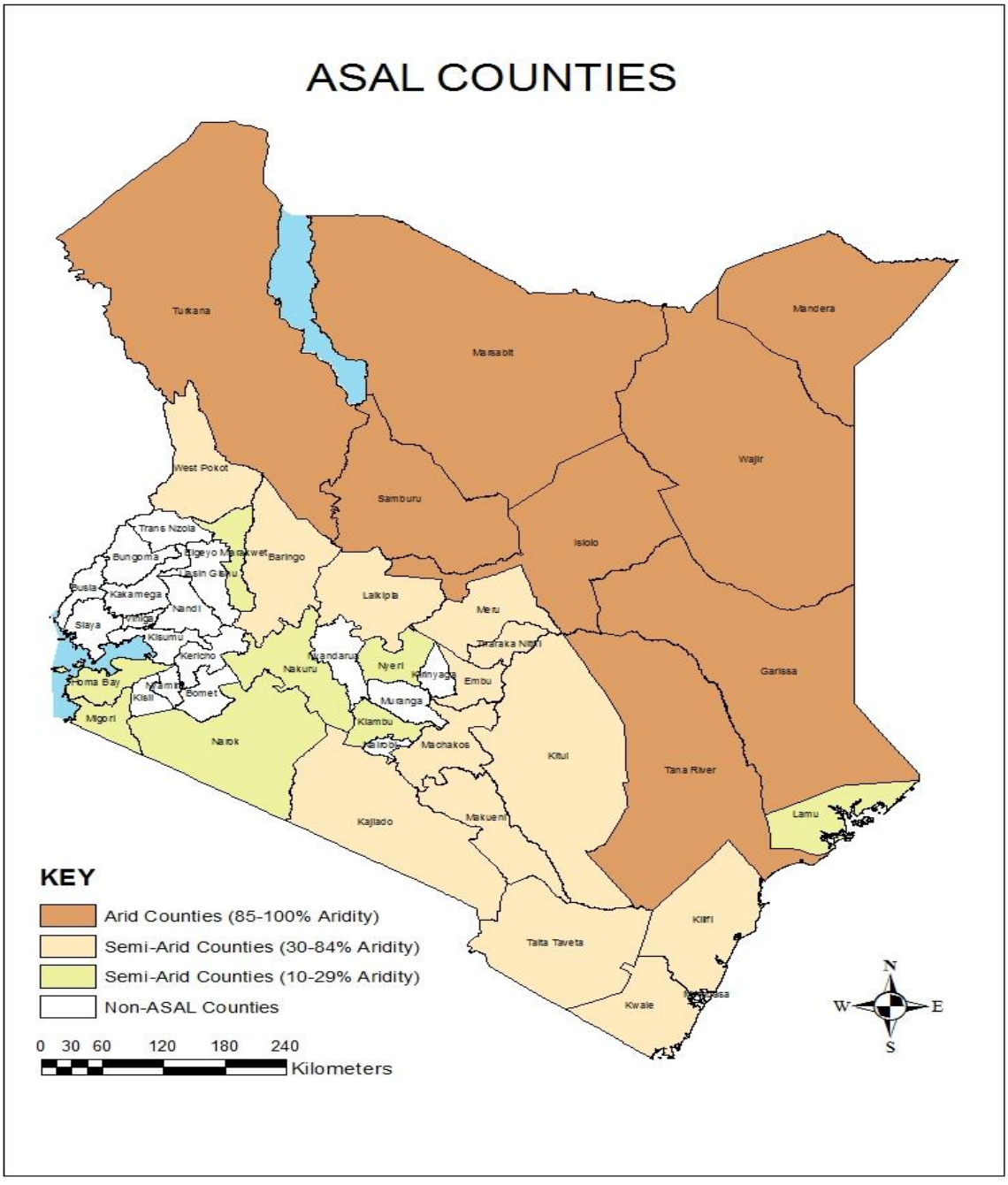
2.2.4 Cut flowers: Kenya's floriculture industry was worth an estimated US$490 million in 2012. Cut flowers are predominantly cultivated under modern farming systems and are produced for export markets. Roughly 160 flower growers exist in Kenya. The majority of producers are medium- to large-scale agribusinesses. However, 20–25 of these growers are large to very large commercial enterprises that together account for roughly 75 percent of total flower exports. Such operations are highly capital intensive, best characterized by their managerial and marketing sophistication and sizable investments in advanced technology and cultivation techniques (Hortiwise, 2012). The leading counties in horticultural production are Kiambu, Nakuru, Meru, Nyandarua, Murang'a, Bungoma, and Makueni, which together account for more than 57 percent of total output value, with the first three counties accounting for more than 30 percent (HCDA 2012).

Domestic prices, supply chain governance, marketing, and other market dynamics for Kenya's key cash crops vary depending on whether the end product is destined for the local or the export market. They are also influenced by the extent of government intervention and participation. The vast majority of tea and coffee produced is exported, while virtually 100 percent of the sugarcane produced in Kenya is refined and consumed domestically. Domestic tea and coffee prices are set via the major auctions in Mombasa and Nairobi, respectively. Prices in both auctions, in turn, are heavily influenced by prevailing prices in external markets. These include tea auction prices in Colombo and Calcutta and other major tea-producing countries, and the New York "C" contract market for coffee. Since market liberalization in the early 1990s, the GoK has assumed only a limited regulatory role in domestic tea and coffee industries through the TBK and the CBK. By comparison, Kenya's sugar industry remains highly regulated, with domestic prices directly influenced via import tariffs and quota protections.

2.3 Kenya ASALs Main Agro-ecologies and their Cropping Systems

The Arid and Semi Arid Lands (ASALs) occupy approximately 89% of the country's landmass (Figure 1) and are home to about 36% of the population, 70% of the national livestock herd and 90% of wildlife (GoK, 2017).

Figure 1: Map of ASAL Counties in Kenya



Source: Ministry of Devolution and ASAL Areas.

Even though the ASALs of Kenya are characterized by low development and high incidence of poverty, they have enormous untapped resources that can be harnessed to sustain resident communities and contribute to national development. Recent research estimates the share of livestock to agricultural GDP in Kenya to be 45%. Since 2003, the Government has demonstrated renewed commitment to the ASALs, for example through the Economic Recovery Strategy launched in 2003 that recognized the important contribution the ASALs can make to national development.

In order to address recurrent drought that has severely impacted on ASALs, the government in 2012 adopted

IGAD-led Ending Drought Emergencies initiative, which established a sector-wide based approach towards ending drought emergencies in Kenya by 2022. The Government recognizes that Kenya will not achieve sustained growth in her economy and progress as a nation if the ASALs are not appropriately factored into national planning and development. The Government also recognizes that Kenya will not achieve the goals of Vision 2030 or meet international commitments such as the Sustainable Development Goals (SDGs) if regional inequalities are not addressed. Accelerated investment in the ASALs is therefore necessary if all Kenyans are to have an equal chance of sharing in the promise and benefits of the Kenya Vision 2030.

2.3.1 Defining Features of Arid and Semi-Arid Lands

The main defining feature of the ASALs is their aridity. Annual rainfall in arid areas ranges between 150 mm and 550 mm, and in semi-arid areas between 550 mm and 850 mm per year. Temperatures in arid areas are high throughout the year, with high rates of evapo-transpiration. The primary policy challenge is how to ensure food and nutrition security in a sustainable manner in environments that are prone to drought, where people's access to and control over critical livelihood resources such as land is insecure, and where unpredictability is set to increase as climate change takes hold.

There are important differences between arid and semi-arid areas. The economy of arid areas is dominated by mobile pastoralism, while in the better-watered and better-serviced semi-arid areas a more mixed economy prevails, including rain-fed and irrigated agriculture, agro-pastoralism, bio-enterprise, and conservation or tourism-related activities. Other groups within the ASALs depend on fishing and other forms of subsistence. The ecology of semi-arid areas allows for the intensification of production in a way that the ecology of arid areas does not. Nevertheless, both arid and semi-arid areas experience chronic food insecurity and face critical challenges such as population increase, degraded ecosystems and climate change.

Most ASAL counties are traversed by major rivers, which include Tana, Athi, Turkwel, Kerio, Ewaso Nyiro and Mara, among others. These rivers present huge opportunities for wealth and employment creation in the ASALs if their waters are harvested and stored for use in irrigation and other uses. Mixed farming is practiced in semi-arid areas and pockets of arid areas with crop farming mostly done for subsistence. Sorghum and millet are the most appropriate food crops for the environment. Small scale irrigated agriculture has demonstrated some measure of success. Livestock contributes 10% of Kenya's GDP and 45% of the Agricultural GDP.

The ASALs host about 70% of the national livestock herd with an estimated value of about KES 70 billion. Livestock accounts for about 90% of employment in the ASALs and over 95% of family income and contributes an average of KES 10 Billion a year from 23.2 million animals (MacMillan, S. 2019). A number of institutions particularly commercial banks and insurance companies have realized the huge potential in this sector and have started initiatives to assist livestock farmers improve productivity of their stocks through interest-free revolving fund for livestock farmers in ASALs, setting aside funds for insurance targeting livestock during drought. Fishing in ASALs is mostly in lakes and rivers. However, there is opportunity for modern fish farming in the region for consumption in urban areas and in other regions, and also for export.

2.3.2 Fodder Production Systems in the ASALs

Availability of fodder is one of the limiting factors in animal husbandry in the arid and semi arid regions of Kenya. Most of the people who live in the dry-land areas are pastoralists who depend on animals for their livelihood. As is the case with humans, there is a direct link between the food and the health of the animals. The livestock and particularly cattle that are not healthy or well fed will not fetch good prices in market therefore, compromising the purchasing powers of livestock owners. Access to fodder crop can save the situation. A growing number of Kenyans living in arid areas are swapping staple crops for livestock fodder like Rhodes or Brachiaria grass, which require less water to grow, according to the Kenya Agriculture and Livestock Research Organization (KALRO). However, there are challenges of inadequate knowledge on the

concept of fodder alongside unavailability of fodder seeds. Even when the seeds and tools are available, many farmers do not know how to plant, conserve and manage the fodder. There is potential to improve pastures through breeding by increasing diversity through germplasm introductions and hybridization of the already available varieties and species.

The unique factor for the ASALs is the availability of expansive land, which is an advantage in that mechanization can be effectively deployed, achieving economies of scale. But it becomes self-defeating with the tendency to look at fodder production in absolute yields instead of maximizing production per acre, which can easily be achieved by using certified seed alongside improved management practices. By using production data, counties in the ASALs can know if they will meet their market targets by either increasing acreage or using improved seed varieties. Data models can also help private investors to not only make informed decisions, but also formulate a business plan when seeking finances. Areas in the ASALs with credible and easily accessible data are more likely to be preferred by investors. In today's food production world, working without data is as good as flying blind! Taking advantage of data could be the low-hanging fruits that can reposition the ASALs to be the fodder barns of Kenya.

The cropping systems in the ASALs are dependent on the level of aridity in different ASAL regions.

80-100% Aridity: The major production system is traditional in nature. This entails shifting cultivation and nomadic herding.

30-84% Aridity: This region practices semi-commercial production system on both livestock and crops.

10-29% Aridity: In this region, semi-commercial system is practiced with both crops and livestock being produced in mixed mode but more intensively.

Table 12: Counties covered by ASALs in Kenya

ARID COUNTIES (80-100% ARIDITY)	SEMI-ARID COUNTIES (30-84% ARIDITY)	SEMI-ARID COUNTIES (10-29% ARIDITY)	NON-ASAL COUNTIES
Turkana	West Pokot	Lamu	Trans Nzoia
Marsabit	Baringo	Narok	Bungoma
Mandera	Laikipia	Migori	Uasin Gishu
Wajir	Meru	Homabay	Busia
Isiolo	Tharaka Nithi	Nakuru	Kakamega
Samburu	Embu	Elgeyo Marakwet	Nandi
Garissa	Kitui	Nyeri	Siaya
Tana River	Machakos	Kiambu	Vihiga
	Makueni		Kisumu
	Kajiado		Kericho
	Taita Taveta		Kisii
	Kwale		Bomet
	Killifi		Nyamira
			Nyandarua
			Muranga
			Nairobi
			Kirinyaga

2.4 Current Status of Agricultural Extension Activities

Agricultural sector extension service plays an important role in sharing knowledge, technologies and agricultural information, and in linking the farmer to other actors in the economy. The extension service is

therefore, one of the critical change agents required to transform subsistence farming to modern and commercial agriculture. This is critically important in promoting household food security, improving incomes and reducing poverty.

The current extension system in Kenya is a product of gradual evolution in extension management practices and the entry of private sector, NGOs and civil society players over time in response to changes in economic policies (GoK, 2012). The changes have implications on how extension is managed, application of approaches and methods, coordination and linkages among key stakeholders, and the most optimal way of financing extension service. The provision of extension service is dominated by the public sector through respective departments of extension in the agricultural sector ministries of the counties.

Until the late 1980s, public extension service was well staffed up to the sub-location level, and adequately facilitated to perform its duties. However, during the last 20 to 25 years, the staffing and facilitation of public sector extension has declined mainly as a result of the freeze on public employment and reduced funding for operations and maintenance. In the public sector, for example, the ratio of frontline extension worker to farmers is about 1:1000 compared to the desired level of 1:400. In the absence of effective private sector operations to fill the vacuum, the situation has led to reduced spatial coverage, targeting and effectiveness of service delivery reflected by clientele complaints. Other Extension Service Providers include NGOs, community-based and faith-based organizations. The entry of these new players has helped fill the gap created by the reduced presence of public sector extension service.

Government extension services are provided by public agencies and are deemed to be relatively affordable because the cost of accessing them is almost entirely borne by the providing agency. Government extension services are long term in nature and reach many farmers, thus, enhancing their impact. However, they are sometimes unreliable because they are constrained by bureaucracy and inadequate funds.

Private extension services are provided by commercial companies for profit. They often target literate farmers with relatively high income because they can afford them. Consequently, these services are well funded and efficient compared to those provided by Government. Nevertheless, they only cover limited geographic area and reach few selected farmers leaving out poor farmers (who are the majority and equally need extension services) unattended. In practice, providers of agricultural extension services do not operate in isolation but target the same farmers. The entry of multiple extension service providers has the potential of creating complementary synergies among collaborators and offering extension clients more choices.

Currently, extension services in Kenya are provided through either or a mixture of three different models:

Model 1: Offers free public extension services mostly to smallholder farmers engaged in growing staple foods and minor cash crops across all the agro-ecological zones.

Model 2: Partial cost-shared provision of extension services, mostly within the public sector where limited commercialization has taken place.

Model 3: Fully commercialized and mostly involving the private (e.g. private companies and cooperatives) and quasi-public organizations mainly for specific commodities such as tea, coffee, sugar, pyrethrum, barley, tobacco, horticulture and dairy. Under this system, extension services are usually embedded in agricultural services.

Different extension providers use different extension approaches. Some of the approaches used include focal area and farmer field schools. Equally, various methods such as face-to-face extension, on-farm demonstrations, shows, field days, film shows, adaptive on-farm trials, and mobile training units (more common in arid and semi-arid lands) are used. However, in some cases, there has been a tendency to replicate a particular approach across different agro-ecological zones and farming systems. Similarly, lack of multi-skilled extension agents has led to piece-meal extension service delivery to clients usually faced with

multiple problems. This has in many cases resulted in low rates of technology adoption.

2.4.1 Challenges

Despite positive aspects in pluralistic extension system, it has its own challenges that include the need for a regulatory system to coordinate the players. Coordination and regulation are required to promote professionalism and reduce unnecessary competition, dissemination of conflicting extension messages to clients, duplication of effort and wastage of resources. An overriding challenge for both public and private sector extension provision is how to mobilize sufficient resources to provide the required services, and formulating a strategy for increasing private sector participation.

Other shortcomings arise from application of unsustainable approaches and methods such as use of handouts disguised as empowerment tools by some service providers, leading to the creation of dependency syndrome and limited client participation. Some of these approaches and methods have been fairly static, emphasizing increasing production with little regard for value addition and marketing, which are critical in transforming agriculture from subsistence to commercial enterprise. Further, some of the approaches and methods are weak in addressing crucial issues such as governance in farmer organizations, mainstreaming cross-cutting issues (gender, equity, HIV and AIDS, drugs and substance abuse, environmental concerns), and fail to target marginalized groups. They have also tended to ignore the importance of indigenous knowledge in their extension messages.

Despite the lack of systematic guidelines, most stakeholders appreciate the need to tailor appropriate extension approaches and methods according to agro-ecological zones (high-, medium- and low-enterprise production potentials) and socio-economic stratification of the extension clientele; both have a bearing on the ability to share the burden of providing extension services and influencing the growth of private sector extension services.

The challenge, therefore, lies in the choice of appropriate dynamic and holistic approaches and methodologies that consider client socio-economic environment, value chain, market demand, cost effectiveness, agro-ecological diversity, client resourcefulness, and the mainstream relevant cross-cutting issues.

Table 13: Current status of agricultural extension activities.

	10-29% ARIDITY		30-84% ARIDITY		85-100% ARIDITY	
AVAILABILITY OF EXTENSION SERVICES	Fairly High		Medium		Low	
EXTENSION BY	**GoK**	**NGO/Private**	**GoK**	**NGO/Private**	**GoK**	**NGO/Private**
	Medium	Medium	Medium	Low	Low	Low

2.5 Level of Adoption of Improved Crop Varieties

Better seeds could dramatically boost food production on Kenyan farms without expanding cropping areas. For most of Kenya's key food crops, quality seeds of improved modern varieties almost always produce a higher yield—by 50 percent at least, but often much more—than seed recycled from the previous year's crop (USAID, 2016). The adoption rate for certified seed is highest for maize, accounting for about 70 percent of Kenya's maize crop. This is because maize is an important staple crop in Kenya, accounting for approximately 30% of daily caloric intake for the average Kenyan. More than 95% of rural households in Kenya grow maize, with smallholder farmers responsible for approximately 75% of production.

For other food crops like beans and millet, the adoption rate ranges dismally low between 10-20 percent, and often below 5 percent. It is estimated that only 5-10% of the common bean seed is sourced through the formal seed system, with the balance of 90-95% of seed sourced by farmers through informal means. While there are many reasons for the dominance of the informal system, the primary factor is that available supplies of quality common bean seed are insufficient to meet the relatively limited demand for early generation seed (EGS). Comparing the formal and informal markets there is a large difference between the planting rates, with the formal planting rate estimated to be 25 kg/ha, with the informal rate estimated to be twice that rate at 50 kg/ha. Interviews coupled with various reports indicate this variance is due to farmers compensating for lower quality of seed in the informal market and the resulting poor germination.

The informal seed system includes farmer-saved seed, seed acquired through trading with neighbours, and seed purchased from neighbours, agro-dealers, or in food markets. Farmer-saved seed makes up the bulk of the informal system, with other channels used when on-farm yields are too low to justify saving grain for seed or when disease pressures intensify. This is common with common bean, millet and other food crops. Interviews with farmers plus various reports indicate that there is an unmet need in the market for certified seed for these food crops, and to fill this gap farmers are turning to the informal system. Many farmers purchase the maximum volume available of certified seed and buy the balance from whatever source is available, whether it is local markets, other famers, or saving it.

If the area planted with certified seed increased by just 10 percent for maize and around 30-40 percent for other crops, overall production would surge, providing an immediate boost to food security. This increase also would energize the economy. Of critical importance, Kenya would be positioning itself to generate commodities to supply new agriculture processing businesses, which would generate jobs. This is exactly the path followed by the Asian countries. It all starts with the political will to lay a foundation for a strong agriculture economy, and the first bricks in that foundation are seeds.

Table 14: Level of adoption of improved crop varieties, by crop.

CROP	10-29% ARIDITY	30-84% ARIDITY	85-100% ARIDITY
Maize	50%	30%	5%
Beans	20%	10%	0%
Sorghum	5%	30%	2%
Potatoes	20%	10%	2%
Wheat	40%	30%	–
Rice	80%	–	–
Tuber crops	20%	10%	–
Peas	10%	4%	–
Green grams	10%	5%	–
Cowpeas	12%	10%	–

Source: Computation based on data from Kenya Seed Company, which produces 80% of certified seeds.

2.6 Level of Utilization of Fertilizer and Manures to Increase Crop Yields, by Crop

Low soil fertility and moisture deficits are major constraints to crop production in the arid and semi-arid areas of Kenya. Farmers in these areas use farmyard manure as a cheaper alternative source of plant nutrients as opposed to the more costly inorganic fertilizers.

2.6.1 Use of Inorganic Fertilizers

In the arid and semi-arid parts of Kenya, inorganic fertilizers are rarely used or they are used in fairly small quantities by the resource poor farmers (18%). This is attributed to the high cost as well as unavailability of

these fertilizers in these areas. Further, many small holders have the perception that the use of inorganic fertilizers has an impoverishing effect on the soil. Continuous use of inorganic fertilizers especially those with high acidity like DAP (Di-ammonium Phosphate) and Urea without using organic materials and/or liming, has been found to result in decreased land productivity. This is due to increased soil acidity, which leads to fixation of P (Phosphorus) and Al (Aluminum) toxicity. Hence, corrective measures must be continually put in place to maintain productivity.

2.6.2 Farmyard Manures

Farmyard manure (FYM) is an organic by-product derived from either purely animal droppings or mixed with plant residues. In the arid and semi-arid parts of Kenya, FYM is widely used across different farming systems as a source of nutrient and general soil fertility improvement. In the sub-humid parts of eastern Kenya, for example, application rates of 4-10 tons per ha are common. In the semi-arid parts of eastern Kenya, more than 80% of the farmers use FYM but the usage is restricted to small plots near the homestead due to transportation constraints (Olale, E.K. 2005). Though these areas produce sizeable quantities of FYM due to large livestock population, much of it is sold to farmers in the sub-humid areas.

Despite the importance of FYM as a source of nutrients and in improving soil properties, its usefulness in most arid and semi-arid parts of Kenya is limited due to the variable composition and the large quantities needed to provide adequate plant nutrients. Further, its nutrients composition remains very variable due to the materials used for feeding and animal beddings. The poor handling and storage also contribute to the low quality of FYM in most farms. The general concentrations of main nutrients in FYM reported in the arid and semi-arid parts of eastern Kenya is 0.42%N, 0.17%P and 0.88%K (Olale, E.K. 2005). However, FYM and compost manure on their own cannot supply all the needed nutrients. Hence an addition of some inorganic fertilizers is necessary to supply the necessary nutrients. Despite the short-comings and deficiencies in compost and FYM as a source of crop nutrients, they will remain key source for soil fertility management in most arid and semi-arid parts of Kenya for a long time.

2.7 General Description of the Current System for Marketing Surplus Production of Staple Crops

Marketing of agricultural produce and products is critical to increasing agricultural productivity and commercialization of enterprises so that farming is perceived as a business. Generally, in Kenya, marketing chains for the different commodities are long, not transparent and consist of many players making them inefficient and unresponsive to producer needs (Etemesi *et al*., 2018). Surplus production is rare in ASALs areas but when it occurs farmers sell in their local community markets. Sometimes middlemen intervene and buy at below market prices then they sell to other regions that have deficiency. Government plays a major role in price fixing although the market is liberalized. With the advent of devolution, county governments are linking farmers to other markets in their neighbouring counties

For all the commodities, market participation is strongly associated with access to land, productive assets, technology use, expected prices and rainfall amount and reliability. Broad-based smallholder market participation can only be realized through interventions that raise smallholder production of marketable surpluses through raising productivity, and this cuts across even the high value sub-sectors such as horticulture and dairy. Also essential alongside such interventions are strategies to improving market access by reducing transaction costs. An array of production and marketing challenges, unique to smallholders, limits their contribution to economic development. For smallholder farming to drive the development agenda in the ASALs, a widespread transformation of these farms from subsistence or semi-subsistence, low-input, low-productivity units to intensive, market-oriented units is needed. Smallholders are also excluded from emerging markets due to enforcement of quality standards and modernization of procurement systems. These challenges, combined with seasonal cash shortages, lack of produce handling facilities and little market information, further weaken farmers' position along the value chain.

Effective markets can potentially play an important role in ensuring agricultural transformation in the ASALs of Kenya by improving rural incomes, enabling efficient allocation of resources, reducing poverty and improving livelihoods. In addition, agricultural markets have the potential to foster economic growth and development. The presence of markets and increased market access are vital requirements for the integration of rural smallholder farmers in the global commercialized economy and for growth of agrarian societies. In order to increase smallholder farmers' output, the focus should be on markets that effectively emphasize greater use of specialized production methods. It is generally expected that farmers with good market access, specifically, those who are able to sell their surplus output and in turn buy goods and services, will be relatively more willing and incentivized to commercialize their produce than those with poor market access.

2.8 Trends in Development of Markets for Staple Food Crops

Kenya faces declining productivity in agriculture accompanied by rapid increases in population, consumption, and food imports. This combination augurs a future of more severe poverty and food insecurity. Food insecurity and poverty affect 43 and 46 percent of Kenya's population, respectively (KNBS, 2019). However, barely half the area under production for Kenya's top four food security crops (maize, beans, sorghum, and cowpea) is planted with high quality, certified seed. This keeps yields intolerably low. In fact, yields of maize, Kenya's most important food crop, have decreased over the past 30 years. Food imports in Kenya have been growing rapidly. For example, in 2010, food imports accounted for 2.96 percent of Kenya's gross domestic product (GDP), at a value of US$1.2 billion for 2.5 million metric tons (World Bank, 2019). By 2011, food imports had grown to 3.94 percent of Kenya's GDP, equaling US$1.65 billion for 3.2 million metric tons of food. Such import levels are unsustainable; they have a major negative impact on the Kenyan economy as money is spent to import food rather than on other priorities.

Opportunities also are missed. For example, a rising proportion of imports are consumer-ready food products. Growing domestic supply of the raw inputs for such high-value foods could foster the growth of a thriving food manufacturing sector. Instead, food imports equal job exports, and lost opportunities for job creation and economic development. Furthermore, the growing value of food imports means that the country's food security is increasingly at the mercy of volatile global food prices. Food price inflation drives overall inflation in Kenya, and has a profound impact on low-income households.

Kenya's increased production volume over the last two decades is the result of more land area being cultivated, rather than improvements in yields. Historically, in other countries, technology improvements and industry competitiveness, both of which drive yield increases, have changed this dynamic. In the United States, for example, between 1960 and 2013, total area under maize production held fairly constant while innovation and competitiveness drove yields up from about 3 metric tons per hectare to almost 10. While one can argue that Kenya is not the United States, it is hard to deny the overall principle that improved technology and a competitive private sector, over time, drive productivity increases. This principle has played out in the agriculture sector in many other countries around the world, such as Brazil, Chile, India, Thailand, and Vietnam, among others and is currently playing out to varying degrees in numerous other countries in sub-Saharan Africa.

Perhaps the most important factor affecting low production levels for crops other than maize is the extremely low use of certified seed by Kenya's farmers. A review of the online Seed Sector Platform Kenya (seedsectorplatformkenya.com) reveals that, among 482 improved varieties of 18 crops released in Kenya, more than half of these (258 varieties) are maize varieties. The only other crops with more than a handful of improved varieties are beans, wheat, sweet potato, and sorghum. In 2013, an estimated 78 percent of the maize growing area was planted with certified seed, but this compares to 3 percent for beans, 16 percent for sorghum, and 13 percent for cowpea. Recycled seed – the majority of it repeatedly recycled for long periods of time – accounted for the remaining land.

While the relative emphasis on breeding maize varieties has improved the prospects for that crop, it also underscores the Achilles heel of Kenyan agriculture: the limited crop diversity found on Kenya's farms. This

lack of diversity has significant implications for crop rotation, soil health, managing diseases and insect pressure, and dietary nutrition. In addition, it exposes Kenya to the potentially severe consequences of a major crop disease or crop failure.

Without aggressive change in the agriculture sector, as Kenya's population and the demand for maize increase, the deficit in maize production and other staple food crops will grow bigger each year. This will prompt even more food imports, a trend associated with higher food prices, rising poverty and anemic domestic growth of the food industry. Aggressive action needs to be taken, without delay. Even if Kenya increases national maize yields by 6 percent or more annually, maize production levels still will not meet demand levels until 2023 at the earliest. Delaying aggressive action only increases the potential deficits and related economic losses.

CHAPTER THREE: NATIONAL AGRICULTURAL RESEARCH SYSTEM

Agricultural research in Kenya has undergone tremendous changes since its inception early in the 19th century by the colonial government. The Government of Kenya recognizes the important role agricultural technology development and application can play in transforming and modernizing agricultural research. Presently, plant breeding and related activities account for a major proportion of the budget allocation in research. These activities are carried out by about ten institutions, but largely dominated by the only public research institution Kenya Agriculture and Livestock Research Organization (KALRO), formerly Kenya Agricultural Research Institute (KARI). Universities, tertiary institutions, NGOs, CBOs and private companies supplement KALRO's research efforts. In the constitution, agricultural research is placed under the responsibility of the national Government, while services to farmers through agricultural extension are placed under the county governments. The Companies Act, Science and Technology Act Cap 250, Agriculture Act, Cap 318, as well as university legislations guide agricultural research in Kenya.

Maize is the most important crop in the breeding programs because it is the main staple food crop in the country. Grain legumes, vegetables and fruits are also well represented in breeding programs. Up to the present the plant-breeding budget was mainly allocated to line development and evaluation but the percentage of resource allocation for germplasm enhancement has been increasing over the years. As in much of sub-Saharan Africa, there has been a decline in both human and financial resources for agricultural research including plant breeding and biotechnology. Therefore, the number of available breeders per crop has become an important constraint. Some of the private seed companies complain also about the limited access to international genetic resources.

3.1 Description of the Public Institutes and Universities Actively Engaged in Crop Breeding

Currently, the agricultural research system comprises public and private agricultural research institutions established under different legal and institutional frameworks. The Kenya Agricultural Research Institute (KARI) now Kenya Agriculture and Livestock Research Organization (KALRO), the Kenya Forestry Research Institute (KEFRI), the Kenya Marine and Fisheries Research Institute (KEMFRI) and the Kenya Industrial Research and Development Institute (KIRDI) are parastatal research institutions established under the Science and Technology (Amendment) Act of 1979, each with a specific mandate.

The Coffee Research Foundation, the Tea Research Foundation of Kenya, the Kenya Sugar Research Foundation, and the Kenya Seed Company (KSC) are State corporations registered under the Companies Act (Cap 486). These institutions are responsible for research on coffee, tea and sugar cane respectively, while KSC is involved in agricultural research relating to seed production. The National Irrigation Board established under the State Corporations Act (Cap 446) has a research division that undertakes research on irrigation technologies and practices.

The universities are established under various Acts and Charters and have faculties of agriculture and allied sciences that carry out agricultural research independently or in collaboration with other agricultural research

institutions. However, these collaborative efforts are constrained. Despite the large number of skilled scientific staff engaged in agricultural research in both public and private universities, no mechanism exists to harness these strengths at the national level or even a designated process to link the universities with the large public or private research initiatives and industry. Private sector institutions undertake some agricultural research. This research is geared at enhancing productivity, product quality and safety, and competitiveness in domestic and global markets. There are also several regional and international research institutions undertaking agricultural research. These institutions have regional and international mandates and offer opportunities for enhancing and complementing the national agricultural research agenda.

Overall, a sizeable pool of agricultural research institutions is managed by independent management boards or councils, with each institution planning and executing research programs independently. The challenge is how to establish an integrated agricultural research system that is well balanced and directed towards addressing the diversity of national development goals and objectives in the light of limited resources.

3.2 Research and Education Institutes with Activities in Plant Breeding

3.2.1 Public Institutes

3.2.1.1 Kenya Agriculture and Livestock Research Organization (KALRO)

KALRO, previously Kenya Agricultural Research Institute (KARI), is a semi-autonomous public organization and has a quasi-monopoly on agricultural research activities in Kenya mobilizing about 75% of all the financial and human resources for research in the country. KARI has been involved in conventional plant breeding since 1927 and in plant biotechnology since 1981. KARI has 21 main research centres, and 12 sub-centres strategically spread throughout the country to cater for different agro-ecological zones and socioeconomic systems. KARI deals with 11 types of crops/crop groups, namely maize, wheat, sorghum and millet, cotton, roots and tubers, forages, small grains (like barley & oats), grain legumes, vegetables and fruits.

3.2.1.2 Agricultural Development Corporation

ADC is a Government Parastatal, which was established in 1965 through an Act of Parliament Cap 346, to facilitate the land transfer programme from European settlers to locals following the country's independence. It was also to be a stabilizing factor to assist in maintaining the good quality livestock and continuity of the breeding programs in the affected farms. In the past 7 years ADC has been breeding and commercializing its own hybrid seed.

3.2.1.3 Faculty of Agriculture University of Nairobi (UON)

Established in 1970, UON is a public sector learning institution and the largest University in Kenya. This college provides training in agricultural sciences leading to BSc, MSc and PhD degrees. Faculty members at the campus also conduct research in the breeding of various types of crops including cereals, grain legumes, oil seed crops and vegetables among others. They are also involved in plant biotechnology since 1979

3.2.1.4 Jomo Kenyatta University of Agriculture and Technology (JKUAT)

JKUAT was established in 1981, with the financial and technical assistance of the Japanese International Cooperation Agency (JICA). JKUAT has been engaged in plant breeding and plant biotechnology since 1992. Its activities focus in the development of disease resistant tomato and in the production of clean planting material of the banana cultivars preferred by farmers, through funding from JICA.

3.2.1.5 Egerton University

Egerton University has a mandate of providing training in various disciplines in the area of Agriculture, leading to BSc, MSc and PhD degrees and to conduct Agricultural research in both the crop and Animal sciences.

Egerton University has been involved in plant breeding since 1995 and in plant biotechnology since 1997. Its activities focus mainly on maize, wheat and grain legumes.

3.2.1.6 Moi University

The university established a Faculty of Agriculture in the year 1991 and a department of Horticulture and Seed Technology in the year 1993. It is within this programme that plant breeding activities at the university are implemented. The major breeding programme in terms of budget allocation concerns grain legumes. This University carries out biotechnology research in the areas of molecular characterization, tissue culture, marker assisted selection and wide crosses.

3.2.1.7 Faculty of Sciences, Maseno University

Established in 1991, Maseno University has been involved in plant breeding since 1995. However it is not involved in any biotechnology research activity. Major breeding programmes in terms of budget allocation cover indigenous vegetables, finger millet, beans and cassava. The resources are utilized mainly for line evaluation.

3.2.1.8 Department of Biochemistry and Biotechnology, Kenyatta University

The Department of Biochemistry and Biotechnology of the School of Pure and Applied Sciences trains BSc, MSc and PhD students and conducts research in biotechnology. Kenyatta University has not been involved in plant breeding. However, it has been involved in biotechnology research since 2005 with a main focus on maize, sorghum and root and tuber crops.

3.2.1.9 Masinde Muliro University of Science and Technology

The faculty of science of Masinde University was founded in 2002 as one of the pioneer faculties of the university. It offers BSc, MSc and PhD degrees in sugar technology and biotechnology among other programmes. MMUST has been engaged in plant breeding and biotechnology since its foundation. It works mainly with maize, sorghum, sunflower and cotton.

3.2.2 Private Institutes

3.2.2.1 Kenya Seed Company

Established in 1956, the private company KSC is currently the largest seed company in Kenya and in the East African region. It is currently dealing with various crops including maize, wheat, sorghum, oil seed crops (sunflower), grain legumes (beans), vegetables and forages. The KSC is involved in various activities including variety development, seed production and inspection, processing and marketing of the above mentioned crops. The company has to date never utilized any biotechnological tools in its crop improvement programme.

3.2.2.2 Western Seed Company (WSC)

WSC is a private seed company that operates in both Kenya and Uganda. In Kenya, this company was officially registered to operate in the country in 1995. Its activities include variety development, seed production and inspection, and marketing. In Kenya, the company mainly deals with maize, beans and sorghum, and produces seed appropriate for four main crop growing regions in Kenya including the High altitude, Medium altitude, Low-mid altitude and the Dry Lowland zones. The WSC has been involved in conventional plant breeding since 1995. It however did not use any biotechnological tools up to today.

3.2.2.3 Pannar Seed Company (PSC)

PSC is a private South African seed company operating in Kenya. The company breeds all its varieties in South Africa, which is where all its main crop breeders are based. The company was established in Kenya in the year 2000. Its breeding activities in Kenya are mainly restricted to evaluation of the South African-bred material, for adaptation in selected regions of Kenya. The variety evaluation trials in Kenya provide data that are used to determine the areas that are suitable for the different introduced materials.

3.2.2.4 The Monsanto Seed Company in Kenya (MSCK)

Monsanto is a private international seed company. MSCK was officially established in Kenya in 1998, when it bought out Cargill Seed Company and re-hired many of its personnel. Cargill Seed Company had been established in Kenya in 1987. Monsanto Seed Company mainly improves maize from a base in southern Africa (Zimbabwe and Malawi). The finished maize products are then brought to Kenya for multi-locational evaluations in order to identify cultivars that are appropriate for specific agro-ecozones, and to generate performance data that are needed for official release of this material in Kenya. Among the private seed companies in Kenya, Monsanto is the only one engaged in crop biotechnology.

3.2.2.5 Pioneer Overseas Corporation (POC)

Pioneer Overseas Corporation is a private seed company, whose headquarters is in Zimbabwe. All the main plant breeders in the company are based in Zimbabwe where all the basic breeding is conducted. Pioneer was officially established and registered in Kenya in 2000. In Kenya, the company maintains very few staff members, whose main task is to evaluate selected maize varieties / hybrids, in various parts of Kenya for adaptation trials, and also to generate variety performance data which are essential for official release in the country.

3.3 Nature of Recent or Ongoing Crop Improvement Activities, by Crop

The program for crop improvement in Kenya has grown into a vibrant and dynamic sector that has undoubtedly made great impact in terms of increasing food security in the country and improving the economic livelihoods of a great majority of people. The program is a well-established formal sector that combines both the conventional plant breeding and also advanced and state of the art methodologies and skills. It is probably one of the most developed programs in sub-Saharan Africa.

The main institutions involved in plant breeding include KARI now KALRO, the Tea Research Foundation (TRF), Kenya Seed Company (KSC), public universities, the Kenya Sugar Research Foundation (KESREF), the Coffee Research Foundation (CRF). These institutions enjoy both financial and technical assistance from a number of other institutions such as CIMMYT, the Rockefeller foundation and CIAT. KALRO, formerly KARI is by far the institution that has released the greatest number of crop varieties. For instance, within the period 1985-2002, it released a total of over 46 improved varieties of food and horticultural crops including maize (*Zea* mays), wheat (*Triticum aestivum*), grain legumes, Irish potatoes and sorghum (*Sorghum bicolor*) and millets (*Eleusine coracana*).

Virtually all agriculturally and economically important crops in the country have benefited from plant breeding activities. Some of these include, maize (*Zea mays*), beans (*Phaseolus vulgaris*), wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), peas (*Pisum sativum*), sunflower (*Helianthus annuus)*, millets (*Eleusine coracana*), oats (*Avena sativa*), barley (*Hordeum vulgare*), cowpeas (*Vigna unguiculata*), cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) among many others. To date, more than 400 improved varieties of various crop species have been released in the market and are now within the farming systems.

The objectives of the breeding programs are as diverse as the crops targeted but overlaps abound between them. As expected, yield and yield stability is by far the trait that has been bred for in almost all the crops. Others include resistance/tolerance to both biotic and abiotic stresses. Incidences of pests and diseases have been shown to significantly reduce crop yields and thus continually threaten sustainable crop production.

Breeding programs have therefore been initiated for most crops with the main objective of strengthening resistance and tolerance to pests and diseases. Some of these include maize streak, grey leaf spot, rust and stem borers in maize (*Zea mays*); angular leaf spot, root rots, common bacterial blight, rust, fusarium wilt and anthracnose in beans (*Phaseolus vulgaris*); cassava mosaic in cassava (*Manihot esculenta*) and late blight in tomato *(Solanum lycopersicum*) among others. Breeding for tolerance to drought and early maturity have also been major breeding objectives. Germplasm sources are mainly from CGIAR centres such as CIMMYT and IITA and genebanks from developed countries. Kenyan breeders have shown a justified preference for materials whose evaluation data is available and those that have undergone pre-breeding. This partly explains why utilization of germplasm conserved at the National Gene Bank of Kenya (NGBK), which has not been evaluated is low.

For forest trees, KEFRI is the main institution with a tree breeding programs. The programs have focused on breeding for yield for various tree species including *Eucalyptus grandis, Grevillea robusta, Cupressus lusitanica* and *Pinus patula*. Some of the programs have also successfully bred for resistance to blister rust in *Cupressus lusitanica* and pine woolly aphid in *Pinus patula.*

While breeding efforts have in the past tended to be conducted by breeders with little or no involvement of farmers, the trend is quickly changing. Globally, it has been noted that when farmers are not involved in the breeding process, their chances of adopting the developed varieties are low since in most cases they lack the preferred traits (Weltzien and Christinck, 2017). For crops such as maize, beans, cassava, pigeon peas and sorghum farmers are increasingly being involved in setting breeding priorities. In addition, they are also involved in the selection process. In most cases, farmers are invited to the research stations during for example preliminary or advanced yield trials where they participate in variety assessment and selection. This approach has been shown to be beneficial as it enables scientists drop unacceptable varieties at early stages of variety development, hence increasing variety selection efficiency. Related to the traditional gender roles, it is especially important to involve women farmers in plant breeding activities (Diiro, G. M., *et al*., 2018). KALRO has successfully conducted participatory improvement of various crops. However, despite these efforts the challenge of low adoption of improved varieties is still great and a concern to scientists.

In order to increase the participation of farmers in research and crop improvement, KALRO launched the Agricultural Technology and Information Response Initiative (ATIRI). The primary objective of ATIRI is to empower farmers to make technological and information demands on KALRO and other service providers, to facilitate KALRO and other service providers to respond to this demand, to promote up-scaling of technology adoption through creation and strengthening of partnerships and to integrate farmer feedback into KALRO research agenda.

Table 15: Crop varieties developed for the ASALs.

Grain Legumes	Varieties	Yields
1. Common bean (*Phaseolus vulgaris*)	Wairimu Dwarf, Kat-Bean 9, Kat/Bean 2, GLP-X 1127 New Mwezi Moja, GLP-585 Red haricot, Canadian Wonder (GLP-24), Mwezi Moja (GLP1004), Rosecoco (GLP 2), Mwitemania (GLP 92), Kat X 16, Kat X56 , Kat X 69 , KK 22 (RWR 719), Kat/Bean 1 (Katheka), KK 8 (SCAM-80/15), KK 15 (MLB 49/879), Kenya Red Kidney, Super Rose Coco, Kenya Wonder, Kenya Sugar Bean, Chelalang, Tasha, Mbigo, KAT-RM01 (KATRAM), EMBEAN14 (MWENDE), MN1(Rosecoco ,Madini) MN3 (Kenya, Almasi), MN6 (Kenya Cheupe), MN9 (Kenya Maua), KK ROSECOCO-194, KK Red Bean-16, KAD 02 (Nyota), KMR 11 (Angaza), KMR 12 (Metameta), KMR13 (Faida), KAT-SW-12, KAT-SW-13, KCB, Cianku, KCB13-09, KCB13-11, KKRIL05/RED13, KKRIL05/CAL33, KCB13-04	Yield range: 0.75-2.5 t/ha

2. Cowpea (*Vigna unguiculata*)	MTW 63, MTW 610, Machakos 66(M66), K 80, KVU – 419 (Kunde 419), KCP 022, Kunde 1, KUNDE MBOGA, SIMLAW KUNDE, 1002/1005/3 (Kunde Faulu), 1005/1002/1 (Kunde Tamu), 1005/1003/3 (KAT Kunde), 1005/1002/1/1/1 (Kunde Soko)	Yield range= 1.5-2.5 t/ha
3. Lab Lab (*Dolichos lablab*)	W5,LG1,G2 and M5	Yield range: 3-5 t/ha
4. Mung bean (*Vigna radiata*)	N26, N22, and the newly released varieties: Ndengu, Tosha, Ndengu Biashara and Ndengu Karembo.	Yield range: 1-2 t/ha
5. Groundnut (*Arachis hypogea)*	CG7 ,ICGV –12991, ICGV-SM-9991, ICGV-SM-99568	Yield range: 1.3-3 t/ha
6. Pigeon pea (*Cajanus cajan*)	Kat 777, Kat81/3/3, ICEAP00040, Mbaazi – 1, Katumani 60/8, Kat/Mbaazi 3, ICEA P00068, ICEAP00850, ICEAP00936, EUMDPV00104, PP08006, PP08008, (Kat/Mbaazi 2)	Yield range = 1-3 t/ha
7. Soybean (*Glycine max*)	Hill, Black Hawk, DPSB19, Nyala, DPSB 8, EAI 3600, Gazelle, Kensoy 009- can do very well if supported with irrigation	Yield range= 1.7-3 t/ha
8. Bambara nut		
Cereal Crops		
1. Dry land Maize (*Zea mays*)	KDV 1,2,3 and 4 (mainly for dry land), KDH 6,7,8 and 9 (mainly for dry land), GAF4 – tolerant to striga and EMCO-Embu, KEMB214, KH500-35E (mainly for mid potentials areas) Other Maize varieties recently released and tolerant to MLND are KATH-16-1,2	Yield range 3-6 t/ha
2. Millet (*Eleusine coracana*)	Maridadi , KAK-Wimbi 1, KAK-Wimbi 2, KAK-Wimbi 3, KAK-Wimbi 4, P-224, Nakuru FM 1, KAT FM 1, MSU FM 60D, EUFM 401 , EUFM 502 and EUFM 503	Yield range= 0.75-2.5 t/ha
3. Sorghum (*Sorghum bicolor*)	Gadam**,** KARI Mtama 1, Serena and newly released Sorghum Hybrid varieties	Yield range = 3-5 t/ha
Fruits		
1. Pineapple	Sweet Cayenne+	50- 70t/ha
2. Banana	Williams, Grand Nain, Giant Cavendish, Chinese Cavendish, Gold Finger, Nusu Ng'ombe, Uganda Green: Sialamuli, Medium Gross-Michel AAA dessert, FHIA 23, FHIA 01—Gold finger, FHIA 02 TU	25-40 t/ha
3. Orange	Pixie, Minneola orange, Washington Naval	40 t/ha
4. Pawpaw	Solo Sunrise, Jubilee 5, Jubilee 6, Sunrise, Kapoho, Waimanalo, Maradol,	40-70 fruits per tree year
5. Mango	Tommy Atkins, Haden, Kent, Keit, Van dyke, Sabine, Alfonse	10 to 30 tons per ha per year
6. Watermelon	Charleston Gray, Crimson sweet, Sugar Baby	Yield range: 40-70 t/ha
7. Guava	Timmy, Jossy, KALRO 1, KALRO 2, KALRO 3, KALRO 4, KALRO-5,	
8. Cape Gooseberry	Brazil, Peru, Netherlands, Columbia, Timboroa, Loitoktok Tok, Busia, Bungoma, South Africa	
Vegetables		
1. Cabbage (Brassica oleraceae)	Copenhagen, Fabiola F1, Blue Jays F1, Pretoria F1, Quisor F1, Triperio F1, Gloria F1, Pkutor F1, Riana F1, Fanaka F1, Haraka F1, Victoria F1, golden acre, Amigo, Amukosi F1, Bluedynas F1, Fieldwiner F1, Hero F1, Oxylus F1, Price Drumhead, Red Dynasty, Red montechristo F1, Red rock, Rinda F1, Rotan F1, Ruby ball, Ruby perfection F1, Savoy Saga, Sugar loaf, Super master, Suzanna fivfffst, Zawadi F1, Fiona F1, Rossy F1, Star 3308, Star3317 F1, Green challenger F1, Green coronet F1,	Yield Range : 40-60 t/ha

2. Capsicums	Vincent Ochieng Red Knight, Admiral, Commandant (green, red), Ilanga (yellow), Paserella (red), Mineva (yellow), Kori(red), super bell, Maxxi bell,	Yield range: 100,000-200,000 fruits per ha
3. Cucumber	Rania RZ, Khassib RZ, Gianco RZ, Media RZ, Bologna RZ, Cumlade RZ, Myrthos RZ, Pluto RZ, Ashley, Danora F1, Palomar, Poinsett, Sarig, Super marketer, Tempo, Toaz, Hybrid victory, Long fellow,	Yield range = 8-10 t/ha
4. Onion	Red creole, Red Pinoy, Bombay red, Texas, Jambar F1, Islero, Red passion, Red Pinnoy,	Yield range: 15-20t/ha
5. Peas	Get from AgnesGreen feast,Ambassander, Sommerwood, Aldeman, Earlicrop	Yield range: 4-6t/ha
6. Sweet Corn	Panar, Saby Asian, Kalahari, Silver Queen , Extra sweet, Early sunglow, Kandy corn.	Yield range = 15-20t/ha
7. Tomato	Cal J, Rio Grande, Onyx, Roma VF (1), Heiz, M82, Money Maker, Marglobe, F1, Eden F1, Kentom F1, Caltana F1, Onyx F1, Monyala F1, Zawadi F1, Assila F1, Anna F1, Kilele F1, Nominneta F1, Tylka F1, Top 11 F1, Bravo F1, Proster F1, Libra F1, Chonto F1, Shanty F1, Nyota F1	Yield Range: 30-180 t/ha (Field to greenhouse environments)
Indigenous vegetables		
1. Amaranthus (*Terere*)	KK Livokoyi, KK Mrambi, grain amaranths: TerereSmart, KATGold	Grain yield: 500 -600kg Ha^{-1}
2. Other ALV's	Spider Plant (Sagaa, Saget), African Nightshade (Managu), Jute mallow (*Mrenda/Murere*), Cowpeas Leaves (*Kunde mboga*), Spider Plant (Sagaa, Saget), African Nightshade (Managu),	
Roots and Tuber crops		
1. Sweetpotato	Mtwapa 8, jayalo, ksp 20 (wanjugu), spk 004, kemb 10, spk 013, mugande, ksp0047, ksp0072, ksp0084, ksp0154, mwavuli, 91-218 , k117, kabode, vitaa, knsp 013, knsp 016, naspot-1, cuny ,namnyekera, Kenspot 1, 2,3, 4, and 5.	15-20t/ha
2. Cassava	Siri ,KME2, KME3, KME4, Karembo, Karibuni, Nzalauka, Kaleso, Guzo, KME 1, KME 61, MUCERICERI, Shibe, Tajirika, Siri, Nzalauka, Karibuni ,Karembo	30-50 t/ha
3. Potato	Shangi, Sherekea, Kenya Mpya,Unica,Asante, Tigoni, Destiny, Wanjiku	Yield range = 30-50 t/ha
Industrial crops		
1. Cotton	AF0903,06K486,06K485, HA-211 / Intercott 211, HA-701 / Intercott 701 and AF0904	Lint yield estimate= 2-5 t/ha
Oil Crops		
1. Soybeans	Nyala, EAI 3600, Kensoy 009, Gazelle, DPSB19, DPSB 8 ,Hill and Black Hawk	Yield range: 1.7-3 t/ha
2. Coconuts	**East African Tall (EAT) variety**;Comes into bearing after 5-7years,50-100 nuts per tree per year, monocrop or intercropped with annual crops such as maize, cowpeas, cassava and green grams, Seeds/seedlings are available in KALRO centres at Mtwapa and Matuga, nursery operators in the coastal counties of Kwale, Mombasa, Kilifi, Tana-River, Lamu and Taita-Taveta. **Dwarf variety**: start bearing in 3-5 years, 80-120 nuts per tree per year, monocrop or intercropped with annual crops such as maize, cowpeas, cassava and green grams, Seeds/seedlings are available in KALRO centres at Mtwapa and Matuga, nursery operators in the coastal counties of Kwale, Mombasa, Kilifi, Tana-River, Lamu and Taita-Taveta.	50-120 nuts per tree per year
3. Sunflower Seed	H067 , Kenya White, Kenya Fedha, Kenya Shaba, H.894, H893, H001, H.898, H8998 ,PAN 7352, PAN 7369, Kenya Almasi, KS-H4038, KS-H4088, KAJ 037 ,KAJ 001, PAN 7031, PAN 7033, PAN 7034, PAN 7043, PAN 7351, SY4200, SY4045, NK aDAGIO, NK KONDI, NK DELFI, NX 55010 (NK NEOMA)	Yield range: 2-3 t/ha

4. Sesame Seed	KSS-6	Yield range: 1.5-2 t/ha
Forage legumes		
1. Green leaf desmodium, Silver leaf desmodium	*Desmodium intortum*	4-7 t/ha
2. Glycine	*Glycine javanica*	3-8 t/ha
3. Lucerne or Alfalfa	*Medicago sativa*	25-27t/ha
4. White clover	*Trifolium ripens*	2-5 t/ha
5. Sesbania (*Grandiflor*a and S. *sesban*)	Sesbania *Grandiflor*a; Sesbania *sesban*	In 3-4 years, yields up to 2 kg dry matter per harvest per tree.
6. Common vetch	*Vicia sativa*	1.2t/ha under dry land conditions.
Grasses		
1. Brachiaria	Cayman, Mulato II, Cobra, Kisii 1, Lanet 1 and Busia 1	Yield Range: 7-10 t/ha
2. Nappier grass	Kakamega 1, French Cameroon, Banana grass, Kakamega I, Kakamega II, Kakamega III, Uganda hairless, and Clone	12 to 25 tons/ha
3. Dual purpose sorghum	Ikinyaruka, BJ 28, BM 30	17-25 t/ha
4. Pasture grasses	Eragrostis Superba	3t/ha
	(ii) Cenchurus Cilliaris	4-10t/ha
	(iii) Enteropogon macrostachus	1.9 t/ha
	(iv) Chloris roxyborghiana	3.1 t/ha
	(v) Chloris Gayana variety xt021	15t/ha
	(vi) Chloris gayana var. Lanet	10 t/ha
	(vii) Forage sorghum E6518	20 t/ha
	(viiii) Setaria sphaceleta (Seteria)	10-20 t/ha
	(ix) Panicum Maximum (guinea grass)	15-20 t/ha
	(x) Forage sorghum (sudan grass)	5- 7.5 tonnes per hectare
	(xi) Sorghum almum (Columbus grass)	4-10 t/ha
	(xii) Eragrostis teff (teff)	

Source: Collated and consolidated from a variety of recent documents.

3.4 Level of Capacity of Public Crop Breeding Institutions

At least one public research institution (KALRO formerly KARI), five public universities, namely, The University of Nairobi, Jomo Kenyatta University of Agriculture and Technology, Moi University, Masinde Muliro University of Science and Technology and Maseno University, have on-going programs for plant breeding research. The oldest and largest among them is the Kenya Agriculture and Livestock Research Organization (KALRO) formerly Kenya Agricultural Research Institute (KARI), which has been involved in plant breeding for more than 85 years. In 1999, the Agricultural Science and Technology Indicators (ASTI) database estimated that KARI accounted for more than half of the national agricultural research expenditure and staff. The KALRO Breeding Institutions are:

1. National Dryland Farming Research Institute, Katumani
   - Maize, pulses, sorghum and millets
2. Embu
   - Maize, sorghum and millets
3. Mtwapa
   - Maize, cassava

4. Njoro
    - Wheat, barley
5. Kakamega
    - Maize, beans, cassava, finger millet
6. Kitale
    - Maize
7. Tigoni
    - Irish potato
8. Kisii
    - Finger millets

The Breeders may not be as many as in the late 90s when we would have a breeder for each crop. The land for breeding purposes is still adequate today. The main activities now however are seed production and promotion. AGRA - Had a training program in the Republic of South Africa for East and Southern Africa, and at the University of Accra for Central and West Africa. The program came to an end about 3 years ago.

A major player representing the private seed sector in Kenya is a producers' organization called the Seed Traders Association of Kenya (STAK), which was established in 1982. STAK, through the auspices of the Kenya Plant Health Inspectorate Services (KEPHIS), is licensed to produce, process and/or distribute seeds in Kenya. STAK members are currently involved in the research and multiplication activities of most important crops in this country, such as maize, wheat, beans, sunflower, vegetables and fodder. The member seed companies, which currently comprise 20 private firms, contribute nearly 90% of Kenya's total formal seed sector. Out of the 20 firms, only four support research and development (R&D) activities (namely breeding and varietal release). The multinational firms carry out most biotech research in Kenya, especially the one that focuses on maize.

3.5 Capacity Building in Scientific Personnel Training and Development of Infrastructure

The capacity of Kenyans to research on genetic engineering has been enhanced through extensive training of staff from KALRO, Ministry of Agriculture and KEPHIS on biotechnology, biosafety, management of biosafety facilities, and regulatory issues. Hands on trainings have been emphasized in Mexico and in Kenya. Infrastructure development include a biosafety level 2 laboratory, a biosafety level 2 greenhouse complex, both at KALRO-NARL Kabete, and an open quarantine site (OQS) at KALRO-Kiboko.

An internal evaluation determined that, in order to fulfill its research potential, KALRO would need to increase agricultural researcher numbers by 40 percent. Yet capacity is actually expected to decline in the coming years because a large number of (especially PhD-qualified) researchers is approaching retirement age. By preventing KALRO from replacing departing and retiring staff with young scientists, coupled with the on-going hiring freeze, further complicates this challenge, creating a long-term impediment to the conduct and continuity of research. The country's total number of agricultural researchers increased only slightly during 2011–2014, mostly due to growth in the number of PhD-qualified researchers. The number of BSc- and MSc-qualified researchers remained fairly stagnant during this timeframe. The government and higher education agencies employed a number of technical support staff qualified to the BSc- and MSc- level; these staff members do not have official researcher status. Large shares of PhD-qualified researchers in most agricultural research agencies in Kenya are in their 50s or 60s. The situation is particularly serious at KALRO where three-quarters of PhD- qualified researchers and about half of all BSc- and MSc-qualified researchers were more than 50 years old as of 2014.

A large number of researchers with PhD degrees left KALRO during 2013–2014 to accept positions with more attractive remuneration at local universities or other agencies. As a result, the number of PhD-qualified Full Time Equivalent (FTE) researchers employed in the higher education sector has surpassed the number employed at KALRO.

Table 16: Kenya's MSc- and PhD-qualified Agricultural Researchers, by Discipline.

Agricultural researchers, 2014	FTEs		Share (%)	
	MSc	PhD	MSc	PhD
Plant breeding/genetics (incl. biotechnology)	37	41	7	10
Plant pathology	24	25	5	6
Plant physiology	3	10	1	2
Botany	2	4	4	1
Seed science and technology	7	5	1	1
Other crop sciences	79	54	15	13
Forestry and agroforestry	5	8	1	2

Source: KARI Annual Reports

3.6 Recent or On-going Collaborations with Public Institutions, Farmer-based Organizations, and Private Sector in Seed Supply

The Kenyan seed industry structure comprises the formal and informal systems and these two systems differ in their magnitude and importance, depending on the commodities they support. It is apparent that commodities that have been supported by massive research efforts tend to have more formal than informal seed system, whereas those regarded as orphan crops are governed more by informal rather than formal seed system (Ayieko and Tschirley, 2006). Table 22 shows the plurality of seed systems in Kenya with examples of crops in the various systems.

Table 17. Plurality of Seed Systems in Kenya.

Seed system	Description	Examples of crops in the system
Farmer-based	Seed saved, used, exchanged and sold between individual farmers.	Sweet potato; Irish potato; bananas; beans; cowpea; millet; sorghum
Community based	Seeds produced, multiplied and either sold or shared within a community	Cassava
Relief seed	Civil society organizations, non-governmental organizations and relief agencies purchase seed either from the public and private sector and distribute to farmers	Hybrid maize; OPV maize; tomatoes; kale; onions
Public formal	Breeding, seed production, multiplication and distribution by public sector only	Wheat; hybrid maize
Mixed public/ private	Breeding undertaken by public sector; seed production, multiplication and distribution by private sector	Hybrid maize; OPV maize; beans
Closed value chains	Breeding, seed production, seed multiplication and seed distribution all undertaken by private sector only	Pineapples; flowers; tobacco

Source: Munyi and De Jonge (2015)

About 80% of all the seeds used in Kenyan farming systems come from the informal sector and despite this, the importance of the informal seed system has been largely underplayed and unappreciated as a distinct and expanding system (Ayieko and Tschirley, 2006). Table 23 below shows the proportion of seed that passes through the formal and informal systems for selected commodities.

Table 18. Proportion of seed made available from different sources in Kenya.

Informal System			Formal System				
Crop	**Farm-saved seed**	**Community-based schemes**	**Public companies/ Parastatals**	**Private local companies**	**Private foreign companies**	**Government distribution schemes**	**Donors/NGOs**
Bananas	80	0	20	0	0	0	0
Beans	80	0	5	0	10	0	5
Cassava	93	2	5	0	0	0	0
Cowpea	75	8	10	2	0	0	5
Groundnut	80	3	0	10	0	0	7
Maize	32	2	40	15	5	5	1
Millet	90	3	1	2	0	0	4
Pigeon pea	80	0	6	4	0	0	10
Rice	15	0	85	0	0	0	0
Sorghum	87	0	4	5	0	2	2
Soybean	99	1	0	0	0	0	0
Sweat Potato	96	3	1	0	0	0	0
Overall	**76**	**2**	**15**	**3**	**1**	**1**	**3**

Source: Ayieko and Tschirley (2006)

With the exception of maize and rice, the seed of other commodities are mainly sourced from the informal seed systems. By comparing the formal and informal seed systems in terms of value shares, formal seed sources account for more than half (52%) of all seed used in the country, compared to 40% from retained sources and only 8% from informal seed purchases (Table 24). The wide disparity in shares could be explained by the high cost of seed from formal sources compared to those from informal purchases.

Table 19. Value share of seed and planting materials sources.

Seed Type	**Share of total value of seed used in country**	**Share of total value of crop production in country**
Retained Seed	40	42
Informal Seed Purchases	8	10
Formal Seed Purchases	52	48

Source: TAMPA, 2004

Cereals, pulses and industrial crops dominate the formal seed source. Among the cereals and pulses, more than half (52%) of the seed by value is from formal seed purchases, while another one-third (34%) of the seed is farm-retained. Among the cereals and pulses, maize dominates the formal seed purchases (87%). This is due to widespread use of hybrids since maize is the most important cereal in Kenya and serves as the staple food for > 90% of the population (ISAAA, 2001). Vegetables and other non-tree fruits are also mainly grown

from retained seed sources (43%) and informal sources (34%), while the tree fruits are mainly produced from retained seedlings (Table 25) (Muthoni and Nyamongo, 2008).

Table 20. Value share of seed source by commodity group.

Commodity Group	Informal Sources		Formal Sources
	Farm Retained	Informal Purchases	Formal Purchases
% of total value of seed			
Cereals and Pulses	34	14	52
Of which: Maize	10	3	88
Others	58	24	17
Tubers	84	16	0
Vegetable and non-tree fruits	43	34	22
Industrial crops	1	0	99
Tree crops	93	7	0
Fodder	98	1	1
Overall	40	8	52

Source: TAMPA 2004.

In terms of value, formal seed sources are important for all agro-ecological zones, except in the Eastern and Coastal Lowlands. Over 40% of all seed purchases from the formal channels are for maize in the high potential maize zone. But retained seed use is spread across a wider geographical area and more crops. Four-fifths of all seed used in Eastern Lowlands by value is retained seed. This may be attributed to the fact that the Eastern and Coastal lowlands are generally arid and semi-arid areas (Table 26).

Table 21. Value share of seed sources by agro regional zones in Kenya.

Zone	Informal Sources		Formal Sources	Total
	Farm retained seed	Informal purchases	Formal purchases	
% Value in the region				
Central Highlands	49	10	41	100
High potential maize zone	31	7	61	100
Eastern lowlands	80	11	9	100
Western lowlands	45	7	48	100
Western transitional	11	4	85	100
Western highlands	35	6	60	100
Coastal lowlands	55	36	19	100

Source: TAMPA 2004.

3.7 Current Status of Crop Variety Licensing Arrangements for Production of Seed by Third Party Entities

Currently in Kenya, crop variety licensing arrangements for production of seed by third party entities is executed through limited exclusivity agreements, where owners of public varieties agree to limited exclusivity for commercialization of their varieties. Such agreements may be permitted under the following conditions: (1) The exclusivity is necessary for the further improvement of such intellectual assets or to enhance the scale or scope of impact on target beneficiaries. (2) The exclusivity is as limited as possible in duration, territory, and/or field of use. (3) The agreements provide that the varieties remain available in all regions/counties for non-commercial research conducted by public sector organizations and, in the event of a national or regional food security emergency, for the duration of the emergency. [SEP]

For example, KALRO or Department of Biochemistry and Biotechnology, Kenyatta University, develop a

promising crop variety, but lacks the resources to effectively disseminate the variety to farmers. The extension agencies also lack the means to get the variety out to farmers. There are a few small seed companies that are interested in marketing the variety, but none of them is willing to even try unless they are granted an exclusive license to commercialize the variety. In the absence of an exclusive license, the companies fear they will end up undermining each other's ability to recoup the modest financial gains that might be available through sales in the country. Under such circumstances, Department of Biochemistry and Biotechnology, Kenyatta University or KALRO can grant a time-limited exclusive license with a research exemption to a single company to commercially market the variety, because this would be "necessary to enhance the scale or scope of impact on target beneficiaries." At the same time, however, KALRO or Department of Biochemistry and Biotechnology, Kenyatta University, would still make the variety available to public sector organizations for research (including breeding) purposes. This would facilitate potentially important further uses of the variety in pursuit of developing other improved materials. Other companies could also, "bulk up" seed for sale once the period of exclusivity is over.

CHAPTER FOUR: STATUS OF SEED SUPPLY

Seed is one of the most critical inputs in agricultural production. Good quality seed has significant potential of increasing on-farm productivity and enhancing food security. The seed industry in Kenya has undergone dynamic changes within the country. With the advent of liberalization, local and foreign seed companies have continued to play an increasing role in seed research, breeding, multiplication and trade. Regional integration and international trade together with scientific advances in the area of biotechnology have posed additional challenges that require the local industry to quickly adapt to the changing environment in order to remain competitive both locally and regionally. In addition the country needs to continue engaging and partnering with relevant international organizations such as the Organization for Economic Cooperation and Development (OECD) seed schemes, International Seed Trade Association (ISTA), International Union for Protection of New Varieties of Plants (IUPOV) and International Plant Protection Convention (IPPC) to improve trade and exchange of seed material.

By the end of 2008, the Kenyan seed industry had developed into a vibrant regional leader with 73 registered seed merchants currently operating in the country. But the informal seed accounts for a higher proportion of the total seed planted by subsistence farmers. In 2007, the national requirement for certified seed ranged between 28,000 and 35,000 metric tones with seed maize accounting for about 80% of the total quantity. Kenya still experiences shortage of quality seed for crops like potatoes, wheat and some pulses and certain varieties of seed maize suited for arid and semi-arid areas (ASALs). In the last ten years, there has been a steady increase in volume of imported seed, particularly of horticultural crops, which cannot be produced locally due to environmental conditions. The increase has contributed positively towards the growth in the horticultural crop production especially for export.

4.1 History of Crop Breeding and Seed Supply in the ASALs of Kenya

The seed industry development in Kenya started in the early 20th century, when the government of Kenya realized the importance of high quality seed in agricultural production. These were supported by research on food, industrial and export crops, which supplied seeds and planting material for the farming community. Kenya's seed industry comprises of the formal and informal seed sectors with the latter accounting for approximately 80% of the seed planted. In 1944 the first seed testing laboratory was set up at the National Agricultural Laboratories (NAL), serving mostly the European large scale farmers who wanted to determine the quality of cereals and grass seeds before exporting. The formal seed sector started with the establishment of Kenya Seed Company (KSC) in 1956 in Kitale to produce pasture seed to serve the then dairy farmers. Later, the company diversified to other crops.

Organised seed supply started around 1963 when Kenya Seed Company through a memorandum of understanding (MOU) took responsibility of seed multiplication and production of pasture for various varieties developed by Government stations. A Seed Unit was established whose task was to ensure that only high quality seed of adopted crop varieties would reach the farmers. The Unit was responsible for field inspection, certification, seed testing and quality control. 1964 saw the beginning of the process leading to the establishment of the Seed Unit Project, later formalized as the Kenya Inspection Service for Seed (KIS). It was formed to promote the provision, improvement and use of high quality seed of superior, well adopted varieties of improved crop species in Kenya.

In 1977 when the East African Community collapsed, the Government of Kenya enhanced various breeding and research sub stations in the different ecological zones. For the ASAL region, the National Research station at Katumani in Machakos was the main research center with sub centers in Kiboko, Kitui and Embu. KSC continued to play a predominant role until the industry was liberalized in the mid 1980s to 1996. With the advent of seed liberalization, more companies and universities emerged and strengthened this effort that was predominantly dominated by Kenya Seed Company. Several companies entered the formal sector and by 2005, there were 50 registered seed companies largely dealing in seeds of maize, wheat, barley, oats, triticale and sorghum; rapeseed, sunflower; pulses; pastures; horticultural crops and Irish potatoes. The distribution of seed was mainly through the Kenya Farmers Association.

The Kenya Seed industry is governed by the Seeds and Plant Varieties Act (Cap 327) of 1972, which became operational in 1975. Regulations to guide seed operations were made in 1977 and revised in 1991 to incorporate plant variety protection (plant breeder's rights) regulations. The liberalization of the seed industry in the mid 1990's resulted in the entry of new seed players in the seed market, resulting in the over 100 seed companies having been officially registered to date. These companies are now dealing with crops neglected previously, due to their low profitability. These include horticultural crops, rice, cotton, pastures seeds, sorghum, millet, pigeon peas, cowpeas, groundnuts and chickpea among others.

Seed production and marketing in Kenya were liberalized through the Ministry of Agriculture's Seed and Plant Varieties Act Cap 326, which allowed private seed companies to cover all stages of the seed value chain. The Act regulates testing, certification and procedures relating to the introduction of improved and new varieties bred locally or imported. All crop varieties fall under Schedule II of the Act requiring mandatory inspection before official registration and varietal release. Seed laws are harmonized with the relevant international conventions. Imported seed requires phytosanitary certificates as well as International Seed Testing Association (ISTA) certificates. Local seed is considered to be over-regulated as production and distribution is subject to stringent regulations. This is coupled with long varietal release processes, which make the seed expensive, and contributes to seed shortages.

Seed traded and used in Kenya is made up of local production and imported seed. As part of the trade business, there are exports of seed to particularly its neighbors in the region. The movement of seed within and between these countries is normally restricted by regulations governing seed certification and standards, phytosanitary measures, variety testing and release procedures, plant variety protection and import and export requirements. Kenya Agriculture and Livestock Research Organization (KALRO) employs 61% of all the trained crop breeders followed by national universities (23%), private companies (9.6%) and international organizations (6%). The majority (90%) are trained in conventional breeding methods and crop improvement programs. KALRO, the International Agricultural Research Institutes (IARCs), the Coffee and Tea Research Foundations are the most active organizations producing improved varieties. KALRO's practice of non-exclusive rights over the distribution of certain varieties has created some conflicts and led to a shortage of breeder seed for varieties of orphan crops and legumes which are pivotal food security crops.

The liberalization of the seed industry has seen a rapid expansion of seed companies. To date, there are more than 100 private seed companies in Kenya. Five are public, including the KALRO seed units and have supported a strong public research capacity with competing private sector entities for the genetic material. The

Kenya Seed Company controls 75% of market share of maize seed and also has a substantial share of seeds of other crops. Foundation seed bulking and commercial seed multiplication are constrained by limited stocks of basic seed. The procurement of seed produced by the public seed system involves lengthy processes that delay the availability of seed to farmers at the appropriate planting times.

There is heavy government involvement in enforcing local and international seed regulations in seed testing, registration, release, certification and marketing through the Kenyan government regulatory body, KEPHIS (Wakhungu *et al.* 2004). The current regulatory and legal framework of the national formal seed system limits the development of the informal seed system. The existing seeds and plant variety legislation are not supportive of the informal seed sector relative to on-farm seed production, exchange, maintenance, development and registration of landraces. The stringent legal criteria for distinctiveness, uniformity and stability (DUS) as well as other quality aspects are difficult to implement in the informal system. The testing, registration, release and certification systems have been designed to handle new varieties from commercial or conventional breeders (Wakhungu *et al.,* 2004). One school of thought postulates that state monopoly in seed inspection and certification has sometimes hampered production of certified seeds and seed growers have lost their crops due to late inspection by an overstretched, under-resourced seed inspection service (Rohrbach *et al.*, 2003). The stifling regulatory system also raises barriers to the dissemination of modern/improved varieties due to long periods of testing required before a variety is officially approved and released for commercial purposes.

The Kenya Plant Health Inspectorate Services (KEPHIS), which was established by the 1966 State Corporate Act (Cap 446), is the National Regulatory Authority responsible for variety evaluation, release, registration, plant protection and the implementation and development of seed standards. KEPHIS conducts seed certification services but is overwhelmed by the demand for seed inspection and certification services and sometimes leads to rejection of crop under trials. The fees charged are considerably high and contribute to high costs of seed. Donors, NGOs and CBOs play a crucial role in filling the unmet demand for seed. These organizations promote the collection, multiplication and distribution of seed using various strategies, including working with farmer groups that they train and provide with seed capital to boost their seed business. They also import seed and disseminate it to farmers using direct distribution of relief seed, the voucher system and seed fairs.

It is a regulatory requirement in Kenya that all seed agents and stockists be registered by KEPHIS to promote traceability of seed movement and enforce quality standards (inspections etc.). KEPHIS registers them as outlets and distributors of seed at a charge of US$1,600 per agent and US$600 per stockist. This is factored into the wholesale and retail price of seed and tends to increase the cost of seeds. Most of the stockists/agents benefit from training on product knowledge, technical aspects of agronomic practice, financial literacy and business skills. KEPHIS also trains some to serve as effective disseminators of information on seed. They have limited access to micro-finance due to limited availability and high cost of capital. Farmers play a very significant, if not the most significant role in the seed industry. They obtain seed through both formal and informal channels, with the latter source constituting the largest source for smallholder farmers. However, the weak research-extension-farmer linkages are a major limitation to adoption of improved varieties.

4.2 Recent and Ongoing Activities aimed at Release of Improved Crop Varieties, by Crop

Good efforts are being made by the CGIAR Centres in collaboration with the national institutions and other key stakeholders to improve the productivity of maize, beans, bananas, cowpeas, cotton, sorghum, millets, rice and wheat in Kenya, to meet the increasing demands. These organizations have put together strategies for re-invigorating the process of developing and disseminating the requisite technology that would increase the production and productivity of the above-mentioned crops among others, to meet the increasing demand in Kenya. For example:

4.2.1 Maize

Several projects have been designed and implemented in Kenya with funding from diverse donors to improve maize productivity at the farm level over the last fifteen years. The Drought Tolerant Maize for Africa (DTMA), the Improved Maize for African Soils (IMAS), the Water Efficient Maize for Africa (WEMA), and the Insect Resistant maize varieties are among the key projects in Kenya, developing and deploying stress resilient and nutritionally enriched maize in Kenya. These projects have made significant contributions in terms of improved variety releases and delivery of maize seed in Kenya. Similarly, under the Integrated Striga Management for Africa (ISMA) project, IITA, CIMMYT and partners in Kenya and Nigeria came together to develop and deploy Striga-tolerant improved maize varieties.

4.2.2 Beans

Generally, CIAT provides common bean genetics to KALRO. The primary roles for KALRO and public universities are to research and select suitable varieties for Kenyan agricultural needs and to produce breeder seed, with private seed companies providing additional support when needed due to capacity shortfalls. Basic and commercial seed is typically produced by a combination of public institutions, such as universities and KSU (Kalro Seed Unit), and regional seed companies. Farmer groups and cooperatives also play a small role in commercial seed production. Marketing and distribution of common bean commercial seed occurs through NGOs, agro-dealers, and local seed companies. As with maize and potato, KEPHIS is responsible for all inspection and certification of common bean.

4.2.3 Bananas

Tissue culture (TC) techniques have been used in Kenya over the last fifteen years to produce large quantities of disease-free banana planting material. Tissue culture (TC) is a form of biotechnology that refers to the production of plants from very small plant parts, tissues or cells grown aseptically under laboratory conditions where the environment and nutrition are rigidly controlled. The basis of the TC technology lies on the ability of many plant species to regenerate a whole plant from a plant part. To ensure farmers' easy access to TC plantlets in various parts of the country, hardening nurseries are critical. Murang'a and Meru Counties are among the regions that are suitable for banana cultivation and value chain development in Kenya, with the support of organizations like USAID-Kenya and Technoserve, among others.

4.2.4 Cowpea

The cowpea seed system is mainly informal with farmer saved seeds accounting for 75% of the seed sources while community-based schemes account for 8%. The formal seed system accounts for 17% of the cowpeas seed sources with public companies/parastatals representing 10%, private local companies 2% and donors/NGOs 5%. In the formal seed system, the main breeders of improved varieties are KALRO, IITA, ICIPE and Western Seed Co (KEPHIS, 2012). Although 10 cowpeas varieties were released between 1987 and 2010, less than 10% of the farmers use improved varieties mainly due to lack of quality seeds in general. Small quantities of certified cowpea seeds are processed, branded and packed in private retailer labels and sold through supermarkets (Rusike *et al,* 2013). The main producing areas in the ASALs include Mwingi, Makueni, Kitui, Mbeere and Tharaka. Other producing areas (albeit comparatively small producers) include Coast province (3.7%), Nyanza (2%), Rift Valley (1.6%), North Eastern (0.8%), Central (0.6%) and Western (0.3%).

4.2.5 Cotton

The cotton sector is set for a drastic shift as the regulator, The Cotton Development Authority (CODA), starts developing varieties grown in particular counties to reduce imports. CODA has been working with the Kenya Agriculture and Livestock Research Institute (Kalro) to produce what is suited to particular ecological zones. Initially the short and medium staple varieties developed by Kalro served government and textile firms well, but as the industry develops, we are seeing rising demand for long staple varieties. The Fiber Crops

Directorate has been pushing for the commercialization of genetically modified (GM) cotton known as Bt cotton because it has been modified to express a protein from the bacterium *Bacillus thuringiensis*, which controls the African bollworm, it is expected to triple yields while reducing the need for insecticides.

4.2.6 Sorghum

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has the mandate for research and development of sorghum, pearl millet and finger millet, among other crops. A number of initiatives are currently ongoing that present good opportunity for the current process to tap from. One of the key ongoing initiatives is: Harnessing Opportunities for Productivity Enhancement (HOPE) of sorghum and millets in Sub-Saharan Africa Project, supported by the Bill and Melinda Gates Foundation, and implemented by ICRISAT in partnership with the national partners in 10 African countries, including Kenya. This initiative has led to significant achievements with the release of high yielding improved sorghum and millet varieties adaptable across different agro-ecologies in Kenya. A number of ICRISAT bilateral projects seek to generate new improved agricultural technologies, seed systems, value addition and capacity building of National partners. Similarly ICRISAT operates several CGIAR Center Research Projects (CRPs), with leadership in the sorghum and millets components of the CRP portfolio.

4.2.7 Wheat

The occurrence of UG 99 in Uganda in 1998 led to the establishment of the Borlaug Global Rust Initiative in 2005 and several projects have since then supported breeding of high yielding rust resistant varieties. Kenya and Ethiopia had been established as hubs for screening and more than 50, 000 wheat accessions from programs around the world are annually evaluated in Njoro, Kenya and Ethiopia. Identifying rust resistant wheat lines at these locations is of paramount importance to stop the spread of UG 99. Several rust resistant varieties were identified in Kenya and Ethiopia and are grown on large scale, thanks to support from various donors for seed production (AfDB, BBSRC, BMGF, DFID, GIZ, USAID).

Table 22: Proportion of seed made available from different sources in Kenya.

Informal System			Formal System				
Crop	**Farm-saved seed**	**Community-based schemes**	**Public companies/Parastatals**	**Private local companies**	**Private foreign companies**	**Government distribution schemes**	**Donors/NGOs**
Bananas	80	0	20	0	0	0	0
Beans	80	0	5	0	10	0	5
Cassava	93	2	5	0	0	0	0
Cowpea	75	8	10	2	0	0	5
Groundnut	80	3	0	10	0	0	7
Maize	32	2	40	15	5	5	1
Millet	90	3	1	2	0	0	4
Pigeon pea	80	0	6	4	0	0	10
Rice	15	0	85	0	0	0	0
Sorghum	87	0	4	5	0	2	2
Soybean	99	1	0	0	0	0	0
Sweet Potato	96	3	1	0	0	0	0
OVERALL	76	2	15	3	1	1	3

Source: Ayieko and Tschirley (2006)

4.3 Recent and Ongoing Activities aimed at Increasing Supply of Improved Seed

Farmers in Kenya, particularly small-scale farmers, are involved in multiple kinds of seed systems, which help them produce and obtain the seed they need. These systems can be broadly divided into two types: a formal

seed system and a local system. The local system is also sometimes called the "informal," "traditional," or "farmer" seed system. The "local" or "informal" seed system is the one that provides most farmers with seeds most of the time. There are five identified dominant seed systems in Kenya (Table 23), 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 such as parastatals and private companies (Muthoni and Nyamongo, 2008).

Table 23: Dominant seed systems in Kenya.

	Farmer-saved Traditional, for food and subsistence crops (Informal)		**NGO/Cooperatives** Varieties and basic seed from public research; development and community based targeting food security (intermediary)	**Parastatals** Varieties and basic seed from public research; structured quality seed production and marketing (formal)	**Private International Companies** Own varieties and basic seed; structured quality seed production and marketing (formal)	**Private Local Companies** Own or license varieties and basic seed; structured quality seed production and marketing (formal)
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	Positively selected		Certified and positively 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
Market						

share	75-80%	20-25%

Source: Reported from interviews carried out in 2016 by USAID field research team.

As discussed above, the dominant source of seed varies by crop, but crops tend to be aligned with one of the 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/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 transaction, sales and barter, in Kenya.

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.

Certification is primarily concentrated in maize as well, with maize accounting for 80-90% of annual certification at KEPHIS. However, the overall volume of certified seed declined approximately 30% between 2012 and 2014, with maize certification declining by approximately 25% during that time period (USAID, 2016). Based on field interviews, this decline in maize certification is primarily due to disease pressure that has rendered some seed production land unusable, resulting in decreased maize seed production overall.

For dryland crops such as pigeonpea, cowpea, mung bean, common beans, sorghum, millets, open-pollinated maize, and tuber and root crops, farmers in arid and semiarid areas obtain seeds from local sources, especially own-saved seeds, social networks (relatives, and other neighbouring farmers), and local traders (shopkeepers and open-air market grain traders). The majority of farmers in marginal areas rely on seed saved from their own harvests and continue recycling seed as long as the harvest is "adequate" and they are able to keep some for subsequent seasons. Local traders play a critical role in rural communities by purchasing grain at harvest, storing it and selling it back later to the same farmers, either as food or as seed at planting time. These seed institutions are critical to the livelihoods of the marginalized and poor households in the supply of food and seed grains.

In order to improve farmers' access to seed of locally adapted and improved crop varieties, governmental organizations and NGOs have been carrying out community-based seed interventions in arid and semi-arid areas. These interventions include seed and cultural fairs, community-based seed bulking, community-based grain banks and seed recovery and banking. Crop diversity is increasingly recognized as crucial for improving food production and food security among marginal farming communities in semi-arid areas. Management and preservation of seed, based on farmer skills and community participation, could help conserve crop diversity and improve food security among farming communities in drought-prone areas.

Although farmers tend to conserve crop varieties that give them better yields, activities that reinforce appreciation of their existing crop diversity are important avenues for increasing improved seed supply. One such activity is local community seed and cultural fairs. Seed and cultural fairs offer a venue for displaying crops commonly grown in the region. During the cultural fairs, traditional foods and tools used in farming within the region are displayed. The objective of seed and cultural fairs is to help farmers appreciate their large crop

diversity by encouraging them to exhibit planting materials. Farmers have the opportunity to access crop varieties that they need and also to exchange and share information and experiences on farming under their local conditions. The seed and cultural fairs also provide a suitable forum for farmers to share information and exchange seeds beyond their locations, thus giving them access to a wider choice of varieties and maintaining a high level of crop diversity.

Community-based seed production seeks to involve small-scale individual farmers, farmer groups, NGOs and governmental organizations in forming small but effective seed multiplication units with the objective of supplying quality seeds for farmers' own use and for sale to other farmers. Activities include the selection of farmers or farmer groups to be involved in seed bulking and training on seed multiplication techniques and marketing. The Kenya Agriculture and Livestock Research Organization (KALRO) Katumani Seed Unit, based at the National Dryland Farming Research Centre, provides both the required training and foundation seed to the community-based seed farmers.

Community-based grain banks are commonly used to increase seed supply to farmers. This is a system where the grains produced locally are stored and distributed to participating farmers as seed at planting time. Community grain banks are managed by farmers, with supervision from CBOs and local NGOs. If run properly, they alleviate shortages of seed and ensure timeliness of seed supply to rural farmers. They can also act as a safety bank for seed, especially in times of drought. The success and sustainability of these grain banks is of paramount importance for local seed security.

Seed recovery and banking programme is a system where farmers are facilitated to prepare a list of crops and varieties they require, with emphasis on reliable dryland food crops. The seeds are procured from local seed merchants (local seed markets) and kept in a central store (seed bank) at village level. These are then distributed to farmers at planting time. After harvest, farmers return twice the amount of grain or seed given. Village committees manage the seed recovery and banking with the assistance of location extension staff from the Ministry of Agriculture and local CBOs and NGOs. These CBOs and NGOs usually give the communities initial funds for seed procurement. Each seed bank is run at village level. The village committees monitor the crop in the field and establish and manage the seed banks. Sublocational committees monitor the village committees and provide a forum for sharing experiences.

Emergency seed distribution in Kenya is a relatively new development, which started as a collaborative effort between the government, NGOs, CBOs, farmers and other development agencies to supply seeds to communities faced with acute seed shortage following drought-related stress. In the last decade, considerable quantities of maize, bean, cowpea, sorghum, pigeonpea and green gram have been acquired from seed companies and local markets for distribution. Although intended to be a limited, one-time intervention, emergency seed distribution has become a regular source of seeds for ASAL communities as droughts are repeated and frequent. The Government of Kenya through the Emergency Drought Recovery Programme has distributed relatively large quantities of emergency seed to farmers in ASALs since 1992, with a distribution nearly every year. Several NGOs have complemented the government efforts in seed distribution in specific locations and seasons.

Two approaches are regularly used to distribute emergency seed to the drought-affected communities in the ASALs. These included the conventional seed procurement and distribution (CSPD) and seed vouchers and fairs (SVF) approaches. In the conventional seed procurement and distribution approach, the Government and NGOs request seed bids from locally registered seed companies. The Ministry of Agriculture or the implementing agency, based on the ability of the seed companies to supply the types of crop, assesses the bids, variety and amounts required, packaging and the unit cost. Successful bidders transport the seed to the affected district areas, where it is received by the implementing agency for storage, awaiting delivery to the divisions and finally to locations where it is distributed to the beneficiaries. The Divisional Officers and local chiefs distribute the seed to the beneficiaries at the Divisional or locational levels. Where the NGOs are

involved, the seed from the seed companies is delivered to the NGOs' local offices for subsequent distribution to the farmers. NGO staff supervise the distribution, often in collaboration with Government of Kenya staff.

In the seed vouchers and fairs approach, the affected communities identify seed-needy households based on their own set criteria. The households are then issued with seed vouchers of a predetermined monetary value. Farmers and local traders with surplus grain to be sold as seed are sensitized to bringing a surplus to a selected seed fair site. Seed fairs are special markets organized for the local farmers, grain traders, seed stockists and seed companies to distribute grains as "seed" or certified seed to seed-needy households. Voucher holders then exchange their vouchers for seed of crop varieties and quantities of their choice, depending on the monetary value of seed vouchers. On completion of the seed fairs, seed vendors redeem the vouchers for cash. The seed fairs provide an opportunity for local seed vendors and seed-needy farmers to interact. It also provides an opportunity to gather information on the kinds of crops and varieties available for sale and on the varied preferences of farmers. In this way, the SVF approach strengthens rather than undermines the operation of the local seed systems.

Agricultural cooperatives in Kenya help farmers increase their yields and incomes by pooling their resources to support collective service provisions and economic empowerment. Agricultural cooperatives are categorized in the intermediary seed system because they have features of both formal and informal seed systems. They play a key role in meeting seed demand and contribute greatly to seed supply improvement through high-volume production of seed, crop, and variety diversification, and seed delivery to farmers. They produce and market the seed through various market channels, including direct sales to farmers, sales through contractual agreement, and sales directly to institutional buyers.

4.4 Current Options for Smallholders to Access Improved Seed

There are a number of options for Kenya's smallholder farmers to access improved seed. These include:

4.4.1 Agro-dealers

Cultivating New Frontiers in Agriculture (CNFA), an international non-profit development organization, estimates that there are over 10,000 agro-dealers active in Kenya delivering seed, fertilizer and other agricultural products to farmers. Agro-dealers are a vital link in the seed supply chain providing farmers with access to the required seed and seed companies with the conduit for reaching farmers. Seed companies nominate local agro-dealers for registration with local agricultural boards, which verifies credentials and refers them to KEPHIS, which then provides the initial certification and ongoing oversight.

With many agro-dealers operating at the village level, they are the only local contact point for farmers and because of this, agro-dealers tend to carry an assortment of agricultural inputs, with seed representing a significant portion of their overall sales. This diversification is required due to the nature of the seed sales cycle, with only certain windows in the calendar being relevant for seed sales.

Many agro-dealers lack access to affordable credit, resulting in the need for seed companies to provide product to them on credit. Banks have historically viewed agriculture as a risky sector for lending, which has led to higher rates than most agro-dealers can afford to pay. This view has been changing recently, with more lenders entering the market targeting agriculture and the riskiness of agriculture being lowered by new insurance products in some instances (e.g. adverse weather).

While it is the seed company's responsibility to ensure quality seed is reaching the farmers, the agro-dealer plays a crucial role in providing feedback on demand and farmer preferences. Additionally, the agro-dealer is inspected by KEPHIS to ensure they are providing quality seed and not selling any seed with incorrect packaging, bad germination, or other substandard qualities.

4.4.2 Private Seed Companies

The private sector consists of international and regional seed companies mainly focused on hybrid maize and local seed companies focused on a variety of crops, including hybrid maize. Table 17 highlights a select group of private seed companies active in Kenya, their estimated share in the formal seed market, their reasons or motivation for participation in the market, and key crops in their product portfolio. More than 110 seed companies are registered with KEPHIS, with a majority focused on vegetable seed trading or the importation of seed for their own use (e.g., large commercial farmers).

Kenya Seed Company (KSC), a parastatal company owned jointly by public and private shareholders (52% public, 48% private), holds a substantial portion of overall market share. Initially, KSC was formed to multiply and market varieties developed by the public research system under the Ministry of Agriculture. Interviews indicate that this has stunted growth in the private sector, specifically in maize where KSC historically had sole access to the output of the KALRO breeding programs. KSC also has significant advantages compared to other private seed companies in terms of production assets and capabilities, including a substantial amount of company owned land, wet cob drying capacity (competitors have to field dry maize seed), modern storage facilities, processing and packaging capacity, and has recently instituted a proprietary breeding program.

KSC's dominance has lessened in recent years following the liberalization of the seed industry. This policy change resulted in public varieties being available more broadly to private sector actors, and not exclusively to KSC. However, the significant asset advantage referenced above still allows KSC to dominate the vast majority of the formal sector market share.

Many private seed companies, including KSC, PANNAR, and SEEDCO utilize their land and facilities in Kenya for the production of certified seed that is exported to surrounding countries, including Rwanda, Tanzania, Uganda, and South Sudan. Typical crops include maize, wheat, sunflower, soybean, and a variety of vegetables. Private companies utilize this arrangement due to the lack of commercial seed production resources and facilities in those countries. Interviews indicate that in some instances, seed is imported from Zambia and then re-exported to Rwanda. Expectations are that this practice may increase with harmonization of seed regulations across the region.

4.5 Number of Private Seed Companies Operating in the ASALS and their Estimated Annual Supply

The main private seed companies operating in ASALs are about 10 with about 70 other small starters. The annual supply statistics by crop are not available at the moment.

Table 24: Some private seed companies active in Kenya.

No.	Company	Country of Origin	Formal Seed Market Share (%)	Motivation	Key Crops
1.	Kenya Seed Company	Kenya	70-80	Parastatal company, significant market share, with long history as a government-owned industry leader	Maize (primarily hybrid), common bean, cowpea, sorghum, rice
2.	PANNAR	South Africa	5-10	Long history as provider of hybrid maize seed across Africa, expansion into other crops.	Hybrid maize, sunflower, soybean, sorghum, wheat
3.	SEEDCO Kenya	Zimbabwe	5-10	Significance presence in major maize markets across Southern Africa	Hybrid maize, vegetables, soybean, sorghum
4.	Monsanto	U.S.	3-5	Strong fit between agro-climatic needs and Monsanto's portfolio of hybrid maize	Hybrid maize

5.	Pioneer	U.S.	3-5	Strong fit between agro-climatic needs and Pioneer's portfolio of hybrid maize	Hybrid maize
6.	East African Seed	Kenya	1-3	40+ year history in Kenya of working with KALRO to develop hybrid maize varieties	Hybrid maize, common bean, sorghum, cowpea, vegetables
7.	Western Seed	Kenya	1-3	Only private company in East Africa with an end-to-end maize research, breeding, and distribution program	Hybrid maize, common bean, sunflower
8.	Dryland Seeds				
9.	Kenya Highland Seed				
10.	Royal Seed				
11.	Freshco				
12.	Amiran Kenya				
13.	Simlaw Seeds				
14.	Greenlife				
15.	Griffaton				
16.	Premier Seed				

Source: Context expert analysis, company websites.

We do not have good data on the current volume of certified seed produced in Kenya, but an adequate proxy is the hectares of seed certified by KEPHIS. From June 2006 to June 2010, the volume for the major crops grew from 10,250 to 13,410, an increase of 31%. However, the average production during this five-year period was 11,756 (and this average was negatively impacted by the 2009 drought). So the 2006–2010 growth is not indicative of overall strong performance given the fact that the formal sector is still a relatively small fraction of the potential market size.

Table 25: Seed Crop Hectares Inspected and Approved for Harvest.

CROP	2006	2007	2008	2009	2010
Maize	9,238	10,852	11,494	7,247	9,843
Beans	354	639	974	459	1,222
Soya bean	1	3	5		
Cow pea	217	227	379	842	796
Green gram	179	144	227	226	696
Pigeon pea	1	37	7	108	
Chick pea					
Potatoes	22	21	38	35	37
Rice					3
Sorghum	238	319	332	506	813
TOTAL	**10,250**	**12,242**	**13,456**	**9,423**	**13,410**

Source: Compiled from KEPHIS annual Reports. Data not reported for many crops.

4.6 Other Non-Governmental and Farmer-based Organizations Active in Seed Production and Supply

Few farmers are able to access seed of improved varieties because of the absence of a formal bulking and distribution system as well as cost, with the price of improved seed varieties being as much as four times

higher than the traditional farmer saved seeds. To address this shortcoming, partnerships are forged between the Government of Kenya (GoK), and a number of other interested parties such as the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Program (UNDP), the Dryland Farming Research and Development Project (DFRDP), the Machakos Integrated Development Program (MIDP), nongovernmental organizations (NGOs), cooperatives and farmer-based organizations to make the seed available to farmers.

4.6.1 Alliance for a Green Revolution in Africa (AGRA)

AGRA works across 18 countries focused on distinct problems related to seed production, soil health, and agriculture markets. AGRA has worked with partners in the public and private sector, and the alliance has reached out to 17 million family farmers and thousands of local African-owned agriculture businesses.

In Kenya specifically, from 2007 to 2015, AGRA made 86 grants totaling approximately $43 million covering research capacity building; research and development; input production and distribution; awareness creation on agriculture transformation; adoption of improved inputs; and production, postharvest handling, and marketing of produce. AGRA has worked directly with over 5,000 agro-dealers to provide training, and with multiple seed companies to provide financial and technical support, creating linkages with breeders, and in licensing varieties from KALRO. The goal of these efforts is to help agro-dealers and seed companies become better organized enterprises and to increase responsiveness to smallholder farmer demands.

4.6.2 Consultative Group on International Agricultural Research (CGIAR)

The key CGIAR centers active in Kenya include the International Potato Center (CIP), which is actively engaged in both Irish potato and sweet potato; the International Maize and Wheat Improvement Center (CIMMYT), which is actively engaged in maize; and the International Center for Tropical Agriculture (CIAT) which is actively involved in common bean.

4.6.3 One-Acre Fund

One-Acre Fund is a nonprofit organization that supplies smallholder farmers in Kenya and East Africa with asset-based financing and agriculture training services to reduce hunger and poverty. The organization is headquartered in Bungoma County in western Kenya, near the Ugandan border.

Using a market-based approach, One Acre Fund facilitates activities and transactions at various links of agricultural value chains, including seed sourcing and market support. In 2014, farmers who worked with One Acre Fund realized a 201% return on their investment and significantly increased farm income on every planted acre. The organization works with more than 135,000 Kenyan farmers who have increased their annual incomes by an average of $211.

4.6.4 Cooperatives, Farmer groups, and Contract Growers

According to the Government of Kenya (GoK), there are approximately 5,900 cooperatives in agriculture, with more than four million total members. These cooperatives can play a variety of key roles throughout the agricultural value chain, including input procurement and distribution, production, processing, packaging, and marketing. Cooperative unions play a major role in securing credit, fertilisers, seeds and farm machinery for members. Many of them are involved in the production of crops. The importance of cooperatives varies by crop, with high involvement and importance in the coffee and tea markets, and lower involvement and importance in the maize and common bean markets. Cooperatives are registered entities and tend to be more structured and professionalized than farmer groups.

Farmer groups are assembled primarily to facilitate the sharing of knowledge, marketing of crops, and self-financing. These groups are generally viewed as less structured entities than are cooperatives. Farmer groups

have a more difficult time finding affordable credit than cooperatives and often rely upon the savings of members to fund themselves. Contract farming is an emerging model in Kenya's agricultural sector. It is viewed as a powerful model that links the small-scale farmer to the global market, resulting in higher, stable and highly predictable returns on farming. Contract seed growers are important actors in the seed system. These growers are contracted to produce seed by contractors such as KALRO, universities, and private seed companies, although the hiring entity (e.g. KALRO) maintains ownership of the seed throughout the process.

A shortlist of some main cooperatives, farmer groups and contractors involved in Seed Production and distribution in Kenya are presented in Table 26.

Table 26: Selected Cooperatives, farmer groups and Contractors involved in seed distribution.

	Cooperative	Farmer Group	Contractors
1.	Kenya Grain Growers Cooperative Union	Agricultural Society of Kenya, Nairobi	Kenya Seed Company
2.	Kenya Planters Cooperative Union	Kenya Coffee Growers Association (1991), Nairobi	Kenya Agriculture and Livestock Research Organization.
3.	Mwea Rice Growers Multipurpose Cooperative Society Limited	Kyanzavi Farmers Co Ltd, Nairobi	East Africa Seed Limited
4.	Mugama farmers co-operative unionLimited	Mbaki Agric-Inputs Distributors Ltd, Nairobi	SUBA Seeds Company
5.	Ndumberi coffee growers co-operative society	United Aloe Association, Kiambu County	Freshco Seeds

4.7 Facilities and Equipment Available for Seed Processing and Packaging in the ASALs

There are currently no tangible facilities that help small-scale farmers in ASAL areas for seed processing. Majority (82%) of the traders place grain/seed bags on pallets while over 88 percent of traders use paper bags for keeping their grains (Kiambi and Mugo, 2016). Traders undertake some limited efforts to improve the commercial value of their grain/seed. These include the following:

1. Buying only well-dried and clean grains/seed – common practices of testing the dryness is by biting the seed.
2. Drying and re-drying: where necessary, and when the traders notice that the grains are not well dried, an extra effort is put in re-drying the grain/seed to avoid damage in store.
3. Cleaning of maize and beans using locally fabricated cleaners is a common practice. Treatments of seed/grains with Actellic Super and Skana Super for long duration storage, especially when they buy seed 3 to 4 months before the planting time.

4.8 Tonnages of Seed Certified and Marketed in the Past Three Years, by Crop

An important factor – perhaps the most important factor – contributing to low crop productivity is the seed that Kenyan farmers are planting. All too frequently, the seed they plant is recycled or of poor quality and inherently low yielding. This puts Kenya at a global disadvantage, as farmers in many other parts of the world have access to improved seeds bred for qualities such as high yield, and disease and pest resistance. Further, Kenyan farmers frequently plant varieties that are not well suited to their particular agro-ecological conditions, such as altitude or water availability. Agro-ecologically speaking, the seed is out of position.

As shown in Table 19, in 2014, the volume of locally produced and imported maize seed certified by Kenya Plant Health Inspectorate Service (KEPHIS) was 31,121 metric tons, or 88 percent of the total. In contrast, the volume of beans, sorghum, and cowpea—Kenya's next three major food security crops as defined by FAO—certified by KEPHIS was only 878 metric tons, or 2.5 percent of the total. On one hand, the relative prioritization of maize in seed production both reflects and also reinforces Kenyans' view that "without maize, there is no food!" On the other hand, the low usage of certified seed for non-maize crops contributes to their low yields, low production volumes, lack of crop diversification, and food insecurity.

Table 27: Maize and non-maize seed certified by KEPHIS, in metric tons, 2012-2014.

Crops	2012		2013		2014	
	Local	Imports	Local	Imports	Local	Imports
Cassava	0	0	0	0	0	0
Chickpea	0	0	2	0	0	0
Climbing Beans	0	0	0	75	5	56
Bush Beans	816	495	486	592	415	39
Cowpea	173	0	504	0	183	0
Dolichos Beans	4	0	6	0	5	0
Finger Millet	148	0	0	0	1	0
Foxtail Millet	0	0	0	0	0	0
Green Grams	226	0	188	0	251	0
Groundnuts	0	0	0	0	0	0
Irish Potato	740	22	757	66	560	100
Maize	36,578	4,176	31,188	4,061	28,364	2,757
Millet	107	0	0	0	0	0
Pearl Millet	0	0	98	0	67	0
Pigeon Peas	4	0	2	0	7	0
Rice	129	0	256	0	300	0
Sorghum	2,222	120	524	9	239	2
Soya Beans	0	0	0	0	0	0
Sweet Potato	0	0	0	0	0	0
Wheat	3,378	0	4,780	0	1,902	0
TOTAL	**44,525**	**4,813**	**38,791**	**4,803**	**32,299**	**2,954**

Source: KEPHIS Annual Reports

Perhaps most importantly, the data shows that overall total levels of certified crop seed, both imported and locally produced, dropped 11.6 percent from 2012 to 2013 and then a further 19.1 percent from 2013 to 2014. Experts estimate that the percentage of Kenya's land that was cultivated using improved, certified seed in 2013 was 78 percent for maize, 3 percent for beans, 16 percent for sorghum, and 13 percent for cowpea. In total, just 53 percent of the area under production was planted with certified seed for these top four food security crops.

Despite the fact that an estimated 78 percent of the maize cropland is planted with certified seed, yields are still dropping and maize deficits growing. Many factors, both seed-related and non-seed related, contributes to this. The seed-related factors include: overall seed quality; prevalence of counterfeit certified seed; seed planted out of position; the age of the varieties planted by farmers; access to appropriate varieties by smallholder farmers; and the emergence of new, perhaps climate change induced, diseases such as Maize Lethal Necrosis Disease, which impact negatively on maize yields. The non-seed-related factors include access to and appropriate use of the correct fertilizer, as well as management practices and rainfall.

The major question arising from this data is whether this low usage of non-maize certified seed is driven by lack of supply or lack of demand. Field experience indicates that it is the former, as few seed companies currently report significant volumes of carryover stocks of non-maize seed.

4.9 Number of Agro-dealers Currently in Operation, by Region

Agro-dealer Surveys: Cultivating New Frontiers in Agriculture (CNFA) through Kenya Agro-dealer Strengthening Program (KASP) project, made possible by a grant from the Alliance for Green Revolution in Africa (AGRA), carried out agro-dealer surveys in all 85 districts of KASP operation and developed a comprehensive database of 5,156 agro-dealers, representing 52% of the estimated 10,000 agro-dealers in Kenya at the time (CNFA, 2018). The team also developed GIS-based maps showing agro-dealer density and distribution. Agricultural Market Development Trust (AGMARK) boasts the most comprehensive database of agro-dealers in Kenya and is now used by leading stakeholders in the agricultural inputs industry.

Table 28: Distribution of Sampled Agro-dealers by County.

Region	County	Number Interviewed	Percentage of Total
Central	Murang'a	65	14.8
Coast	Taita-Taveta	50	11.4
North Rift	Trans Nzoia	46	10.5
Western	Bungoma	61	13.9
Nyanza	Kisii	38	8.7
Central Rift	Nakuru	70	16.0
South Rift	Kericho	58	13.2
Upper Eastern	Meru	50	11.4
TOTAL		**438**	**100**

Source: Kenya Markets Trust

CNFA worked to improve the input supply and output marketing distribution channels available to smallholder farmers in rural Kenya by expanding a commercially viable network of rural retail enterprises. KASP built on the foundation of existing agro-dealers in Kenya and expanded the network to cover 85 districts located in targeted agricultural areas across the country. Expansion of this network benefited smallholder farmers by greatly reducing the distance traveled to obtain needed equipment and farm inputs.

4.10 Summary of Prospects for Improving Seed Supply

The availability of seed of desired varieties at the right time and place, and client knowledge of where this seed is available, are critical for an effectively functioning and sustainable seed system. In contrast, hindrances to availability of seed in a timely manner of desired, good-performing varieties, cause economic and productivity losses and discourage reliance on that particular seed channel. To improve seed supply to smallholder farmers in Kenya and particularly in arid and semi-arid rural areas, the following are important considerations.

4.10.1 Regulatory and Cultural Norms

The regulatory context encompasses socio-cultural as well as legal norms, both of which influence the availability of seed to farmers. Socio-cultural norms regarding seed handling and acquisition can be important determinants of seed availability for smallholder farmers. Seed proximity and timeliness of seed availability,

coupled with issues of trust, are vital to farmers' seed acquisition decisions. Hence, consideration of cultural norms regarding seed and variety issues is critical for the design and development of effective seed dissemination initiatives. Encouraging and supporting indigenous knowledge, skills and practices to produce and store one's own seed can go a long way in improving seed supply for two reasons: (a) security in case their favorite hybrid seed is not available or the family is unable to mobilize sufficient cash to buy seed; and (b) to ensure availability of seed of local varieties that cannot be accessed otherwise.

The official registration, release procedure, and controls as to which varieties can or cannot be made available in commercial seed systems, can and do affect the rate at which seed is availed to farmers. Currently, local cultivars of maize and sorghum are basically not released in Kenya, which blocks availability of these varieties through commercial channels and exposes long-standing farmer practices relating to seed exchange to criminal charges. Furthermore, the commercial availability of new varieties is slowed down through the official release procedure. However, in a situation where commercial seed systems cannot provide farmers with the quality and diversity of seed that is actually required, these restrictions appear counter-productive to sustainable seed system development. Therefore, exploring alternative legal seed regulation and pathways to speed availability of new varieties and to ensure commercial availability of local varieties, should be a top priority if we want to improve seed supply to farmers.

Also, seed certification services could be decentralized, or that seed commercialization based on standards such as QDS (Quality Declared Seed) could reduce costs and delays caused by the certification process. Such a system appears to march farmers' experience and expectations for traditional staple cereals, with responsibility for seed quality borne by those who produce and provide seed. Furthermore, it could also encourage local initiatives in the breeding and seed sector; for example, the development of India's private seed industry could not have been possible without the provision of a QDS type system (Gadwal, V.R., 2003). In summary, regulatory systems that provide space for a diversity of approaches for varietal development, release and seed production are expected to have a better chance of meeting the enormously diverse needs of smallholder farmers in Kenya, with a wide range of agro-ecological conditions and production systems, compared with systems that focus on a narrow range of actors and variety types.

4.10.2 Collaboration Between Seed System Actors to Improve Availability of new Varieties

Availability of seed of new varieties to farmers is highly or entirely dependent on collaboration between public and private sector actors. Constraints on variety development due to limited funding levels, and dependence on short-term project grants, are seen by breeders as hindering availability of new varieties. At the same time, private sector investment in variety development is currently limited to just a few crops and target ecologies, for which sufficient returns on investment can be expected. Therefore, examination of models for effective public-private collaboration and innovative funding models, even for small and specific markets, should be carried out for seed system development in Kenya with a view to enhancing seed supply to farmers.

A wide array of options exists, from public sector breeders 'nurturing' emerging seed companies, to farmers and value-chain actors raising their own funds for demand-driven public research; such options are described in more detail by Weltzien and Christinck (2017). Particularly in view of rapidly changing agro-ecological production conditions, climate change, and socio-economic transformations, such innovative models of collaboration could enhance the dynamics and innovation capacity of seed systems, making more and better varieties available to farmers and increasing the level of varietal diversity. Furthermore, the potential of improved collaboration between actors for reducing transaction costs could be a matter of shared interest.

4.10.3 Using Diverse Models for Seed Dissemination

Improving the seed dissemination of improved varieties to the millions of mostly smallholder farmers in a country like Kenya, with diverse and changing variety needs, is the defining challenge for sustainable seed system development. Hence, to be effective, seed delivery channels need to respond to this challenge.

Different models of seed dissemination that are common in Kenya and Mali were identified by Christinck *et al.* (2017) and compared based on the seed system functions to which they contribute, or where each is adding value to the system. The first model is 'farmer seed-producer cooperative' that is engaged across most functions, from collaboration with breeders, through production, to marketing and selling seed. The second types of enterprises are companies that are most strongly engaged in conditioning and packaging seed they purchase, and are thus identified here as 'seed processing and trading companies.' Seed companies found in Kenya, whether privately owned or parastatals, operate along these seed processing and dissemination paths, even though they may differ as to whether they invest in their own breeding or depend entirely on licensing publicly bred varieties.

There are two main reasons why farmer-managed seed cooperatives in Kenya have comparative advantages for improving availability of improved seed in rural areas. One factor is simply their location in rural areas, where they are usually engaged in agricultural development for their village, community, or a larger area, and proximity to clients with minimal cost. Another factor is their active collaboration with national research stations and breeders. Farmer-managed seed cooperatives and breeders often plan seed production together, including early generation seed, based on interest and demands arising from variety evaluation trials and joint collection of feedback from other farmers.

Private seed companies, in contrast, conditioning and packaging their seed in a central facility, have significant costs and challenges to make their seed available to distant and geographically dispersed farmers, which usually occurs through multi-level distribution networks. Furthermore, their access to farmer feedback depends considerably on the company's capacity to interact with their clients, which implies additional costs. Hence, such distribution networks are most effective for large-scale distribution of a few, well-known varieties to areas where they are widely used, and is less effective for situations where demand is limited and highly diverse.

4.10.4 Cost of Seeds

The relatively high price of seed in Kenya could explain why farmers tend to consider the seed price when choosing a hybrid to purchase (Mathenge *et al*., 2014). Definitely the high cost of seed would limit access to this important farm input. Kenyan farmers producing maize seed sign contracts with seed companies that fix the price for the seed that they produce. This price was reported to be approximately one-third of the retail seed price. Thus, approximately two-thirds of the seed purchase price paid by farmers cover the costs to the seed company for certification, conditioning, packaging, marketing and distribution, as well as any contributions to the breeding of the varieties. Hence, the distribution of revenues among seed system actors is an issue that deserves attention to enhance or promote seed access, particularly in view of the potential of more decentralized seed production and dissemination models, for income generation in rural areas.

4.10.5 Cross-cutting Issues

Developing gender perspectives in agricultural research can be seen as part of a general approach to improving the scientific understanding of agricultural systems, and to better understand the needs for, as well as potential benefits of, new technologies for specific groups of users. For example, gender differences in preferences for specific varietal traits can be expected when women and men farm under different conditions, if they have different roles and responsibilities in the production process, grow the crop for different purposes, or if crops are grown only or predominantly by either women or men (Christinck *et al.*, 2017).

Hence, a more gender-inclusive approach to seed system development should not just look at women as a 'disadvantaged' customer group, but rather consider needs and potential contributions of women and men systematically with regard to all seed system functions. Also, many issues on how information exchange among various seed system actors could be improved to help actors make more informed decisions, have severally been raised during interviews and workshop exchanges. One major communication challenge is how to enable millions of smallholder farmers to gain access to varietal information of pertinence to them.

Information sharing is also important in terms of improving seed supply. Besides classical approaches, such as field days or demonstration plots, some interesting new approaches to provide information on varietal performance to farmers on a large scale need to be identified, e.g. based on online search portals or mobile applications. Such approaches could build on the 'traditional' method of farmer-to-farmer exchange networks, while new communication technologies using applications for use with mobile devices, farmer-to-farmer video messaging, etc. could be used to accelerate and scale up knowledge sharing.

Also, collaborative learning of actors with diverse and complementary expertise can be a powerful tool for creating collaborative advantages and facilitating innovation, and can be very relevant for seed system development. One example is the collaboration between seed-producer cooperatives and plant breeders, which can evolve from joint learning experiences in participatory variety evaluation. This activity can provide farmers with rapid access to varietal information pertinent to their conditions and production objectives, while they in turn give direct feedback to the researchers on varietal performance and demand for new varieties. Individual breeding programs can collaborate with numerous cooperatives, associations or unions of cooperatives.

CHAPTER FIVE: NATIONAL SEED POLICY FRAMEWORK

The National Seed Policy Framework is the government's outline of policy interventions to be pursued in order to address current constraints in the seed sub sector and to improve its performance and contribution towards improved agricultural productivity.

5.1 Documents, which Control the Production and Supply of Seed

The Seed industry is governed by a number of Acts among them, the Plant Protection Act (Cap 324), the Noxious Weeds Act (Cap 325), the Seeds and Plant Varieties Act (cap 326), the Pest Control Products Act (Cap 346), and the Specific Commodity Acts. Different institutions enforce these Acts; hence, coordination has been a challenge.

5.2 Process for the Official Release of Improved Crop Varieties

The Seed and Plant Varieties Act, Cap 326 of the Laws of Kenya, guides the regulatory process of seed release, certification, and production. Variety release procedures usually consist of performance testing through multiplication trials and administrative registration procedures. Two types of trials are run to conduct national performance trials (NPTs):

- Client-managed trials where a client with technical knowledge runs the trials and KEPHIS plays a defined supervisory role on behalf of the National Performance Trials Committee (NPTC)

- KEPHIS-managed trials, where KEPHIS fully manages trials on behalf of the NPTC.

  To be officially released and registered in Kenya, a new variety listed under the Second Schedule of The Seeds and Plant Varieties Act (CAP 326) must:

- Undergo NPTs for at least two seasons and be found to be superior in terms of yield or other special attributes. Where a plant variety has already been officially released in any country within the regional economic blocks to which Kenya is a member and has harmonized performance trial regulations (emphasis added), the variety shall undergo performance trials for at least one season in similar agro-ecological zones, provided that an applicant shall provide the data leading to release of the plant variety in that other country.

- Be proven to be distinct, uniform, and stable (DUS) in the essential characteristics.

- Have a valid descriptor for seed certification.

- Have been approved and released by the National Variety Release Committee (NVRC) (Kuhlmann and Zhou (2015).

Once a variety has been officially released, it is gazetted and entered into the National Variety List. Commercialization can either be done by the applicant or by another party who is permitted to multiply varieties under license.

The DUS and value-for-cultivation use (VCU) tests are usually carried out for at least two seasons according to International Union for the Protection of New Varieties of Plants (UPOV) protocols. The two tests may be done concurrently. In addition to VCU and DUS data, on-farm data must also be submitted by the breeder, which includes initial field performance evaluations and data. After completion of the DUS and VCU tests by KEPHIS, the data are submitted to the NPTC for assessment. KEPHIS chairs the NPTC meetings, which include various stakeholders from the seed sector, including the Seed Traders Association of Kenya (STAK). At the end of the meeting, the NPTC recommends whether or not the variety should be approved for full release, pre-release, or rejected. The recommendations are forwarded to the NVRC for endorsement and final recommendation and approval by the MoA, which then announces the released varieties before they are entered into the national variety catalogue.

Under regional harmonization, the whole process could be shortened by accepting third-country data if the same varieties have been registered in other countries in the same regional blocs. However, the precise frameworks and processes surrounding regional variety release will vary. For example, within the EAC, Kenya, Tanzania, and Uganda agreed to allow for more open trade of varieties approved in another country through an agreement developed by the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The association provides that only one season of additional NPT testing in the destination market will be required if DUS and VCU data are submitted from the first registration and similar agro-ecological conditions exist.

Similarly, under the Common Market for Eastern and Southern Africa (COMESA), a variety registered in one member state could also be subjected to a streamlined NPT process. According to the COMESA Seed Trade Harmonization Regulations of 2014, a variety registered in one COMESA member country can be entered into the COMESA variety catalogue after one season of NPT/VCU testing in the second member state's market and submission of relevant DUS and VCU data from the first member state. A variety registered in two COMESA member states can be entered into the catalogue with an application containing the appropriate DUS and VCU data.

5.3 Procedures for Seed Certification

KEPHIS Activities and Services: The Kenya Plant Health Inspectorate Service (KEPHIS) activities and services involve offering inspectorate services on all matters related to plant health and quality control of agricultural inputs and produce. The activities include:

- Certification of the quality of seeds and fertilizers.

- Testing and monitoring the presence of harmful residual agro-chemicals on agricultural produce, soils and water systems.

- Co-ordination of the release of superior and well-adapted varieties/cultivars to the farming community.

- Protecting the rights of the breeders/discoverers of new plant varieties through grant of rights to the owners of such varieties and registering them.

- Preventing introduction into the country of harmful foreign weeds, pests and diseases through adherence to strict quarantine regulations and procedures.

- Inspecting and grading agricultural produce for import and export to ensure that they are of high and acceptable quality.

- Implementing the national policy on the introduction and use of genetically modified plant species, insects and microorganisms in Kenya.

The above activities of KEPHIS are undertaken at four regional offices based at its Headquarters in Nairobi, and Regional Offices at Mombasa, Nakuru and Kitale. Seed certification as stipulated in the Seeds and Plant Varieties Act (Chapter 326) of the Laws of Kenya ensures that only high quality seed of crop varieties are available for use by the farmers.

Seed Certification Process: The process of certification involves the following activities:

i. Field inspection

This is the first step in seed certification. Before field inspection commences the seed merchants must:

- Register their fields for inspection.
- Provide proof of origin of the parental materials of the varieties registered for inspection. If a new variety, this must also include the descriptors of the parental materials.
- Minimum isolation distance must be observed. Timely inspection in the fields is conducted to ensure that seed resulting from a crop meant for seed purpose is of the designated variety (trueness to type) and has not been contaminated genetically or physically (varietal purity) beyond certain specific limits. The crop must be healthy and free from diseases (especially seed borne).

ii. Seed Processing

Seed crops of approved fields are harvested and processed to remove undesirable contaminants such as weed seeds, inert material, immature seeds, broken and diseased seeds. The seeds are also graded into different sizes and treated with protective chemical.

iii. Seed Testing

Laboratory seed testing is useful in determining quality factors such as purity, germination capacity, moisture content, and health status (seed-borne diseases) of seed lots.

iv. Labeling and Sealing

Upon satisfactory fulfillment of the prescribed requirement, every seed lot is provided with a label and a seal. Containers are labeled and sealed in such a way the seed cannot be removed or changed without damaging beyond repair, either the container, the label or the sealing device.

v. Post Control

These are tests designed to ascertain whether or not the preceding control measures have been effective. The tests ensure that the characteristics of cultivars/varieties have remained unchanged in the process of multiplication. Under special circumstances, pre-control tests are necessary to determine satisfactory fulfillment of doubted factors.

vi. Post Certification Survey

To ensure that all is well with the certified seed till planting time, a post certification survey is conducted at the time of planting throughout the country, by the four regional offices of KEPHIS. Samples are taken from seed stockists, farmers planting and at market places. These samples are planted alongside the post control plots and comparisons made. When complaints of low quality seed arise, such claims are easily verified. All appointed and licensed stockists/sellers must therefore ensure that they only offer for sale certified seed or seed meeting the minimum standards outlined in Cap 326. (All seeds sellers must be registered by KEPHIS).

vii. Seed Importation / Exportation

All intending to trade/import/export seed must register with KEPHIS as seed merchants. A seed Import Permit and Plant Import Permit must be obtained before any importation of seed is undertaken. All imported seed must be accompanied by a phytosanitary certificate and an international Seed Testing Association (ISTA). Seeds of all crops are subjected to laboratory quality tests upon arrival and must meet the gazetted minimum standards before being offered for sale. Similarly, all seed for export must meet the gazetted minimum standards and be accompanied by Kenya's phytosanitry certificate and an export permit.

Farmers should:

- Consult the Agricultural Extension Service for advice on the suitability of various crop varieties for their specific regions.
- Buy seeds from recognized dealers/agents/stockists who must display their license and the name of the company they are representing.
- Avoid buying seed weighed from opened packets. All seed packets must have the original seal by the seed company and must be properly labeled.
- Upon payment, farmers should insist on being issued with an official receipt, which should be retained. The empty seed packets and any other labels accompanying the seed should not be destroyed, as they will help in tracing the source of such seed in case of problems.

All seed agents and stockists are expected to be registered with KEPHIS to promote traceability of seed movement and enforce quality standards (inspections, etc.). KEPHIS registers them as outlets and distributors of seed for a fee of $1,600 per agent and $600 per stockist.

5.4 Current Status of the Regulatory Agencies in Charge of Seed Certification

Kenya Plant Health Inspectorate Service (KEPHIS) is the regulatory body in charge of seed certification. It was established under the State Corporations Act (CAP 446) pursuant to Legal Notice No. 305 of 18th October 1996. Currently, KEPHIS operates under the KEPHIS Act No.54 of 2012 that was assented to on 31st December 2012 by H.E. The President of the Republic of Kenya. Under the first schedule of the KEPHIS Act, KEPHIS is mandated to implement the Agriculture Produce (Export) Act (CAP 319), Plant Protection Act (CAP 324) and the Seeds and Plant Varieties Act (CAP 326). The role of the Corporation is to undertake regulatory function in the agricultural sector relating to plant protection and seeds and plant varieties that assure the quality of agricultural inputs and produce, thereby promoting sustainable agriculture and economic growth.

Table 29: Active personnel - Staff Establishment for Seed Certification in Kenya, 2019.

Item	Optimal Level	Current Level	Deficit
Inspectors	75	38	37
Examiners	21	12	9
Seed Analysis and Lab Technicians	14	9	5
Statisticians	2	2	0

Total	**108**	**61**	**51**

5.4.1 Human Resource

Human resource is an important asset to the achievement of KEPHIS mandate and objectives. KEPHIS has maintained a continuous investment for a highly skilled workforce to ensure effective response to opportunities and challenges of the industry in timely and appropriate manner in an ever-changing market environment. KEPHIS puts effort to attract and recruit employees with requisite skills to maintain optimal number of staff. Further, the corporation in its new strategy indicates that it will review its current organization structure, train and develop staff; implement a competitive compensation and reward system; implement a effective performance management system in order to retain and maintain a highly skilled workforce. Currently in Kenya, there are 22-gazetted Private Inspectors, 5 Private Analysts, 2 Active Private Inspectors, 2 Active Private Analysts; 1 gazetted Private Seed Testing Laboratory and 1 gazetted Private Inspection Entity (Information gathered from KEPHIS, 2019).

5.4.2 Infrastructure

KEPHIS as a science-based organization relies heavily on technology in its functions for delivery on the institutional mandate. Advances in laboratory testing and diagnostics, and information, communication and technology (ICT) continue to have decisive influences on operations of KEPHIS. Major strides have been made to improve the ICT infrastructure and systems namely; automation of human resource system, import and export electronic systems, initiation of the automation of the seed certification and plant variety system. KEPHIS will, during the implementation of its current strategic plan 2017/2018 – 2021/2022, seek to leverage on the latest and most competitive ICT in order to enhance its service delivery processes.

5.5 Current Status of Basic (Foundation) Seed Supply

A critical component to the realization of quality certified seed is high quality foundation seed or parent seed. However, many of the independent seed companies that service Kenya's smallholder markets have difficulties with production and maintenance of quality foundation seed, resulting in a low and inconsistent supply, which in turn impacts the availability of certified seed for sale to farmers.

It is believed that, 80 percent of the Small and Medium Sized seed companies, who can reach more than 60 percent of smallholder farmers in Kenya, struggle to produce a consistent supply of quality foundation seed due to technical, infrastructural and financial challenges. Inconsistency in production of foundation seed is depriving farmers and seed companies of the opportunity to benefit from improved varieties and in turn raise productivity, thus limiting the impact of the genetic gains, such as tolerance to stress and pests as well as improved quality and yield attained by various breeding programs.

Various global food crop improvement programs in Kenya have made investments worth millions of US Dollars, to breed and release suitable and locally adapted crop varieties, particularly maize hybrids that offer high productivity opportunities to smallholder farmers. However, it is not easy for the independent seed companies to operate a functional foundation seed production system without the government providing a conducive environment for such an elaborate, time consuming and costly process. It is estimated that such a venture could cost a company – regardless of size – up to millions of US Dollars per year from hand-off from the breeders to the time the seed is available for commercial seed production.

To assist seed companies address the challenge of accessing essential parent seed, a specialized foundation seed supply firm, called QualiBasic Seed Company (QBS) was established in Kenya by the African Agricultural Technology Foundation (AATF), with grant funding from the Bill & Melinda Gates Foundation, to offer a commercially sustainable foundation seed supply solution to seed companies. QBS supports seed companies in Kenya and East Africa to ensure the quality of certified seed by operating a centralized system that manages foundation seed production, quality control and storage, in a highly effective and efficient way. QBS

benefits from economies of scale and applies rigorous processes to its foundation seed production, based on similar models in other parts of the world such as the USA and India.

This specialized and highly focused foundation seed model has helped Kenya and the neighbouring countries not only address critical quality aspects but also to ensure high productivity. In addition, this model of doing business saves seed companies cost, and builds a good reputation among end users.

When certified seed is produced from quality foundation seed, it means that the end-product that gets to farmers will deliver the intended genetic gain – meaning the farmer will reap the full value intended by the breeder such as improved yield and quality, which will in turn contribute significantly to the increased maize production envisioned in the 'Big Four Agenda'.

5.6 Procedures for Production and Supply of Basic (Foundation) Seed

Foundation seeds are the direct result obtained by growing breeder seeds. Foundation seeds are certified seeds often produced under the supervision and control of the breeder or releasing institution.

Producing good quality seeds starts with a complete understanding of the protocol guiding production. The quality of seeds to be produced thus begins from the choice of seeds, the agro ecological condition, the treatment and the cultivation practices the seed stock is subjected to. Often farmers see and could be attracted to the seeds in packages but the actual quality determinations starts from the field. A poorly grown seed will do no good to a farmer who will depend on it for providing food for his family and from which s/he also hopes to earn an income.

The seed production process or protocol should start with proper identification of the seeds bearing a clear scientific name, the origin of the seed distribution and the description of how it was produced.

The protocol for the production of planting materials including seeds from clean planting material source should include the following:

- Field facilities and equipment
- Source of material, including positive selection
- Field requirement
- Field inspection
- Agronomic practices such as isolation, rotation and negative selection
- Harvesting and handling
- Post-harvest treatments
- Storage and transport
- Quality standards for the supplied product

5.7 Access by Private Seed Companies to Basic (Foundation) Seed

High cost of release coupled with lengthy processes, hamper availability of foundation seed to companies. Inadequacy of foundation seed for non-maize crops such as beans, cowpea, and sorghum, still impedes on seed merchants' efforts to produce these seeds according to latest findings by The African Seed Access Index (TASAI Report, 2019). This in turn contributes to an apparent insufficiency of the seeds for farmers. Small seed companies, the seed index says, are the most affected by this shortage, which is largely attributed to lengthy and costly seed certification and release processes.

Most seed companies, according to the report, take up to 36 months to realize a variety, and sometimes this duration persists to 60 months. Lack of adequate demand forecasts, insufficient land, as well as limited irrigation use in seed production has also been cited as other factors contributing to the seed insufficiency. According to the seed access report, the cost of variety release in Kenya is notably higher than in several African countries.

Several companies also view the process as being too time consuming and bureaucratic, necessitating a complete overhaul. For local seed producing companies, the primary sources of foundation seed for the three crops, as well as maize are Kenya Agricultural and Livestock Research Organization (KALRO), universities in the country, other private companies, and CGIAR centers, such as the International Maize and Wheat Improvement Center (CIMMYT) for maize and the International Centre for Research in the Semi-Arid Tropics (ICRISAT) for sorghum.

The basic seed shortfall however demanded sourcing of foundation seed for beans from outside Kenya in countries like Mexico, Brazil, and the USA. The country's seed sector, according to the report, is also not entirely satisfied with its number of breeders, which currently stands at 60, according to statistics by the Plant Breeders Association of Kenya. Only 34 of these are active breeders of the country's priority crops. Just 53 percent of seed companies feel satisfied compared to 88 percent in South Africa. The companies are most satisfied with maize breeders, with those of the other crops despite being 'fair', are still unsatisfactory.

Private breeders such as Quality Basic Seed, focused on production of basic seed for maize, started operations in 2017 and supplies foundation seed to seed merchants in Kenya, which is a positive step in enhancing access to early generation seed of new maize varieties for companies without parent seed production programs. There are challenges in the seed sector but also there are significant strides being made such as in import and export processes of certified seed, seed security labeling, authorization of private seed inspectors and analysts, seed demonstrations and field days and the role of the Seed Trade Association of Kenya (STAK) in linking the private sector industry to the government and other actors. Inadequate farmer awareness on seed security labels however needs to be comprehensively addressed to foment the fight against counterfeit seed.

5.8 Policies for Supply of Basic Seed by Private Sector

Currently, Kenya regulates the seed sector through a number of legal instruments, including the Seed and Plant Varieties Act (Seed Act; Cap 326, Commencement 1975; last amended 2012; gazetted January 4, 2013); the Crops Act 2013 (gazetted January 25, 2013); the Plant Protection Act (Cap 324); the Agriculture, Fisheries, and Food Authority Act 2013 (gazetted January 25, 2013), the Pest Control Products Act (Cap 346), and related regulations such as the Seeds and Plant Varieties Regulations (Seeds Regulations), the Seeds and Plant Varieties Regulations (National Performance Trials Regulations), and the Plant Breeder's Rights Regulations, all of which are currently subject to amendment. In general, the laws provide a broader framework for governance of the seed sector, while regulations contain more specific guidelines for regulatory processes and day- to-day operations. Even with a comprehensive legal and regulatory system, laws and regulations on paper will not address every possibility that could arise in practice, and issues surrounding clear and consistent implementation of laws and regulations are common. As the regional seed protocols enter into

force, the potential for developing Kenya's seed system will increase, as will the possibility of challenges with implementation of the legal and regulatory system.

In general, a country's seed laws govern the processes of variety release, registration, testing, marketing, packaging, and certification (quality control), among other things (Kuhlmann, 2013). A clear and properly designed legal framework on seeds is one of the most important requirements for the development of the agricultural sector, as it facilitates the development of the seed sub-sector and create a suitable environment for seed stockholders (FAO, 2011).

Under Kenya's seed laws and regulations, different institutions have been established to implement seed laws and regulations. The Ministry of Agriculture, Livestock and Fisheries is mandated to formulate, implement, and monitor agricultural acts, regulations, and policies that support agricultural research, promote technology, ensure quality of seeds and other inputs, and control pests. MOA also has the final approval on all varieties released to the market. As noted above, KEPHIS is the primary regulatory authority for seeds and has a regulatory mandate to protect seeds and plant varieties, provide seed certification and laboratory services, and administer sanitary and phytosanitary (SPS) matters. KEPHIS is also the national authority mandated to regulate seed trade. Seed distribution, including import, is open to registered seed merchants. Seed import requires a phytosanitary certificate and an import notification letter from the country of origin, a plant import permit, a notice to import and a seed-testing certificate, as required by the Seeds and Plant Varieties Act (GoK, 2012a).

The Seeds and Plant Varieties Act (Cap 326) is central to the seed industry; however, with the dynamic changes following the liberalization of the seed sector, there are a number of areas that are not fully addressed. These include the authorization of seed certification and testing services; regional harmonization of seed laws, policies, and regulations; and a thorough review of the legal framework. Laws and regulations will be a significant factor in determining how different elements of the seed system can be taken to scale. For instance, regional harmonization of seed rules and regulations can both serve to streamline market regulation and, in some cases, add another layer of complexity on top of national level laws and regulations.

CHAPTER SIX: SUMMARY AND CONCLUSIONS

6.1 Current Status of Access to Improved Seed among Smallholder Farmers

While tremendous progress has been made in variety development and release, access to varieties in the public domain still remain a big challenge in Kenya. Smallholder farmers in arid and semi-arid parts of Kenya can increase yields through widespread use of improved hybrid maize varieties. Farmer access to improved germplasm, however, is limited. This is attributed to poor seed distribution and marketing in the rural areas. To increase farmers' access to improved seed, researchers and development practitioners first need to understand how the seed market channels are structured, how they operate, the bottlenecks to them operating more effectively and the reasons why farmers decide to access seed via formal or informal channels. These issues are not clearly understood in the semi-arid areas of Kenya. Furthermore, it becomes clear that the formal domain constitutes a very small part of the totality of seed systems in Kenya as most farmers obtain their seed from informal sources such as the saving, exchange or local trade of seed.

Novel mechanisms are needed to get information on new publicly released and public sector-managed (i.e., local varieties in gene banks) varieties to farmers and at scale. In addition, improved access to foundation seed is crucial for an effective seed value chain development. In almost all the counties in Kenya, there is very limited coordinated action to ensure that seed sector development activities aligns with the stated Comprehensive Africa Agricultural Development Program (CAADP) and the African Seed and Biotechnology Program (ASBP) commitments. Whereas there is increased policy interest and commitment at national level to develop a more pluralistic and integrated seed sector, the policy support and investment still favours the formal seed systems. Improved implementation of seed sector development priorities in the Africa Union's CAADP-

ASBP agenda and aligning these with National Agricultural and Food Security Investment Plans (NAFSIPs) can contribute to more strategic and coordinated interventions at national level, thus enhancing improved access to quality seed for farmers.

Integrated Seed Sector Development (ISSD) Africa program supports the development of a market-oriented, pluralistic and vibrant seed sector development in Africa that can provide smallholder farmers with access to quality seed of superior varieties. The program is guided by four themes: promoting seed entrepreneurship, increasing access to varieties in the public domain, matching global commitments with national realities, and supporting the Africa Union Commission (AUC) Comprehensive Africa Agriculture Development Program (CAADP), the African Seed and Biotechnology Program and the seed sector development. Activities have been carried out in 10 African countries: Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Mali, Tanzania, Uganda, Zambia and Zimbabwe. The ISSD Africa Secretariat is hosted at Tegemeo Institute of Agricultural Policy and Development, Egerton University, Kenya.

6.2 Current Status of Government Support for Improving Seed Systems

The National Seed Policy (GoK, 2010a) outlines interventions that aim to address constraints in the seed sector with a view to contribute to agricultural productivity. Seed certification is presented as the main tool effecting quality control. To enhance certification the policy proposes registration of all actors in the seed value chain (including relief seed suppliers) and prescription of stiffer penalties for those flouting certification procedures. There is also a call for the continued support of public breeding institutions to maintain varieties and produce seed for those varieties not attractive to the private sector. Targeting informal seed systems is a proposed policy on 'provision of advisory services with a view to transform it to the formal sector' (GoK, 2010a). While the nature of advisory services is not expounded, the policy calls for strengthening of farmer extension and advisory services with a view to make farmers appreciate the benefits of using good quality seed. It is expected that through these services this transformation to formal sector will occur. Under the International Convention for the Protection of New Varieties of Plants (UPOV) 1991, farmers are only allowed to save and re-use seed of a protected variety "on their own holding" and "within reasonable limits and subject to safeguarding the legitimate interests of the breeder" which may imply that farmers have to pay a royalty to remunerate the breeder. The exchange and sale of farm-saved seed, as is common practice amongst farmers in informal seed systems, is now prohibited for protected varieties (De Jonge, 2014).

The primary novelty of the 2013 Crops Act regarding seeds is the classification of crops as either scheduled or non-scheduled. 112 crops varying from food, cash, and vegetable crops to fruit trees are listed as scheduled crops with the Minister for agriculture having power to increase the number of these crops. The difference between scheduled and non-scheduled crops lies in the requirement for government authorities to assist the development and market promotion of each scheduled crop. As laid out in section 8 of this statute, these measures include establishing experimental stations and seed farms for suitable varieties, facilitating marketing and distribution of the produce of these crops, and devising strategies for value addition for export crops. Virtually, all food crops grown in Kenya are listed as scheduled crops. While the rationale for this classification is not clear, it is likely to induce the market structures that will be prevalent for these crops and influence farmer options and choices, as it obliges the government to not only set seed quality standards but also to determine the cost of farm inputs, and provision of markets for produce. This statute also requires active participation by government in the crop value chain for virtually all crops, and shows the intention of the government to formalize the entire seed sector.

The 2013 Kenya Agricultural and Livestock Research Act sought to overhaul the structure of the agricultural research system in Kenya, by merging various agricultural research institutions in the food crop, cash crop and livestock sectors. From the outset, section 5 of this statute emphasizes that the principal function of the restructured organization is regulation, promotion, streamlining and coordinating agricultural research. Unlike in the past scenario where some of the agricultural research institutes such as KARI carried out plant breeding as well as seed multiplication and distribution, the intended focus of these public institutions under the new structure appears limited to undertaking research only. Any actions of the organization in dissemination of

research outcomes appear limited to training and building capacity of users, and activities for demonstration purposes. This may have implications for smallholder farmers, as it removes KARI from participating in downstream seed activities (as KARI used to do), which is important in terms of ensuring that there is downstream support for improved varieties for crops that may not be attractive to the private sector.

6.3 Trends and Opportunities for Seed Systems improvements

Seed systems are the vehicle through which farmers get good quality seed of the new crop varieties they want and need. Effective seed systems have the potential to increase production quickly and economically. Give farmers access to good seed and knowledge of improved practices and their harvests can rise dramatically. The development of impact-oriented seed systems is a strategic issue. Informal seed systems models are not delivering with the efficiency and effectiveness needed. For example, farmers often rely on seed distribution from their fellow farmers, which is just too slow for new varieties to have a major impact. In parallel, formal seed systems tend to focus on a few profitable seed crops such as maize and vegetable seed, leaving legumes, including beans, largely by the wayside.

There's need to identify leverage points by which varieties can be moved at high volumes, across geographic zones, and with wide social reach. Reducing the time it takes for newly released varieties to reach farmer fields, say from about five years in the past to almost immediate at present has gone a long way in improving seed systems. Impact-oriented seed systems can be catalyzed by fostering partnerships, evaluating diverse models of seed production and delivery, developing information crucial for making informed choices, and working to shape policy towards the benefit of smallholder farmers.

- **Partnerships for scaling up:** Supporting the development of seed platforms uniting actors all along the value chain to create sustainable seed systems can spur links with formal seed producers. Within these platforms, one can work to foster Private-Public partnerships and identify possibilities for integrating formal and informal seed systems. Platform members simultaneously work 'at scale' and aim to scale up multiple decentralised seed initiatives and stimulate members of the formal sector to increase their participation in seed systems.

- **Research for 'best bets' in seed production and delivery:** One size does not fit all, especially in the seed sector. Diverse seed production and delivery options are tested to meet the diverse contexts in which smallholder commodity farming unfolds. Research and Development on capacities of various seed production options and their implication of seed quality, such as farm-based seed production or centralised producers; sale in non-conventional outlets such as open markets; and packaging in farmer-friendly sizes are among the options tested to get desired seed products to all users.

- **Development of resource materials:** Seed system developers and practitioners need decision-making tools and practical guidance at the varied stages of design and delivery. Resource materials that aim to address the multiplicity of information needs should be developed:

    - Articles for program managers to determine system goals, such as how to promote and supply varieties responding to nutrition and resilience needs;

    - 'How-to' manuals for seed producers and business entrepreneurs (link to publications) spearheading the advances on the ground, can be developed;

    - Posters and radio programs geared to helping farmers make informed variety and seed choices.

- **Shaping seed policy for wider impact and lower farmer risk:** Policies have to be enabling and geared toward meeting the needs of smallholder farmers. Those influencing seed system development in both

normal and stress periods should be supported. The government should provide a conducive environment and play an active role in shaping national, regional and international seed policy by:

- Supporting processes for regional seed harmonisation policies within the East African Community, COMESA and SADC regions to facilitate access to improved varieties through eased germplasm exchange, increased regional seed trade, private sector investment and economies of scale. The production of basic seed, which used to be the onus of National Agricultural Research System (NARS), is now undertaken by both NARS and private entrepreneurs, contributing to increased genetic diversity and efficiency in seed systems.

- Facilitating guidelines for seed security responses.

- Providing evidence-based experience to shape decision frameworks. For instance, the increased acceptance of the quality declared seed grade in seed regulation and the increased prioritisation of varieties as a result of engaging policy makers.

Ultimately, seed system development goes well beyond activities revolving around producing and marketing seed. It should also aim at catalyzing efficient seed systems, which can move multiple varieties, provide production and nutrition gains, and which can be accessed by all smallholder farmers.

During periods of disaster–whether drought, flood, earthquakes, political instability, civil strife or displacement—seed system responses need to take place quickly. There's therefore, need to collaborate with national and international organizations with the aim of improving seed security in high stress and vulnerable areas across the country.

6.4 Recommendations

- Specific requirements for seed production such as weight, volume, color, moisture content, germination levels and seed health standards should be met. Seed production involves technical operations such as assembling, processing, labeling, sealing, bagging, packing, and storing. If properly undertaken, these practices will help ensure farmers' access to seed that is true to type, free from pests, diseases, and other foreign matter, and that will germinate well if planted. In general, availability of seed that meets these requirements would be beneficial to farmers, seed producers and vendors, and society at large. However, producing quality seed has cost implications that need to be justified in terms of benefits.

- The quantity of seed handled through local trade is low and represents a major constraint to private sector participation. Developing varieties that match farmers' requirements would contribute to increased demand for seed and improve prospects for private sector entry. Dryland crop breeders should offer farmers a choice between open-pollinated, self-pollinated, and hybrid varieties. The latter, if assessed as superior by farmers, would increase demand for purchased seed. In addition, training and demonstrations should be organized to build and strengthen farmers' capacity to manage seed on-farm. Techniques transferred to farmers should be based on a sound understanding of local seed management strategies and practices.

- Seed production costs and supply prices are high and a major constraint to the development of local seed trade. Further research to reduce production costs and institutional arrangements that can reduce production and distribution costs should be explored.

- Accessing finance has been a major challenge to farmers, especially those in arid and semi-arid areas, and this has always compromised the yields. Planting is a timely activity that has to be done within a specific time frame and that some farmers have been doing it late due to financial challenges.

Contracted farmers should be assisted to access credit to ease their struggles with accessing finance. Such a move will boost quality of seed in the country as growers will have cash in time to buy all the required inputs. The financing enables contracted growers to meet the seed production costs and grow them within the scheduled planting season.

- Encouraging adoption of crop insurance as a mitigation measure to climate change, is likely to encourage use of improved and certified seed in the ASALs. Insurance takes away an additional portion of downward risks, not only with respect to weather but also pests and diseases. This in turn may reduce the expected cost of modern inputs (in marginal utility terms). Secondly, improved seed varieties may be more responsive to complementary inputs than traditional ones. If the cross term of certified seed and other inputs (e.g. fertilizer) is positive, then by incentivizing the purchase of certified seeds through crop insurance, we will also be increasing the value of the marginal product of other inputs.

- There's need for stronger actor orientation to enhance seed system functioning at all levels. Focus on enhancing relationships among actors, e.g., by regular dialogue and functional feedback loops, is crucial to enable individual actors to contribute to collective goals and understand other actors' needs. Advantages of this approach are that it is feasible with simple explicit efforts to focus on all actor types and their interrelations, and it can serve as a springboard to concrete actions with potential for sustainably enhancing seed system functioning.

- Sustainable seed system development requires that farmers' needs and capacities receive central focus since (a) farmers engage and have insights in all seed system functions; and (b) value must accrue to farmers and those who use the crop produce before other actor groups can obtain benefit. Such a 'farmer focus' requires that farmers be recognized as key actors rather than just as 'beneficiaries', and that their voices are actually heard on a continuing basis.

- Major potential for seed system development lies in improved collection and sharing of varietal information and performance data. Strengthening actors' capacities to collect, share and assess information about varieties and their comparative performances will contribute to dynamic, responsive seed systems in which well-informed decisions can be made. Practical examples include enabling public access to what national varietal performance data exists, farmer experiential learning through variety tests, and gathering varietal performance data from demonstration plots to build 'data banks' on varietal performance and profitability for diverse farmer and production conditions.

- Enhancing how information is shared, including training and use of multimedia and new ICT tools such as applications for mobile phones; video; or radio, and efforts to provide user-differentiated information, particularly for smallholder farmers, including women and men, all represent major opportunities.

- Decentralized seed production and marketing based on farmer-groups and cooperatives can provide nuclei for an emerging locally-based seed industry, where market opportunities are limited for highly specialized, large-scale seed companies, or where farmers' needs for varieties are diverse. Such farmer enterprises integrate elements of traditional farmer-managed seed systems, such as short distribution pathways and trust among actors, while also speeding up innovation by collaborating with breeding programs in variety testing and development. A study of why these farmer enterprises currently don't play a major role in Kenya could be informative.

- Plant breeding, as the source of value creation, needs to be regarded as an integral component of functioning seed systems and requires appropriate funding for sustainable seed system development. There's need for joint consideration of what demands for innovations actually exist, in order for seed systems to advance. For example, increased attention to desired grain traits for on-farm use and

processing could substantially help raise varietal adoption by small-scale farmers and women for whom household food security is an important priority. Enhanced linkage of breeders with different seed system actors will improve information flow and result in variety portfolios that better respond to actors' priorities for production and use.

- Lastly, though not the least, seed systems in Kenya could benefit from more rigorous assessments of how interventions, new technologies, policies and formal organizations influence seed system innovation and sustainable development. Benefit and cost analyses for specific actor groups to guide decisions, rather than reliance on conceptual or assumed benefits, would provide clearer 'realistic field-views.' By shifting funds and resources from regulation and relief towards creative efforts such as capacity building, breeding and innovative dissemination strategies involving diverse types of actors, costs could be reduced and value increased where it is most needed — in rural areas, in the hands of small-scale farmers and their market partners.

Practical opportunities for addressing these entry points for sustainable seed system development through targeted action and capacity building, can be broken down by crop, and the actors directly concerned would be involved in defining these actions in detail, thus enabling ownership, completeness, and depth.

6.5 Likely Impact from the Improvement of Access to Improved Seed by Smallholder Farmers

Globally the provision and adoption of improved seed and planting material for many crops has raised crop productivity and improved the lives of millions of farmers in developing markets; Kenya, however, has so far not sufficiently benefited from this productivity increase. Crop yields in Kenya are among the lowest in the world, due to limited access to quality inputs especially improved seed varieties suitable for the different climatic conditions and soils. The Kenyan seed market has great potential for growth given that quality certified seed of high performing varieties is currently available for less than 10% of the total arable acreage.

A distinction should be made between direct and indirect impacts on the smallholder farmers, due to the improvement of access to improved seed. Improved varieties can bring about crop productivity gains resulting in rise in farmers' incomes and consequently poverty reduction (direct impacts). Improved varieties can also benefit both adopting and non-adopting households through increased employment opportunities; wages increases and lower food prices associated with the rise in agricultural production caused by improved varieties (indirect impacts). These impacts will have competing effects, as individuals are unlikely to be exclusively producers, consumers or wage earners. Direct and indirect impacts can be brought about only if these modern varieties are adopted. The introduction of improved varieties onto the market is often accompanied by interventions to increase adoption. Extension, subsidies and other promotional approaches are very common forms of encouraging developing countries to increase adoption rates. The reality is that adoption rates of modern varieties remain remarkably low to date.

In terms of direct effects, improved varieties have characteristics that can lead to greater agricultural production, on average, than traditional seeds. These seeds have higher yield potential, are more responsive to fertilizer and irrigation, have shorter maturation periods, have longer storage capabilities, are more tolerant of environmental stresses and/or have a higher nutrient content. For example, in West Africa, the improved seed New Rice for Africa (NERICA) was found to mature more quickly and produce greater quantities of rice than traditional rice seeds in usual and drought conditions (Kijima *et al*, 2006). The International Maize and Wheat Improvement Center, a CGIAR Centre, created and disseminated a drought-tolerant maize variety in East and Southern Africa, which has been shown to yield 20 per cent more on average under drought conditions than previous maize seeds (World Bank 2008). However, numerous external factors, such as political instability or extreme climate shocks, may eliminate productivity improvements. In addition, households may lack a sufficient level of education and experience to adequately cultivate these improved varieties. Becerril and Abdulai (2010) and Asfaw et al. (2012) have found that more educated farmers may benefit more from improved varieties.

For households producing and selling on the local market, higher agricultural yields at a constant cost level may be associated with greater income and greater profits. Similarly, for self-subsistence households, assuming that the farmers purchase the quantity of food needed that is not met by own production, with higher yields farmers will benefit from a reduction in expenditure on food, leading to a reallocation of expenditure away from food to assets. In addition, with greater production, farmers can enter the local market selling excess production. Thus, improved varieties can reduce poverty through higher yields for adopting households, and the income gain may be sufficiently large to exit poverty. However, access to the market may be hindered by a rise in transaction costs associated with greater production, such as greater storage and transportation costs, preventing the sale of the agricultural production. Furthermore, prices and costs in the food market may change with the dissemination of improved varieties and may lead to indirect impacts on other markets.

Additional income allows a household to invest in durable assets. Investing in productive assets such as land, machinery or livestock will further improve the productivity of the farmer and provide a higher and more stable income in the future. The accumulation of income-generating productive assets may enable farmers to pass the "Micawber" threshold (below which households lack sufficient assets to generate income levels above the poverty line in the absence of a positive shock) and end chronic poverty (Barrett and Carter 2006). Investing in non-productive durable assets such as home improvements, furniture or technology may serve as insurance against future income shocks. These direct impacts of improved varieties benefit adopting households.

However, access to improved varieties may be limited to certain households only. In fact, wealthier households may be more likely to adopt, for several reasons. First, these households have stronger connections with input suppliers and research institutions that provide information about such technology. Secondly, wealthier households have financial resources at their disposal or can access credit to purchase improved varieties, whereas other households often lack the secure ownership or tenancy rights that they would need to obtain credit. Households with a very limited asset base are also more likely to be risk averse than richer households, which may discourage adoption. Richer households with large asset bases are more capable of recovering from failed investments. Improved varieties may thus be associated with greater inequality.

As far as the indirect effects are concerned, processing greater production associated with the productivity gains resulting from improved varieties requires more workers in the labour market, leading to a shift in the labour demand curve. These greater farm employment opportunities have varying effects on wages depending on the local environment. In areas with a highly inelastic labour supply, the wage gains may be substantial, but they may create an incentive for employers to switch to machines (Hazell and Haddad 2001). Demand for labour in non-farming sectors may be indirectly affected by increased farm economic activities. Improvements in the employment rate and wages in both farm and non-farm sectors may have positive long-lasting effects on poverty through greater investment in households' assets and greater household income and consumption, as described above. However, for producers, hiring additional labour at higher wages increases the cost burden, eliminating the income gains resulting from the direct impacts of improved varieties described above. The income associated with the additional production needs to be greater than the additional labour costs to reduce poverty among producers.

A vast literature describes the reduction of food prices following a rise in productivity levels (Irz *et al.* 2001; Varangis *et al*., 2017). Because the poor allocate a larger share of their budget to food, they benefit proportionally more than the non-poor, and this generates significant indirect impacts on poverty and welfare. Using an international multimarket model (the IMPACT model) developed by the International Food Policy Research Institute, Evenson and Rosegrant (2003) estimated that, without any CGIAR research, developing countries' food and feed prices would have been 18 to 21 per cent higher across 37 countries and 18 agricultural commodities. The benefits are not restricted to rural households, as the urban poor also spend most of their budget on food. In the long term, lower prices in agriculture create a surplus that can then be extracted and invested in industrial growth, contributing to rapid poverty reduction and development. However,

the effects of price reduction may be detrimental for both adopting and non-adopting net-selling households. Hazell and Haddad (2001) describe how net-selling farmers who did not receive the new agricultural technology were harmed by the reduction in food prices if they did not experience a reduction in the unit cost of production. The authors describe how these decreasing market prices may push out many non-adopting small farmers. This phenomenon is also relevant for adopting households. With a sharp reduction in food prices, no income gain from greater production may occur (if the quantity effect is smaller than the price effect). The benefits of lower food prices may be eliminated by an increase in other prices due to real exchange rate appreciation associated with agricultural export growth (de Janvry and Sadoulet 2002).

Agricultural research can thus result in welfare improvements and poverty reduction. It is important to note that the relative importance of direct and indirect impacts varies across regions. De Janvry and Sadoulet (2002) estimated that direct impacts were more significant in Africa than in Asia or Latin America, where reliance on the agricultural sector is much less. Furthermore, the magnitude of the indirect impacts of improved varieties is highly dependent on the magnitude of the direct impacts. By focusing on direct impacts, we can assess whether poorer households adopt improved varieties and the extent to which they benefit from productivity increases that translate into income growth and poverty reduction.

In conclusion, Kenya has a unique opportunity to drive significant economic growth, increase social well being, and pursue more environmentally sustainable land use practices through modernization of its seed industry. The paths taken in other countries can serve as fertile ground for ideas and lessons about implementation. While there are many strengths upon which to build, the industry at present embraces many practices, which are not consistent with a mature, well-functioning industry. The net result of many of these practices is the low rate of product innovation, a sluggish supply response to seed demand, and high costs for seed production, processing and distribution entities.

With global demand for food rising, and agriculture currently playing a strong role in the Kenyan economy, improving the seed industry offers great hope for increased economic activity domestically, regionally, and beyond the region. However, one hallmark of proposals for seed industry change in Kenya is that there have been many, and for a long time. If Kenya wishes to take advantage of this opportunity, it will be important to move with vision and a sense of urgency from discussion to action.

REFERENCES

Asfaw S., Berresaw, M.K., Simtowe, F., and L. Lipper (2012). Poverty Reduction Effects of Agricultural Technology Adoption: A Micro-evidence from Rural Tanzania. Journal of Development Studies 48(9):1-18.

Ayieko M.W., and D.L. Tschirley (2006). Enhancing Access and Utilization of Quality Seed for improved Food Security in Kenya. Tegemeo Institute of Agricultural Policy and Development, Working Paper No 27/2006.

Becerril, J., and A. Abdulai (2010). The Impact of Improved Maize Varieties on Poverty in Mexico: A Propensity Score-Matching Approach**.** World Development, vol. 38, issue 7, 1024-1035.

Carter, M.R., and C.B. Barrett (2006). The economics of poverty traps and persistent poverty: An asset-based approach. The Journal of Development Studies, Vol. 42, 2006, Issue 2.

Center for Global Development (CGD) 2018. Commitment to Development Index 2018. Washington, DC; United States of America

Christinck, A., Weltzien, E., Rattunde, F. and J. Ashby (2017). Gender Differentiation of Farmer Preferences for Varietal Traits in Crop Improvement: Evidence and Issues. CGIAR Publication.

CNFA (2018). Annual Report. Published on Jun 7, 2019.09.28.

Cultivating New Frontiers in Agriculture (CNFA). 2018 Annual Report.

De Jonge, B., (2014). Plant Variety Protection in Sub-Saharan Africa. *Journal of Politics and Law* pp. 100 - 111 ISSN: 1913-9047.

De Janvry A., and E. Sadoulet (2002). World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects. Journal of Development Studies, 2002, vol. 38, issue 4, 1-26.

Etemesi, D.O., Adam, R., Otieno, D.J., and W.O. Kosura, (2018). Characterising Smallholder Farmers' Marketing in Kenya: An Insight into the Intra-Household Gender, Wealth Status, Educational and Credit Access Dimensions. Journal of marketing and Consumer Research. Vol. 28, 2018.

Evenson, R. E., & Rosegrant, M. (2003). The economic consequences of crop genetic improvement programmes. In R. E. Evenson & D. Gollin (Eds.), *Crop variety improvement and its effect on productivity* (pp. 473-497). Wallingford, Oxon: CABI Publishing.

FAO (2019). FAO Global Fishery and Aquaculture Production Statistics v2019.1.0, published through FishStatJ (March 2019; www.fao.org/fishery/statistics/software/fishstatj/en).

Gadwal, V.R., (2003). The Indian seed industry: Its history, current status and future. Current Science 84(3).

GoK (2007). Kenya Vision 2030: A Globally Competitive and Prosperous Kenya. Ministry of Planning and National Development and National Economic and Social Council. Government Printer

GoK (2010a). National Seed Policy.

GoK (2010b). Agricultural Sector Development Strategy (ASDS), 2010-2020.

GoK (2012a). Seeds and Plants Varieties Act.

GoK (2012b). National Agricultural Sector Extension Policy (NASEP).

GoK (2017). National Policy for the Sustainable Development of Arid and Semi-Arid Lands 'Unlocking Our Full Potential for the Realization of the Kenya Vision 2030', August 2017.

GoK (2018a). Eye on the Big Four. Parliamentary Service Commission; Budget Watch for 2018/19 and the Medium Term Plan. August 2018 |Edition No. 11

GoK (2018b). Kenya Vision 2030, Third Medium Term Plan 2018-2022

GoK (2019a). Sector Plan for drought risk management and ending drought emergencies. Vision 2030 - Third Medium Term Plan 2018-2022.

GoK (2019b). Agricultural Sector Transformation *and* Growth Strategy (2019-2029). Towards sustainable agricultural transformation *and* food security in Kenya**.**

Hazell, P., and L. Haddad (2001). Agricultural Research and Poverty Reduction. Food, Agriculture, and the Environment Discussion Paper 34; International Food Policy Research Institute Technical Advisory Group; Consultative Group on International Agricultural Research.

Horticultural Crops Development Authority (HCDA), Ministry of Agriculture, USAID (U.S. Agency for International Development) (2012). Horticulture: Validated Report. Nairobi, Kenya: Republic of Kenya.

Hortiwise (2012). A Study on the Kenyan-Dutch Horticultural Supply Chain. The Hague, Neth- erlands: The Dutch Ministry of Economic Affairs, Agriculture and Innovation.

Irz, X., Lin, L., Thirtle, C., & Wiggins, S. (2001). Agricultural Productivity Growth and Poverty Alleviation. Development Policy Review, vol. 19, no. 4, pp. 449-466.

ISAAA (International Service for the Acquisition of Agri-biotech Applications) (2001). Maize. Available online at http://www.isaaa.org.

Kenya Livestock Insurance Program (KLIP) (2018). Report on "Executive Seminar on Index Based Livestock Insurance", Safari Park Hotel, Nairobi, Kenya; 24 July 2018.

Kenya Ministry of Agriculture [MoA] (2009, 2011 & 2012). Economic Review of Agriculture (ERA).

Kenya National Bureau of Statistics (KNBS), 2019.

Kenya Plant Health Inspectorate Service (2012). Annual Report and Financial Statements for 2011/2012.

Kenya Plant Health Inspectorate Service. (2011). Annual Report and Financial Statements for 2010/2011.

Kenya Sugar Board (KSB) (2010). The Kenya Sugar Industry Value Chain Analysis: Analysis of the Production and Marketing Costs for Sugarcane and Sugar Related Products. Nairobi, Kenya: KSB.

Kenya Sugar Industry (KSI). (2009). Kenya Sugar Industry Strategic Plan 2010–2014. Nairobi, Kenya: KSI.

Khainga, D. (2018). Harnessing the Potential of irrigated Agriculture for Food Security. KIPPRA Publication, Kenya.

Kiambi D., and L. Mugo (2016). Seed Systems and Value Chains in Kenya:
Case Study on Sorghum and Cowpeas. ISSD Africa.

Kijima Y, Sserunkuuma D & Otsuka K, 2006. How revolutionary is the NERICA revolution? Evidence from Uganda. Developing Economies 44(2): 232–51.

Kuhlmann, K., and Y. Zhou (2015). Seed Policy Harmonization in the EAC and COMESA: The Case of Kenya. Working Paper. Syngenta Foundation for Sustainable Agriculture. The African Seed Access Index (TASAI) Report, 2019.

Kuhlmann, Katrin, 2013."Planning for Scale Brief #6: Enabling Environment." Written in partnership with the Ag PartnerXChange.

MacMillan, S. (2019). Kenyan livestock sector to grow 'exponentially' – Adapted from Kenya National Bureau of Statistics. https://clippings.ilri.org/2019/07/31/kenyan-livestock-sector-to-grow-exponentially

Mathenge, M., Smale, M. and J. Olwande, (2014). The impacts of hybrid maize seed on the welfare of farming households in Kenya. J. Food Policy 44.

Muma, M. (2019). Bee Bulking and Farmer Capacity Building in Bee Keeping: An Opportunity for Increasing Youth Employment and Food Security in Rural Areas. KIPPRA Publication, Productive Sector Department.

Munyi, P., and B. De Jonge (2015). Seed Systems Support in Kenya: Consideration for an Integrated Seed Sector Development Approach. Journal of Sustainable Development Vol. 8(2) · February 2015.

Muthoni, J, and D.O. Nyamongo (2008). Seed Systems in Kenya and Their Relationship to On-Farm Conservation of Food Crops. Journal of New Seeds, pp. 330-342.

Muyanga, M., Jayne, T.S., Yeboah, K., Chamberlin, J., Wineman, A., Anseeuw, W., Chapoto, A., and N. Sitko (2017). Rise of Medium-Scale Farms in Africa: Causes and Consequences of Changing Farm Size Distributions. Global Donor Working Group on Land side on "The Impact of Increasing Capital Flows to Rural Areas: Experiences in Sub-Saharan Africa" during the 44 Committee on World Food Security(CFS). Rome, Italy, October 9, 2017.

Muyanga, M., and T S Jayne (2019). Revisiting the Farm Size-Productivity Relationship Based on a Relatively Wide Range of Farm Sizes: Evidence from Kenya. American Journal of Agricultural Economics, Volume 101, Issue 4, July 2019, Pages 1140–1163, https://doi.org/10.1093/ajae/aaz003.

Mwololo, H.M., Nzuma, J.M., Ritho, C.N., and A. Aseta (2019). Is the type of agricultural extension services a determinant of farm diversity? Evidence from Kenya, Pages 40-46; Published online: 20 Feb 2019, https://doi.org/10.1080/21665095.2019.1580596

Olale, E.K. (2005). Adoption of Soil Fertility Management Technologies in the Semi-Arid Areas of Kenya: The Case of Machakos, Makueni and Kitui Districts. A Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics, University of Nairobi, Kenya.

Olwande, J. (2012). Smallholder Maize Production Efficiency in Kenya. Tegemeo Institute of Agricultural Policy and Development. Paper presented during a Regional Workshop on an Integrated Policy Approach to Commercializing Smallholder Maize Production; June 6-7, 2012 – The Norfolk Hotel, Nairobi, Kenya.

Otieno, S., (Chief Operating Officer, Cooperative Alliance of Kenya) (2019). The role of cooperatives in social and economic development of Kenya and actions required to accelerate growth and development of the sector in Africa. Paper presented on 21st May 2019 at Cooperatives Conference held in Istanbul, Turkey.

Rohrbach, D., Minde, I.J. and Howard, J. (2003). Looking beyond national boundaries: Regional harmonization of seed policies, laws and regulations. J. Food Policy 28(4):317-333

Rusike, J., G.J. van den Brand, S. Boahen, K. Dashiell, S. Katengwa, J. Ongoma, D.M. Mongane, G. Kasongo, Z.B. Jamagani, R. Aidoo, and R. Abaidoo (2013). Value chain analyses of grain legumes in N2Africa: Kenya, Rwanda, eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe. (Milestone; No. 1.2.6, 1.3.4). Wageningen: N2Africa.

Tegemeo Agricultural Monitoring and Policy Analysis (TAMPA) (2004). Rural Financial Services in Kenya: What is Working and Why? Nairobi, Kenya: Tegemeo Institute of Agricultural Policy.

USAID (2016). Early Generation Seed Systems Study, Feed the Future: Building Capacity for African Agricultural Transformation (Africa Lead II), Country Report.

Varangis, P., Chen, R., Ono, T., Siewertsen, H.,Toda, A., and R. Sberro-Kessler (2017). Strengthening Financial Systems for Smallholders. In: Africa Agriculture Status Report: The Business of Smallholder Agriculture in Sub-Saharan Africa (Issue 5). Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA).

Wakhungu, J.W. B. Ogolla, and D. Wafula. 2004. Wither farmers' rights? Reflections on Kenya's Seed and Plant Act. Nairobi, Kenya: ACTS Press.

Weltzien, W. and A. Christinck (2017). Chapter 8 - Participatory Breeding: Developing Improved and Relevant Crop Varieties With Farmers. In "Agricultural Systems" (Second Edition) Agroecology and Rural Innovation for Development 2017, Pages 259-301, Elsevier Inc.

World Bank (2019). Country Report - Kenya Economic Update: Transforming Agricultural Productivity to Achieve Food Security for All. World Bank Publication April 8, 2019.

World Bank (2019). Kenya Economic Update. Unbundling the Slack in Private Sector Investment - Transforming Agriculture Sector Productivity and Linkages to Poverty Reduction. April 2019 / Edition No. 19

World Bank. 2008. The World Bank Annual Report 2008: Year in Review. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/7524 License: CC BY 3.0 IGO."