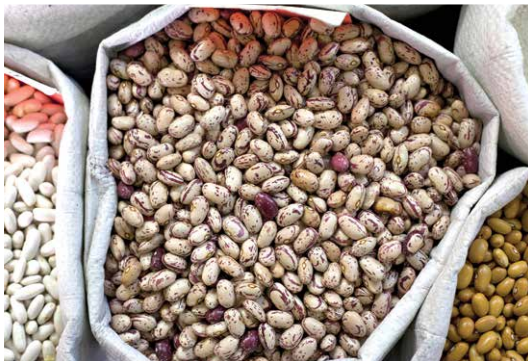
Food and Agriculture Organization of the United Nations

Mainstreaming Efficient Legume Seed Systems in Eastern Africa

Challenges, opportunities and contributions towards improved livelihoods



MAINSTREAMING EFFICIENT LEGUME SEED SYSTEMS IN EASTERN AFRICA

Challenges, opportunities and contributions towards improved livelihoods

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FOREWORD

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Through the Malabo Declaration on "Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods", African leaders strongly voiced their determination that Africa should be able to feed itself by 2025. This ambitious agenda, aligned with the Sustainable Development Goals (SDGs), stresses the need to increase public and private investments in agriculture, necessary to boost production and productivity. There is also a focus on making diets more nutritious and food systems more resilient to external (climate) shocks, as captured in Africa's overarching policy framework for agricultural transformation and food security, the Comprehensive Africa Agriculture Development Programme (CAADP).

The 68th UN General Assembly declared 2016 the International Year of Pulses (IYP) and FAO was nominated to facilitate the implementation of the Year. FAO recognizes the pivotal role of seeds in agricultural development. Increasing the quality of seeds can increase the yield potential of the crop and is one of the most economical and efficient inputs to improve crop production and productivity. In the build-up to celebrations of the IYP, FAO and the International Center for Tropical Agriculture (CIAT) organized a workshop in Nairobi, Kenya (28-30 January 2015) that brought together more than 50 experts working on grain legume value chains to share experiences on proven legume seed systems and identify the most appropriate and scalable legume seed systems.

Legumes such as beans, groundnuts, cowpeas, pigeon peas, chickpeas, soybeans, lentils and faba beans play a crucial role in human food and nutrition security, trade and income generation, and the sustainability of agro-ecosystems. For small-scale farmers they double up as cash crops for income and subsistence crops for family nutrition. However, smallholder farmers still struggle with access to good quality seed of improved varieties. This is because unlike other crops such as maize and rice, legume seed systems are woefully inadequate to meet farmers' needs. Many farmers rely on their own seed while private sector involvement in legume seed markets remains low and poorly developed. Although many new improved varieties have been developed with potential to drastically improve production, farmers are still not aware and are hence not using them. Yet if seed systems are improved, countries in the region would get enhanced access to new and better legume varieties, and thereby improve their food and nutrition security in a gender equitable manner.

This technical paper begins with an introduction to grain legumes and their importance in Eastern Africa, followed by trends in production and productivity, variety development, release and promotion. It proposes and describes 12 basic principles necessary to mainstream legume seed systems (and thereby legume production and utilization) in crop development programmes for sustainable agricultural intensification in Eastern Africa. These principles include a closer look at the legume seed theory of change, taking note of how the various players help move activities of stakeholders through outputs, outcomes and impacts and how they interact through spheres of action, influence and interest; innovative approaches for early-generation seed (EGS) supply; a connection between EGS and commercial class seed; strong policy environment; strong institutional framework; multistakeholder involvement; linkage to utilization and markets; and the role of legumes in empowering women and youth.

This technical paper focuses on the Eastern Africa subregion, particularly on Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Somalia, South Sudan and Uganda. Examples and cross-references are provided from other parts of Africa and beyond for cross-learning and experience sharing. The development of the technical paper was a highly collaborative effort among technical experts at the FAO Subregional Office for Eastern Africa, CIAT, ICRISAT, ICARDA and Jomo Kenyatta University of Agriculture and Technology. The technical review of the paper was undertaken by a Seed Security Expert of the Seeds and Genetic Resources Team (AGPMG) at FAO Rome.

ACKNOWLEDGEMENTS

The contributions of grain legume value chain stakeholders who took part in the Legume Seed Systems Workshop jointly organized by FAO and CIAT in Nairobi, Kenya (28-30 January 2015) are gratefully acknowledged. Experts from Burundi, Ethiopia, Kenya, Uganda, Rwanda and South Sudan presented case studies on innovative practices in legume seed systems, which helped to enrich this technical paper.

The technical paper also drew extensively on the experiences of major legume value chain development initiatives such as the Pan-Africa Bean Research Alliance (PABRA) and the Tropical Legumes Project, which have tested and deployed several innovative and impact- oriented legume seed systems in Eastern Africa. The authors are grateful to PABRA and the Tropical Legumes Project for their generous support.

Our gratitude goes to Solomon Gelalcha, National Consultant – Crop Production Specialist at FAOSFE, for the technical review of various draft versions of the manuscript, which he did painstakingly. Shawn McGuire, Agricultural Officer (Seed Security) of the Seeds and Genetic Resources Team at FAO Rome, undertook a detailed review of the manuscript and made valuable suggestions for improvement of the paper. His diligent technical review and expert advice are sincerely appreciated.

ACRONYMS

ACTESA	Alliance for Commodity Trade in Eastern and Southern Africa
AFAAS	African Forum for Agricultural Advisory Services
AFSTA	African Seed Trade Association
AGRA	Alliance for Green Revolution in Africa
ASA	Agricultural Seed Agency
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AUC	African Union Commission
ASBP	Africa Seed and Biotechnology Program
BMS	Breeding management system
CAADP	Comprehensive Africa Agriculture Development Programme
CBO	Community-based organization
CEDO	Community Enterprises Development Organization
CEO	Chief executive officer
CGs	CGIAR centres
CGIAR	*Consultative Group on International Agricultural Research*
CIAT	International Center for Tropical Agriculture
COMESA	Common Market for Eastern and Southern Africa
COMSHIP	COMESA's Seed Trade Harmonization Implementation
CRP-GL	*CGIAR* Research Program on Grain Legumes
CRP-GLDC	*CGIAR* Research Program on Grain Legumes and Dryland Cereals
CSA	Central Statistical Agency
CSP	Community seed production
DIIVA	Diffusion and Impact of Improved Varieties in Africa
EAC	East African Community
EAS	Extension and Advisory Services
ECOWAS	Economic Community of West African States
EGS	Early-generation seed
EIAR	*Ethiopian Institute of Agricultural Research*
ESE	Ethiopian Seed Enterprise
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agriculture Research in Africa
FIPS-Africa	Farm Input Promotions Africa
FPVS	Farmer participatory variety evaluation and selections
FSE	Farmer seed enterprise
GCP	Generation Challenge Program
GDP	Gross domestic product
GIS	Geographic information system
GS	Genomic selection
GTPII	Growth and Transformation Plan II
HLI	Higher learning institution
IBP	Integrated Breeding Platform
ICARDA	International Center for Agriculture Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and communication technology

IITA	International Institute of Tropical Agriculture
ISSD	Integrated Seed Sector Development in Africa
KALRO	*Kenya Agricultural and Livestock Research Organisation*
KEPHIS	Kenya Plant Health Inspectorate Service
LZARDI	Lake Zone Agricultural Research and Development Institute
MABC	Marker-assisted backcrossing
MARS	Marker-assisted recurrent selection
MAS	Marker-assisted selection
MoAL	Ministry of Agriculture and Livestock
MT	Metric tonnes
NAADS	National Agricultural Advisory Services
NARES	National *agricultural* research extension systems
NARO	*National Agricultural Research* Organisation (Uganda)
NARS	National *Agricultural* Research System
NASFAM	National Smallholder Farmers' Association of Malawi
NGO	Non-profit organization
PABRA	Pan-Africa Bean Research Alliance
PICS	Purdue Improved Crop Storage
PPP	*Public-private partnership*
PVS	Participatory varietal evaluation and selection
QDS	Quality declared seed
QTL	Quantitative trait locus
R&D	Research and development
RUSF	Ready-to-use supplementary foods
RUTF	Ready-to-use therapeutic foods
SADC	Southern African Development Community
SCQSU	Seed Certification and Quality Control Services Unit
SDGs	Sustainable Development Goals
SFSA	Syngenta Foundation for Sustainable Agriculture
SIMLESA	Sustainable Intensification of Maize and Legume Systems for Food Security in Eastern and Southern Africa
SSA	Sub-Saharan Africa
SSA	Seed security assessment
SSD	Single Seed Descent
SWOT	Strengths, weaknesses, opportunities and threats
TLS	Truthfully labelled seed
TLII	Tropical Legumes Project II
TOSCI	Tanzania Official Seed Certification Institute
UN	United Nations
UNICEF	United Nations Children's Fund
UNSSCN	United Nations System Standing Committee on Nutrition
USAID	United States Agency for International Development
USD	United States dollar
VBSE	Village-based seed enterprise
VSLAs	Village savings and lending associations
WECARD	West and Central African Council for Agricultural Research and Development
WFP	World Food Programme
WHO	World Health Organization

EXECUTIVE SUMMARY

Legumes are important components of sustainable farming systems. They are useful to diversify and intensify cropping systems as double, catch, relay and intercrops; fix 'free' nitrogen to soils from the atmosphere and improve soil health that boost cereal crop yields; act as rotation crops for breaking disease and pest cycles; increase and diversify smallholder incomes (and hence buffer them from the effects of price, pest and climate-related production fluctuations); enhance quality of household diets because of their higher protein and micro-nutrient content compared with starch-based staple cereal crops; and provide good sources of animal feed (high protein crop residues and byproducts) and low carbon footprint, mitigating climate change.

Legumes can therefore play a critical role in achieving the Sustainable Development Goals (SDGs). Legume production is challenged by several policy, regulatory, institutional and technical factors including a number of biotic (diseases and pests) and abiotic (heat, frost, drought and salinity) stresses, edaphic factors (associated with soil nutrient deficits), and climate change. The National Agricultural Research System (NARS) and the Consultative Group on International Agricultural Research (CGIAR) have made significant investments to address these challenges by developing improved varieties and complementary integrated crop management practices. A substantial number of improved varieties developed through various initiatives have been released by NARS. The weak legume seed sector has been identified as one of the key constraints limiting the availability of and access to high-quality seed of improved varieties by smallholder farmers, thereby hindering adoption.

The legume seed sector does not get the attention it deserves from the public sector nor the opportunity to attract private sector investment due to myriad of policy, institutional, technical and socio-economic constraints. Institutional and technical innovations to disseminate legume crop technologies have shown promise. These include an integrated seed system approach including formal public-private sector partnerships and a variety of farmer-based seed production and supply initiatives. Areas of action in an integrated seed system could include i) increasing total seed production and availability (e.g. through licensing decentralized production); ii) increasing access to high-quality seed of improved varieties (e.g. through small packs, financial support and better coordination with extension or development programmes); iii) creating demand for quality seed (e.g. through value-chain support, demonstrations, postharvest handling including seed, business training market linkages); iv) reaching farmers 'at last mile' (bundling seed with other products, piggybacking on existing product supply channels such as fertilizers and pesticides and also through strengthening community seed production approaches); and v) lowering costs of seed (e.g. through quality declared seed). The basic principles required to mainstream legume seed systems and thereby legume production and utilization include, but are not limited to, a closer look at the legume seed delivery theory of change; a strong and enabling policy and regulatory environment; a strong institutional framework; innovative approaches for early-generation seed supply and commercial seed producers; multi-stakeholder involvement; and linkage to grain markets and utilization.

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1. INTRODUCTION

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Malnutrition resulting from the intake of imbalanced diets deficient in proteins and micronutrients (vitamin A, iron, zinc and iodine) remains the most devastating problem facing the majority of the poor and needy people in Eastern Africa (FAO, 2015; Ojiewo *et al.*, 2015a). The tragic consequences of malnutrition include mortality and morbidity, poor mental and physical development, poor performance in school and as a result, retarded national socioeconomic development (COHA Report, 2013). A malnourished society lacks the physical and mental capacity to produce sufficient food to feed itself and depends on external sources for livelihoods (Ojiewo *et al.*, 2015a).

This document focuses on the Eastern Africa subregion, particularly on Burundi, Djibouti, Ethiopia, Kenya, Rwanda, Somalia, South Sudan and Uganda. Examples and cross-references are provided from other parts of Africa and beyond for cross-learning and experience sharing. Data from some of the focus countries are not readily available due to various reasons including limited sharing, political instability and limited legume production activities.

Legumes play a prominent role in addressing malnutrition. Some of the common legumes in the subregion include common bean, groundnut, pigeon pea, soybean, chickpea, lentil and faba bean. These legumes are rich in protein, oil and micronutrients such as vitamins, iron and zinc. Their amino acid profiles complement those of cereals and consuming them together raises the nutritional effectiveness of both.

The high iron and zinc content of these legumes is especially beneficial for women and children at risk of anemia, and genetic elevation of mineral content in beans has been shown to improve child health in Rwanda and Democratic Republic of Congo (Bouis *et al.*, 2011). Due to high nutrient content and palatability, pastes made from groundnut (Plumpy'nut) and chickpea ("wawa mum") are distributed by famine relief agencies for life-saving emergency feeding of severely malnourished or starving children. The question is: Why wait to consume legumes until it is an emergency?

Legumes are often companions to staple foods in most meals and most staple dishes taste better if accompanied with legumes. Dhal, a split-grain curry made from chickpea, pigeon pea, lentil and other grain legumes is widely consumed by the poor; beans boiled with maize, a staple dish (e.g. 'githeri') or beans with rice a common combination in many households in Eastern Africa; peanut butter consumed with bread worldwide or peanut soup/sauces popular in Uganda, Kenya and francophone West Africa; high-quality cooking oil from groundnut and soybean used globally; roasted nuts from groundnut, chickpea, faba bean and soybean eaten as snacks worldwide; a range of soy products such as soy milk, yoghurt, tofu/cheese and flour in African countries such as Nigeria; fresh or canned pods with growing export markets in Africa; and cowpea leaves consumed in stews in Eastern and Southern Africa. Other local dishes common in major legume-producing countries of Eastern Africa include 'Shiro', a popular legume-based sauce in Ethiopia and 'Fuul', the most popular legume-based breakfast in Sudan and Ethiopia.

Legumes therefore play a significant role as food and cash crops and contribute to the nutrition, health and income of smallholder farmers. They represent the most affordable source of protein and micronutrients available to the rural and urban poor and are especially important for the hundreds of millions of women and children living in these geographical areas. In addition, legumes are important components of cropping systems and assist in intensifying the staple cereal, roots and tuber cropping systems as catch, relay and intercrop options, by providing nitrogen and other soil health benefits associated with crop rotation to the subsequently grown crops.

Improving food security through increased productivity ensures the health and nutrition of the undernourished and micronutrient-deficient children, youth and women. Reducing hunger, and eventually eradicating it, remains a continuing challenge and ranks high on the national agenda in the developing countries where millions of people suffer from the unavailability or limited access to adequate food. Diversification of agricultural production with legumes can contribute to improved food and nutrition security through direct consumption, improved income from sales, better employment opportunities, improving crop and livestock productivity and increasing commercialization of the rural sector (Ojiewo *et al.*, 2015a). This requires sustained multi-sectoral participatory efforts (Figure 1) of legume scientists (academia, nutritionists, public health experts, socio-economists, soil scientists), institutions (public, private, NGOs), policy-makers and civil society champions to develop the advocacy models and carry out focused nutritional campaigns. The higher learning institutions (HLIs) have the critical role of building the human resource capacity to undertake research for the generation of technologies to address the challenges faced in the production of legumes.

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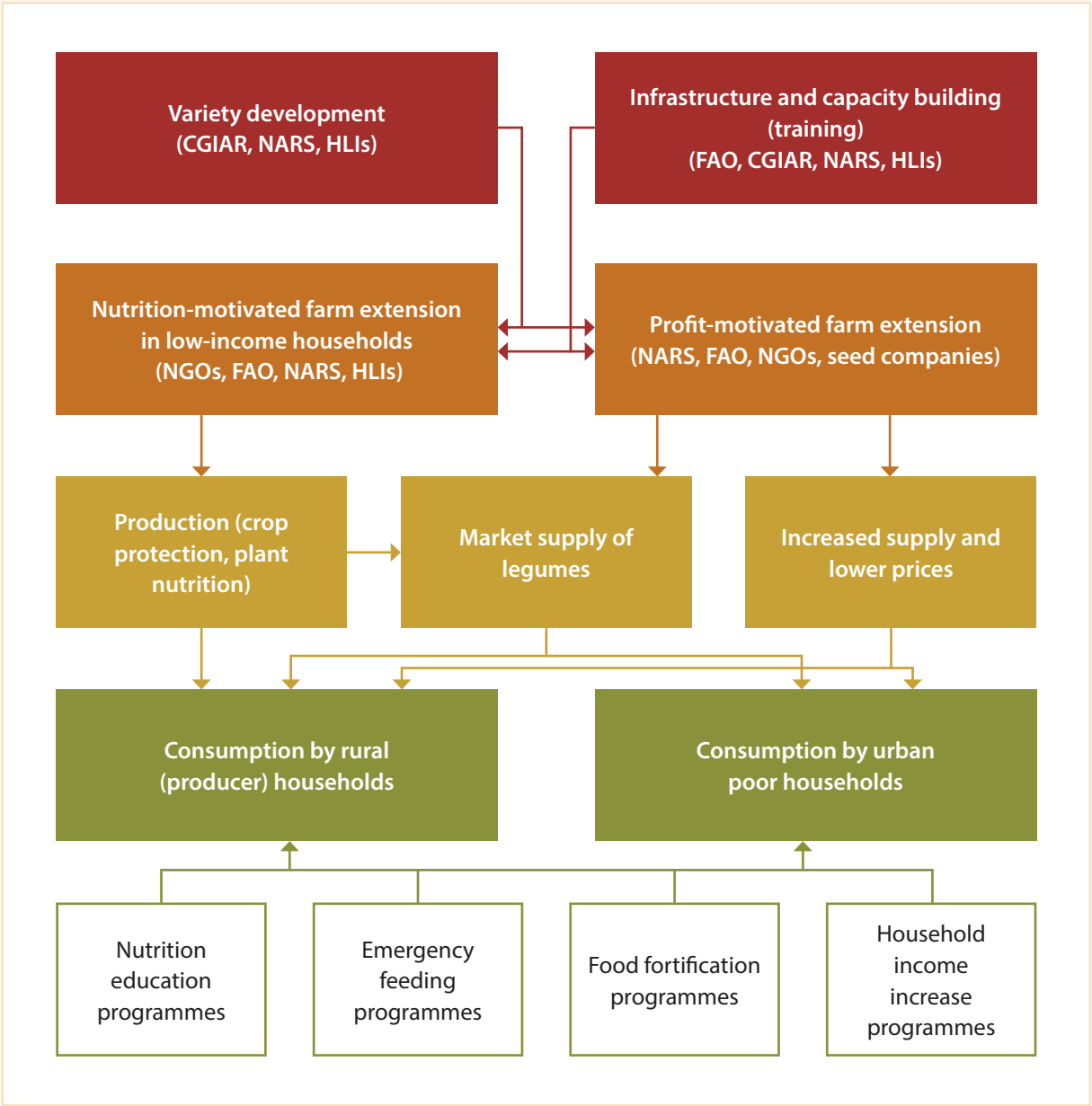
Figure 1. A schematic representation of multisectoral participatory efforts to enhance legume utilization.



Legumes also play an important role in the crop-livestock farming systems in Eastern Africa. Legume straw is an important and nutritious feed resource where pastures and communal grazing lands are shrinking on account of several factors, including land degradation due to an increasing livestock population, conversion to agricultural lands or for settlements due to population pressure and urbanization. Compared with cereals, legume straw is not only nutritious and preferable, but also improves the production and quality of meat, milk and eggs. The ability of legumes to fix nitrogen and improve soil health enhances farm productivity and smallholder incomes. Livestock manure moreover improves the soil structure and fertility, thereby improving crop productivity. The joint overall soil improvement from nitrogen fixation and livestock manure benefits subsequent crops, mostly cereals, thereby enhancing food security.

Agricultural research and development has focused mainly on cereal crops while relatively little attention has been given to legumes despite their nutritional, health, ecological and economic importance. Cereal crops are referred to as staple or food security crops, while most legumes are non-staple crops or considered as cash crops for export. Thus policy-makers and stakeholders recognize two categories of crops: cash crops and non-cash crops. Legumes are often wrongly grouped in the latter category, while they are targeted for cash sales, even fetching better prices in the local markets.

In order to mainstream legumes into production and food systems, the challenge of legume seed supply must be tackled to ensure availability, accessibility, affordability and sustainability. While the presence of market-oriented and/or export-led commercial agriculture remains the major driving force for the development of vertically organized and sustainable legume seed industry in developed countries, by contrast, in many developing countries, including the Eastern Africa subregion, a significant proportion of legume production is still for subsistence purposes and mostly produced by small-scale farmers under rainfed conditions primarily for home consumption with surplus for market (Bishaw *et al.*, 2008). It is worth noting that some bean production is very market- and export-oriented (e.g. haricot bean growers in Ethiopia's Central Rift Valley and common bean growers in NW Tanzania). Empirical evidence and practical experience show that the legume seed sector in general remains weak in Eastern Africa. There are many contributing factors that make accessing quality seed at affordable prices, in required quantities and at the right time and place from the formal seed sector a serious challenge.

Legumes generally have a lower seed multiplication rate than most cereals. Thus legumes require extra space, labour, time, efforts and more generations to move from breeder seed to certified/QDS seed in commercial scale.

Second, some legumes have a relatively large seed size – for every hectare up to 100 kg of seed is needed, which has cost implications for the storage and transportation of seed, thereby making it more expensive for smallholder farmers to access improved seed. Third, some legume seeds are very fragile and easily damaged in storage and during transport. Fourth, seeds of some legumes deteriorate rapidly after harvest, especially if shelled. Seed producers and traders could address these challenges by investing in proper storage, thereby increasing the willingness of farmers to buy seed regularly off-farm with an assurance of better quality than farm-saved seed (Sperling and McGuire, 2010). Most legumes are highly self-pollinated crops and farmers can save their own seed for several seasons and do not need to buy new seed each season, which makes it difficult for seed companies to predict demand for seed. There are also challenges in the mechanization of some legume crops (e.g. faba bean and field pea) with limitations in calibration for mechanical harvesting and difficulty in obtaining appropriate herbicides to control broad-leafed weeds. This hinders large-scale production, as weeding and harvesting need to be done manually. There are also difficulties associated with the control of soil-borne diseases such as root rot and wilt.

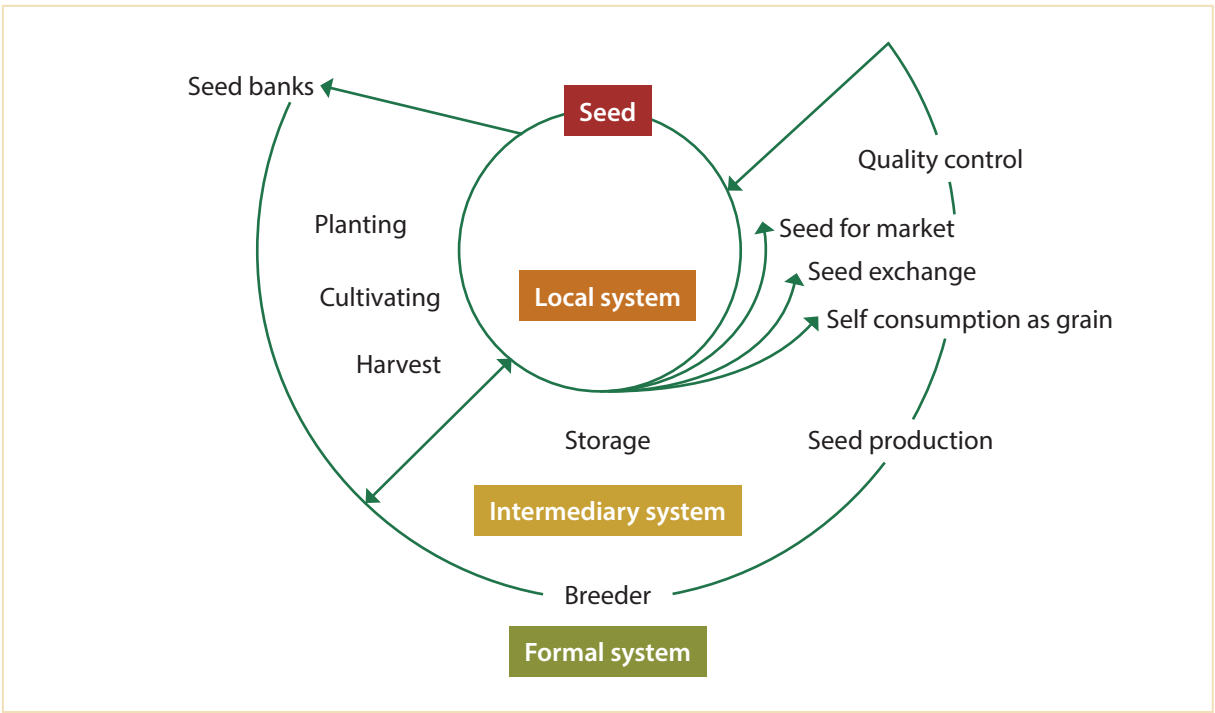
All these factors make producing and marketing legumes less attractive to seed companies and agro-dealers. Even for cross-pollinating legumes like pigeon pea there are no hybrids of legumes being produced commercially in Africa. Although the first known pigeon pea hybrids are currently being promoted in India, their adaptation is still being researched in Eastern Africa.

Farmers in Eastern Africa source seed for planting from both the formal and informal seed systems,

depending on access and the quantity needed. Farmers may buy seed for different reasons, affecting the amount of seed they might purchase and the channel (formal or informal) that they will use. Some of the reasons why farmers purchase seeds include buying a small pack of certified seed of a new variety to try it out and replacing seed stock of an established variety whose seed has lost its quality for replanting (Hanif and Sperling, unpublished). Developing legume seed systems will require a better understanding of the reasons why farmers buy seed to be able to serve these different drivers more effectively. Generally, the informal seed system is the dominant source where farmers obtain seed from own saved seed, exchange, gifts from family members or relatives and purchase from local markets (Figure 2). The proportion of legume seed purchased from local markets is significant at up to 64.4 percent (McGuire and Sperling, 2016), although strictly speaking the farmers could be buying grain and using that as seed. The quality of the seed is an issue in such arrangements in terms of genetic purity, viability and productivity.

There is a need for comprehensive multi-stakeholder involvement from demand creation to capacity development at institutional and grassroots levels in order to deal with the challenges of quality seed supply of improved legume varieties. Unless this is done, impacts will remain patchy and restricted to intervention areas with limited spillovers. To date, the informal seed systems still dominate as the seed source for planting grain legumes, but there is no structural framework on how these systems operate as the informal approaches vary from location to location. Availability of EGS (breeder, pre-basic and basic seed) remains a challenge that cannot be addressed by the informal seed sector. There is therefore a need to accelerate the process of institutional capacity building and innovative approaches for EGS seed production and marketing strategies. Maintaining an innovative systems (network) approach and creation/strengthening of multi-stakeholder platforms for private-public dialogue (innovation platforms) for planning legume seed value chain management, demand creation, market linkages, joint planning and mechanisms for monitoring, evaluation and learning are critical considerations.

Figure 2. A schematic representation of legume seed systems and their interaction[1].



1 Source: Revised from Almekinders and Louwaars, 1999. Farmers' Seed Production: New Approaches and Practices. Intermediate Technology Publication.

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2. STATUS AND TRENDS IN AREA, PRODUCTION AND PRODUCTIVITY OF SELECTED LEGUMES IN EASTERN AFRICA

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Chickpea (*Cicer arietinum L*), pigeon pea (*Cajanus cajan* (L) Mill), cowpea (*Vigna unguiculata* (L) Walp), soybean (*Glycin max* (L) Merr), common bean (*Phaseolus vulgaris* L), groundnut (*Arachis hypogaea* L), faba bean and lentil are the some of the most important grain legumes grown in Eastern Africa. More than 101 million households grow one or more of the six tropical grain legumes in Eastern Africa (Abate *et al.*, 2012).

While the globally dominant cereals like rice, wheat and maize are expected to continue making major contributions to reducing hunger worldwide, challenges associated with climate change and the degraded natural resource base will impact negatively on the productivity of these crops. For example, among the grain crops, wheat productivity is projected to decline by up to 72 percent of the current yield, while maize and rice yields are projected to decline by up to 45 percent by the end of this century (Adhikari *et al.*, 2015). Legumes such as chickpea, pigeon pea, mung bean, cowpea, soybean, common bean, faba bean, lentils and groundnut have shown significant resilience to climate variability and are adapted to a wide range of environments. Chickpea and pigeon pea, for example, are largely drought-tolerant, normally produced with residual moisture in the post-rainy season after cereals are fully grown or harvested in double-cropping arrangements. Their short duration to maturity allows crops such as soybean, groundnut, common bean and mung bean to benefit from short rainy periods and farmers are able to harvest a crop where long duration cereals fail completely. In addition to their high protein and oil content, they have the added benefit of nitrogen fixation. Pigeon pea, in particular, has a trait of phosphorus immobilization, mineral acquisition from deeper soil layers and addition of organic matter to the soil in the form of leaf drops and decaying roots, which contribute to soil health and agro-ecosystem stability.

2.1 Area, production and productivity

The production of grain legumes has increased over decades both in Eastern Africa (Figure 3) and globally. According to FAO (FAOSTAT 2016), the global area under cultivation of some of the major legumes (groundnuts, chickpea, pigeon pea, common bean, cowpea and soybean) in 2014 was about 220 million hectares (ha), with production of about 430 million metric tonnes (MT) at an average productivity of 1.7 MT per ha (beans = 1.6, chickpea = 1.4, cowpea = 0.44, groundnut = 2, pigeon pea = 1.4, soybean = 1.8). During the same period, in Sub-Saharan Africa (SSA), the area coverage was about 36 million ha (about 16.3 percent of global area), with production of about 27 million MT (around 6 percent of global production) at an average productivity of 0.89 MT per ha (beans = 0.94, chickpea = 0.98, cowpea = 0.48, groundnut = 0.96, pigeon pea = 0.86, soybean = 1.01). The Eastern Africa region accounted for 8.8 million ha (about 24.4 percent of the SSA area), 7.7 million MT (about 28.6% of SSA production), with an average productivity of 1.00 MT per ha (beans = 1.29, chickpea = 1.01, cowpea = 0.54, groundnuts = 1.15, pigeon pea = 0.78, soybean =1.28).

The Sub-Saharan Africa region accounted for about 3.5 percent (511 265 ha) of the global chickpea area in 2014, with a total production of 653 522 MT (4.3 percent of global production) at an average yield of about 0.98 MT per ha (FAO, 2016). Eastern Africa accounted for 89.6 percent (585 342 MT) of the total production from SSA with an average yield of 1.01 t/ha. Ethiopia is the largest producer in Eastern Africa. Chickpea production in Eastern Africa is projected to grow at 7.1 percent per annum, i.e. from 548 000 MT in 2010 to 1 082 000 MT in 2020 (Abate *et al.*, 2012).

In 2014, SSA accounted for about 22 percent (over 5 million MT) of the total global bean production on more than 7 million ha – an average yield of about 0.94 MT per ha (FAO, 2016). The Eastern Africa subregion accounted for 61.5 percent (3.1 million MT) of this production from SSA, where Kenya, Uganda, Rwanda, Burundi, Ethiopia and Tanzania are the major common bean-producing countries.

The SSA region accounted for more than 98 percent of the cowpea area and 95 percent of production, with an average yield of about 0.48 MT per ha in 2014 (FAO, 2016). Cowpea production in SSA is projected to grow from about 6.2 million MT in 2010 to nearly 8.4 million MT by 2020 (Abate *et al.*, 2012). Uganda and Kenya are the largest cowpea-producing countries in Eastern Africa.

Groundnut in SSA was grown on close to 13 million ha (about 43 percent of world total), with a total production of over 12 million MT at an average yield of about 0.96 MT per ha (FAO, 2016). Twelve of the top 20 groundnut-producing countries are found in SSA. The major producing countries in Eastern Africa include Tanzania, Uganda and Kenya. It has been projected that production in SSA will jump from about 10.4 million MT in 2010 to nearly 13 million MT in 2020 (Abate *et al.*, 2012).

In SSA, pigeon pea is cultivated on approximately 834 570 ha (<11 percent of world), with a total production of 852 549 MT at an average yield of about 0.86 MT per ha (FAO, 2016). Tanzania, Kenya and Uganda are the largest producers in the Eastern Africa subregion. Pigeon pea production is projected to grow at about 7.5 percent per annum – from 482 000 MT in 2010 reaching 841 000 MT in 2020 (Abate *et al.*, 2012).

The area under soybean was 1 850 955 ha (1.5% of world total), with a production of 2 351 437 MT (0.7% of world total) at an average yield of about 1.01 MT per ha in SSA (FAO, 2016). Uganda, Kenya and Ethiopia are the major producers in Eastern Africa. It was projected that SSA production would grow at a rate of about 2.3 percent per annum (from about 1.5 million MT in 2010 to over 1.9 million MT in 2020) (Abate *et al.*, 2012), a projection already surpassed in 2014.

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2.2 Legume grain trade

Global chickpea export has shown sustained growth over the last two decades, with more than 882 000 MT worth approximately USD 525 million in 2014 (FAO, 2016). Ethiopia's share of export is estimated at nearly 100 000 MT (76 percent of Africa), followed by Tanzania (about 21 percent of the regional share), the second largest exporter in Africa. Projections suggest that Eastern Africa will continue to be the net exporter of chickpea through 2020 (582 000 MT).

Common bean trade in SSA accounts for USD 128 million in imports among 45 countries and USD 37 million in exports among 34 countries. Annual groundnut import is estimated at about USD 54 million, while groundnut export stands at USD 42 million in SSA. SSA would have a net surplus trade of nearly 957 000 MT of groundnut by 2020.

Pigeon pea net trade in SSA is expected to grow at 17.4 percent per annum from 156 000 MT in 2010 to 427 000 MT in 2020. Kenya, Uganda and Tanzania will continue to be the major surplus-producing countries in Eastern Africa. Nigeria and South Africa are slated to be major net exporters of soybean, whereas Tanzania, Somalia, Djibouti and Kenya in Eastern Africa would be major net importers of soybean. SSA is projected to have a surplus net trade of soya bean by 2015 (10 000 MT) and 2020 (nearly 32 000 MT).

2.3 Challenges

Despite their importance, the productivity of legumes is still low in SSA, with average yields (Figure 3), compared with yields of up to 5 000 kg/ha reported from the best performing countries (FAO, 2016). The low productivity is attributed to various production and socio-economic constraints including persistent drought episodes, deteriorating soil fertility, market failures and limited access to improved varieties on account of challenges in the seed systems.

Due to the limited attention given to legumes by research and development programmes in the past, they have been referred to as "orphan crops". Transitioning rapidly from this previous branding of "orphan crops" to the current banner of "climate-smart", "smart-food" and "future" crops, legumes are increasingly sought for their climate resilience, ecological role in improving soil fertility, provision of livestock feed and nutritional value, especially under the looming threat of climate change in dryland ecologies. The inherent resilience and hardiness of crops like groundnut, cowpea, pigeon pea and chickpea in SSA will allow them to continue to be suitable crops in these regions even under climate change.

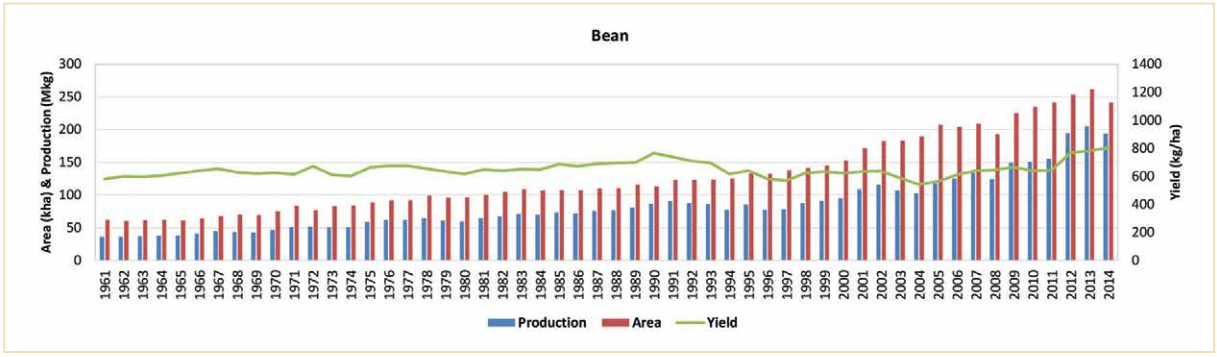
The performance of African agriculture has been impressive, with an annual agricultural GDP growth averaging 5 percent over the past decade. Agricultural public expenditure over the same period grew at an average of 7.4 percent per annum and several African countries are moving towards the Comprehensive Africa Agriculture Development Programme (CAADP) target of at least 6 percent annual agricultural growth rate (AGRA, 2016).

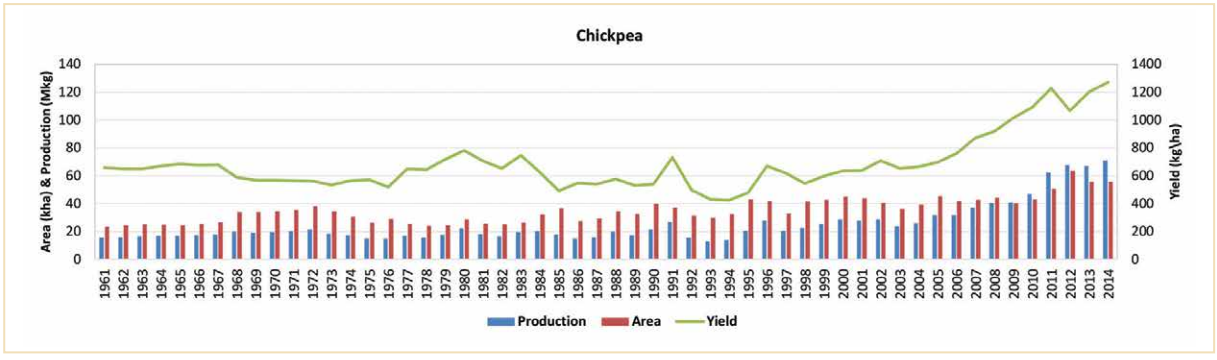
Increasing agricultural productivity through strategies that protect the natural resource base will be key to ensuring food security for the growing rural and urban populations of developing countries. In all developing regions, especially the heterogeneous and risk-prone rainfed systems of Eastern Africa, there is a need for technologies and practices to increase the productivity, stability and resilience of production systems (including postharvest systems) sustainably and to confront the growing challenges of climate change. Strengthening production systems must involve consideration of crops on arable lands, aquaculture, livestock and other food products and improved farming systems that can contribute to the food security of rural and urban populations. Development of climate-resilient crop varieties, integrated crop-management practices as well as systematic approaches to input management are some of the ways to enhance productivity and bridge yield gaps of nutrient-dense crops such as legumes to meet the nutrient requirement of the vulnerable groups. Some of the barriers to increased productivity and effective utilization of legumes are outlined in Table 1.

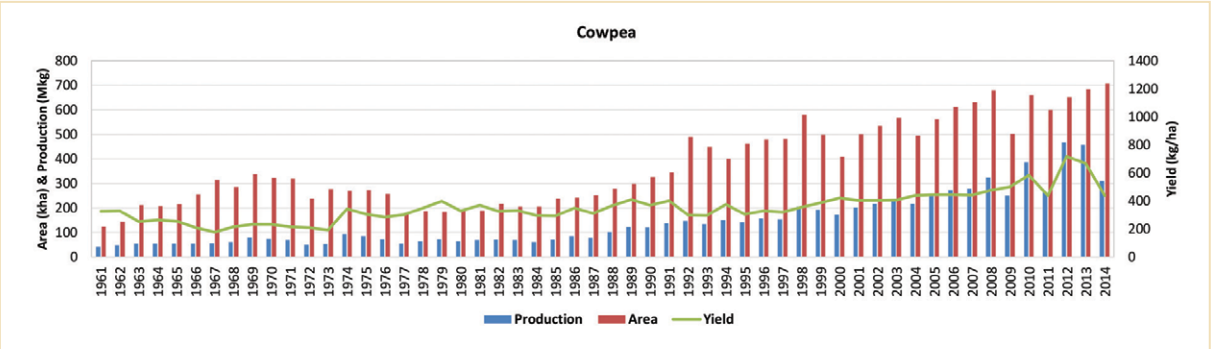
Table 1. Barriers to effective utilization of legumes as mainstream crops and possible solutions

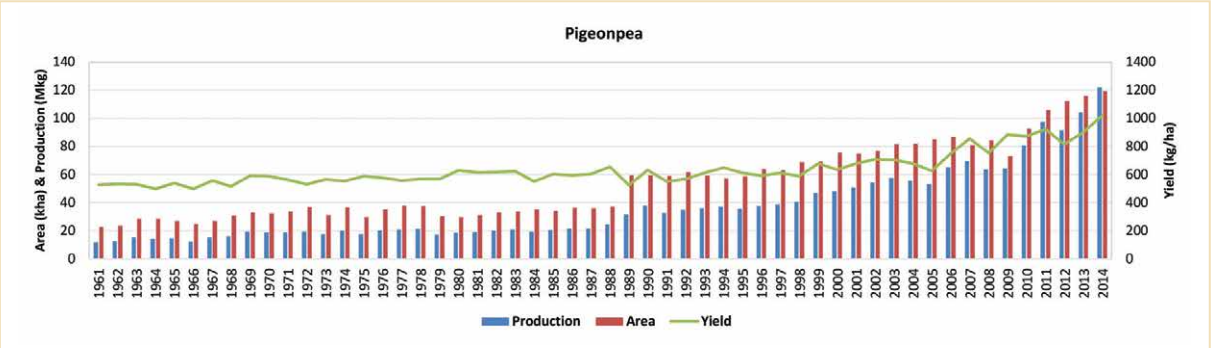
Barriers		Possible countermeasures
1.	Limited information on available varieties, variety profiles, productivity potential and agroecological suitability.	Surveys, inventories, production manuals and handbooks; promotional activities. Inclusion of legumes in training curriculum. Better characterization of soil qualities and of variety performance across agroecologies.
2.	Limited access to high-quality seed of superior varieties.	Innovative approaches that involve the public, private and informal seed sectors.
3.	Limited attention by policy-makers and technical experts for research, development and promotion of legumes for enhanced utilization.	Enhanced awareness on the uses of legumes was created in 2016, the International Year of Pulses. Engagement with policy-makers on the need to mainstream legumes into agricultural and food systems.
4.	Inherent and historical bias against legumes relative to staple cereal crops.	Improvement programmes that render legumes more attractive as high-value income-generating crops.
5.	Limited availability of legume seed, making costs relatively high.	Enhanced productivity, production and supply of legume seed.
6.	Difficulty of handling diverse legume species and varieties.	Decentralized farmer participatory selection approaches, enabling farmers to select varieties suitable to their localities.
7.	Lack of markets.	Processing and value addition; farmer-market linkages.
8.	Biotic and abiotic stresses.	Development of resistant/tolerant varieties; integrated pest management; integrated crop management.

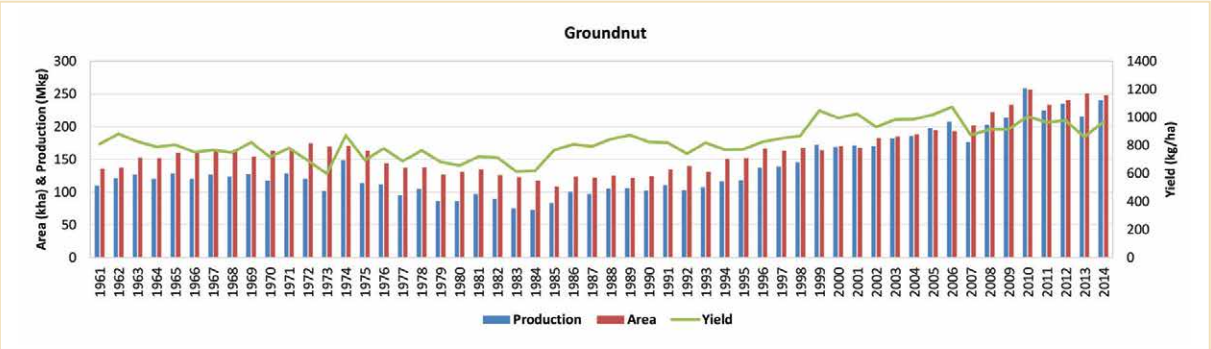
Figure 3. Trends in area, yield and production of selected food legume crops in SSA (from 1961 to 2014).

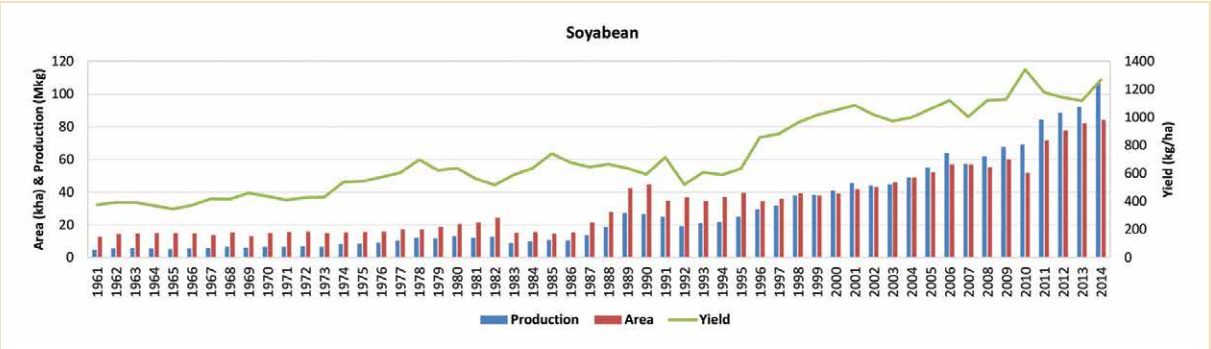












Source: FAOSTAT, 2016.

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3. LEGUME VARIETY DEVELOPMENT, RELEASE AND PROMOTION FOR ADOPTION

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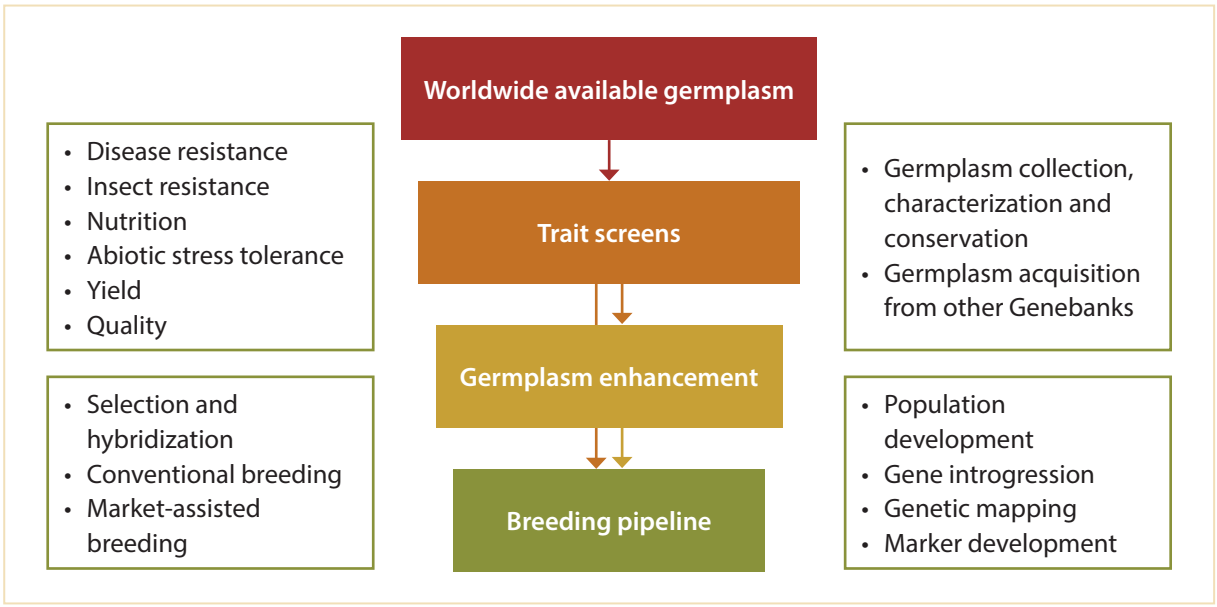
3.1 Variety development

Variety development involves creating breeding populations through crossing programmes, multi-environment evaluation of advanced breeding lines for target environments and, in some cases, farmer participatory variety evaluation and selections (FPVS). Legume variety development begins with phenotypic and molecular characterization of genetic resources. CGIAR centres – ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), CIAT (International Center for Tropical Agriculture), IITA (International Institute of Tropical Agriculture) and ICARDA (International Center for Agriculture Research in the Dry Areas) – in collaboration with the Generation Challenge Program (GCP) – have characterized legume germplasm and produced reference sets corresponding to the genetic diversity of several composite collections. These reference sets have been useful for the development of genetic resources such as pre-breeding, magic and intraspecific mapping populations, as well as genomic resources such as comprehensive genetic maps, whole genome sequences, QTLs and trait-specific markers. In addition, integrated breeding approaches including high throughput genotyping and phenotyping platforms, marker-assisted selection (MAS) in pedigree breeding schemes, marker-assisted backcrossing (MABC) and marker-assisted recurrent selection (MARS) have contributed to the accelerated development of breeding lines and varieties of these legumes.

These genetic and genomic tools have been used to develop new breeding lines with superior characteristics (Figure 4). Development of varieties further involves the use of these breeding lines either for further introgression crosses or adaptation trials and release as new varieties. Regulatory authorities come in at the stage of variety release and registration to validate that the proposed varieties are of superior performance compared with existing ones. The proposed varieties have traits that distinguish them from other varieties, are uniform in terms of identifying traits and maintain those traits from season to season.

Figure 4. Improvement and variety development of legumes for multiple traits.



3.2 Variety release

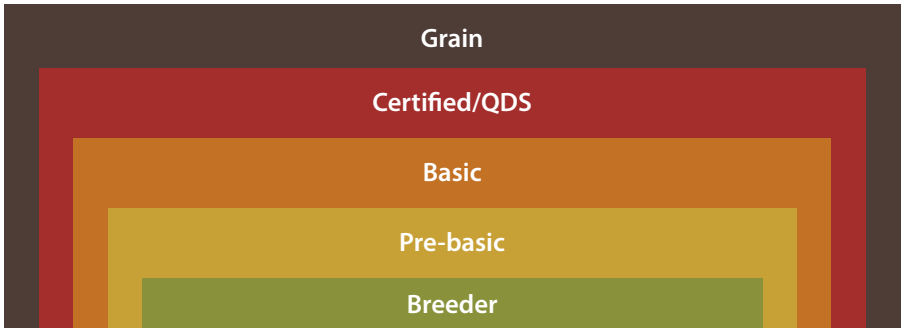
Numerous new, improved varieties have been developed and released to tackle legume production challenges including biotic and abiotic stresses, as well as adaptation and suitability to cropping systems in Eastern Africa. For example, suitable chickpea varieties with a high yield potential combined with market-preferred seed and tolerance to biotic (Fusarium wilt, Ascochyta blight, pod borer resistance) and abiotic stresses (drought and heat tolerance) have been identified and released by NARS. Adoption of these varieties and accompanying integrated crop management practices in Ethiopia contributed to increased chickpea yields – from 550 kg/ha in 1993 to 1 913 kg/ha (248 percent increase) in 2014 and total production from 168 000 tonnes on about 109 000 hectares to 458 682 tonnes (173 percent) on about 240 000 hectares (120 percent) in 2014 (CSA, 2015).

Improved groundnut varieties with early maturity, drought tolerance, groundnut rosette disease resistance, high yield and other positive traits were released in Uganda (10) and Tanzania (5) over the past decade (Monyo and Varshney, 2016).

3.3. Seed production of new variety

The various stages involved in the production of certified/QDS are illustrated in Figure 5.

Figure 5. The generations legume seed passes through from the breeders (breeder seed) to the seed-producing agencies (foundation/basic) before reaching the farmers (certified/QDS) for grain production.



Nucleus seed, often called parental seed, is the genetically and physically pure seed of the target variety produced by the original breeder in the final stages of variety release. *Breeder seed* is the genetically and physically pure progeny of nucleus seed multiplied under the sole supervision of the plant breeder and used for production of foundation seed. *Foundation (or basic) seed* is the progeny of breeder seed produced by recognized seed-producing agencies in the public or private sector, under supervision of seed certification agencies in such a way that its quality is maintained according to prescribed field and seed standards. *Certified seed* is the progeny of foundation (basic) seed produced by registered seed growers under the supervision of seed-certification agencies to maintain the seed quality as per minimum seed certification standards. *Quality declared seed* (QDS) is seed produced according to the QDS principles, guidelines and standards by competent seed producers and suppliers in order to accommodate the diversity of farming systems, particularly in the more difficult areas where highly organized seed systems do not function well (http://www.fao.org/documents/card/en/c/77ebe058-db40-5bdf-afec-81688a2973bc/). Quite often QDS is equated with the informal sector and adopted as a strategy where small-scale farmers are organized into seed producer groups, cooperatives or associations and are registered and trained in producing seed for their own use or for sale mainly to fellow farmers.

3.4 Variety adoption

Variety development and release is only one step in the impact pathway of legumes. Even more critical is the adoption of varieties for large-scale production. This is still relatively poor in Eastern Africa (Figure 6) where it is hampered mainly by limited availability of high-quality seed of these new varieties. Farmers tend to keep their own seed, which is mostly self-pollinated, and recycle the seed over several generations. The variety replacement rate is as much a problem as the seed replacement rate. Therefore, reported variety adoption levels may refer to very old varieties, while new varieties with the potential to revolutionize production, productivity and profitability remain on the shelf. It is not uncommon for researchers to cite yield gaps between the farmers' fields and the research station data. While this is mostly with reference to crop management practices adopted by the farmers, the difference between the average national yields and potential yields could be a complex problem that may be a combination of use of poor varieties, poor quality seed, poor agronomic practices - including non-use of inputs such as fertilizers, rhizobia inoculants, fungicides and insecticides - as well as agro-ecological and edaphic factors.

Similarly, decentralized seed production and distribution of improved varieties contributed to improved dissemination of common bean varieties in Ethiopia. Part of the decentralization involved production of early-generation (pre-basic and basic) seed. Well-established innovation platforms along the bean value chain contributed to sustaining the decentralized seed-production system (Rubyogo *et al.*, 2010). Dissemination, adoption and production of improved varieties contributed to increasing bean productivity by 42.3 percent from 0.861 t/ha in 2004 to 1.49 t/ha in 2014; production by 69.5 percent from 1.38 m tons to 4.57 tons; and exports (particularly of white pea bean) by 27 percent from 61 000 tons to 81 000 tons (CSA, 2015).

In Tanzania, the area under pigeon pea increased by 380 percent from 60 000 ha in 1995 to 290 000 ha in 2011 with corresponding increase in productivity from 0.5 to 0.95 t/ha due to the development, release and adoption of new varieties. In the Babati district, adoption of improved pigeon pea varieties has reached 80 percent, and pigeon pea alone contributes more than 50 percent of the cash incomes for smallholder farmers.

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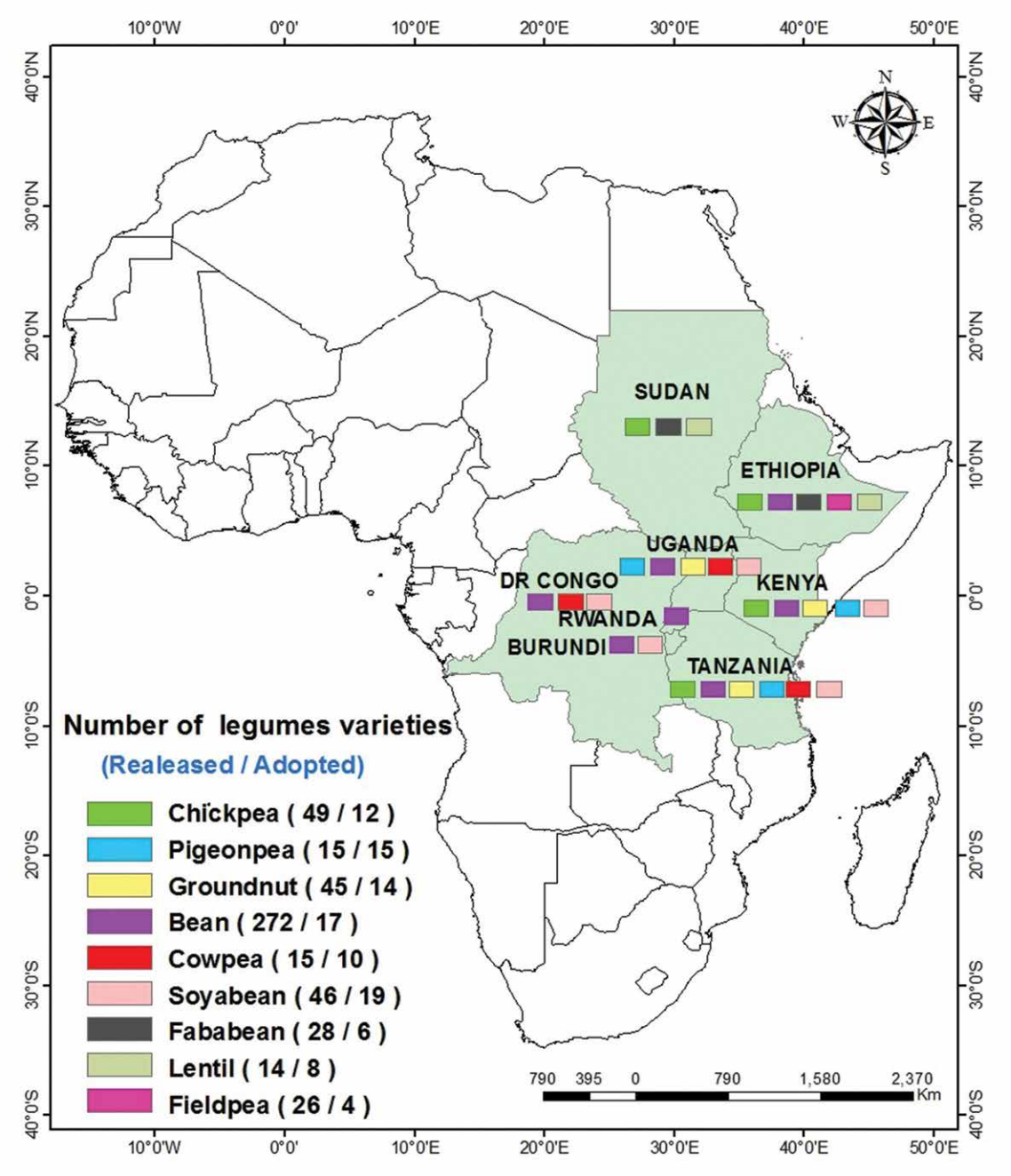
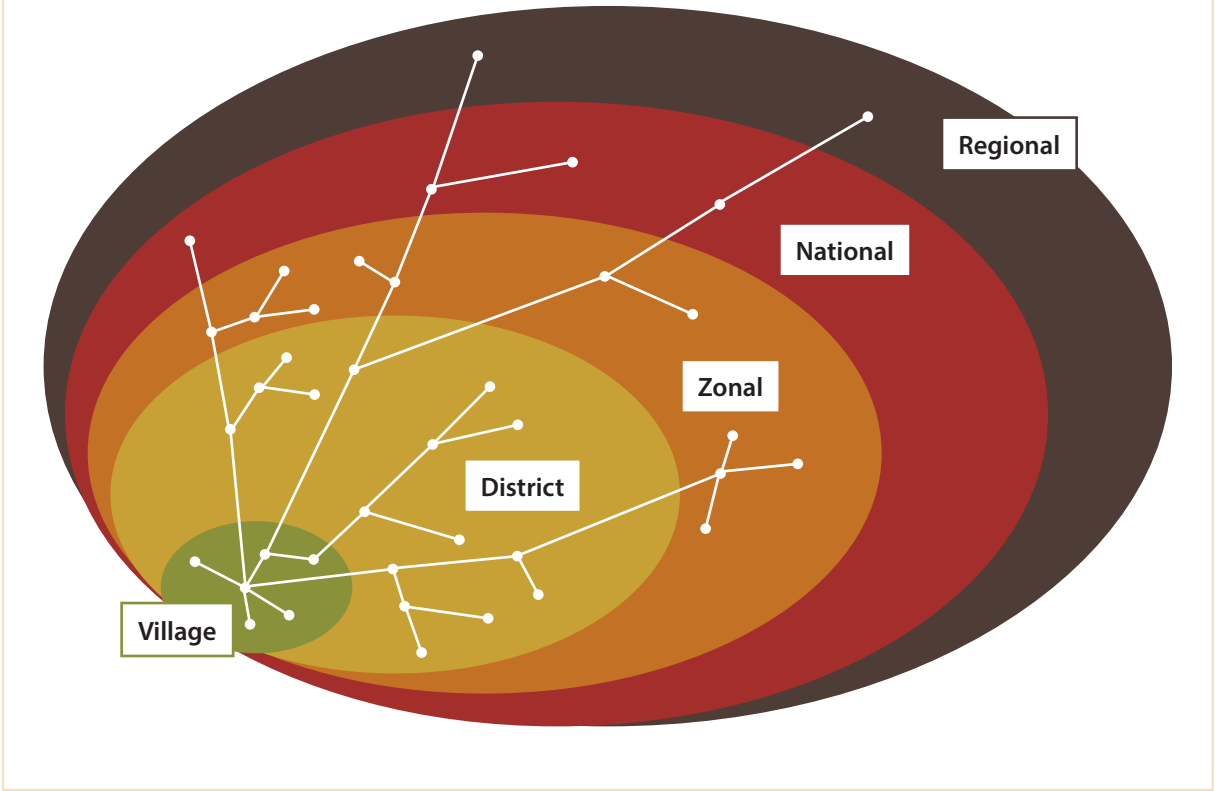
Figure 6. Varieties of selected legumes released and under production (adopted) by various breeding programmes in Eastern African countries as summarized by the CGIAR DIIVA (Diffusion and Impact of Improved Varieties in Africa; http://www.asti.cgiar.org/diiva) project data on selected crops in Sub-Saharan Africa.



3.5 Variety popularization and promotion

Promotion of new varieties through participatory variety evaluation and selection (PVS), whereby several advanced lines are tested against standard varieties in the farmers' fields and stakeholders jointly participate in selecting the best bet variety based on agreed criteria and priority traits, has been the most common approach. Researchers consult with farmers who advise about the varieties best suited to their particular needs. Selected varieties are then scaled out/up through on-farm demonstrations together with accompanying production packages. Other promotional avenues include field days and mass media (radio, television, print). The starting point may be a small unit such as a village within a district. Together, several such target villages have a multiplier effect to spread the technologies to the rest of the district. Activities within the districts then spread out to neighbouring districts within a zone, province or region. Depending on the popularity of the variety or its level of adaptation, it can spread across the region to most of the agroecologies within the country where the crop is grown. For a crop with cross-border or regional importance, the popularity of well-promoted varieties spreads across the region and stimulates international trade (Figure 7). More recently, additional approaches such as mobile apps and short text messages are being integrated into extension services.

Figure 7: Scaling out seed of improved legume varieties beginning with PVS at the grassroots (village) level and demonstration of variety performance together with accompanying production packages.

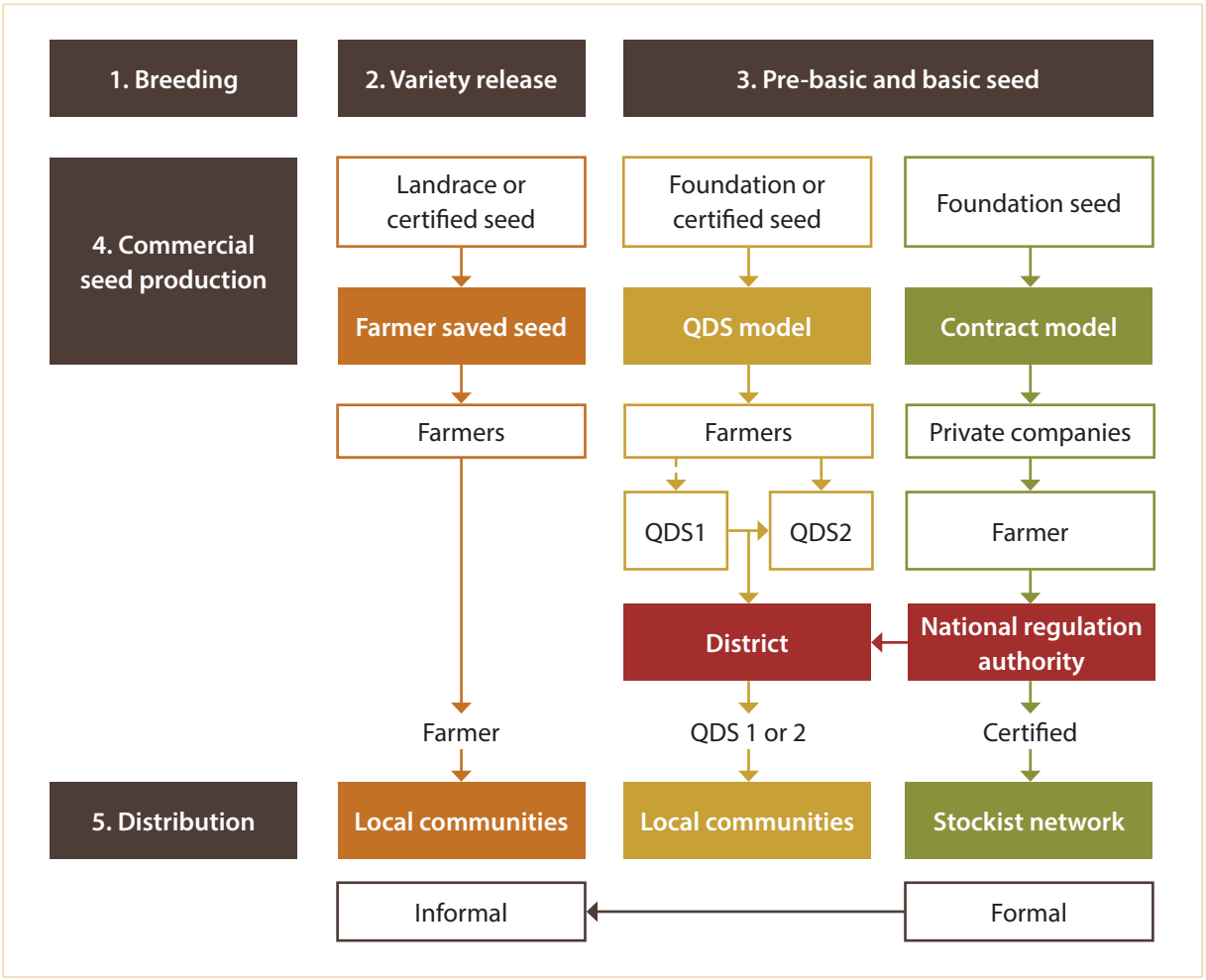


3.6 Legume seed delivery

Adoption of new varieties can never be successful until efficient seed-delivery systems are in place. The seed value chain begins with the development of new varieties, followed by a formal release and registration. Ideally, there should be sufficient *breeder seed* at the time of variety release. Then follows production of *basic seed* (with pre-basic seed in between) under regulatory rules. It is the basic seed that is used to produce *certified seed*, which could also be certified as *quality declared seed* (QDS). In Tanzania, the QDS is produced for a specific locality and distribution is restricted to an administrative area where inspection takes place. Quality regulation is managed largely by authorized district inspectors, who are generally extension officers with some additional training from the formal regulatory board. However, the formal inspectors are required to do the final germination and purity tests that are needed before the seed can be sold. This involves sending samples to a laboratory for testing but does not require inspectors to visit. QDS1 may be bulked to give QDS2. Certified seed is usually subject to a stringent government regulatory framework and production may be undertaken by public or private sector companies (Figure 8).

This is one way to show the distinction and interrelationship between certified and QDS seed, but there are other possible links between channels, which may help with reaching farmers. These include new (and certified) seed through more local outlets, or occasional injections of seed into local channels (e.g. community-based enterprises).

Figure 8. Stages in the development of sustainable integrated seed systems for legumes[2].



2 Adapted from a presentation by Danny Romney on "Seed systems for small-scale farmers: experiences and lessons in Eastern Africa" at the CSP Convene 2013 in Addis Ababa, Ethiopia.

4. TWELVE PRINCIPLES IN MAINSTREAMING EFFICIENT LEGUME SEED SYSTEMS IN EASTERN AFRICA

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Developing a sustainable legume seed sector requires a particular approach to analysing the legume seed chain's critical bottlenecks that hinder technology flow from supply through adoption, to developing support strategies and solutions to the barriers identified as well as clear impact pathways and plans to assessing developmental impact. Seed security assessment (SSA) becomes critical here in order to identify the bottlenecks by collecting and analysing data to allow an understanding of the parameters of seed security, as well as how best to intervene to support seed security (http://www.fao.org/3/a-i5548e.pdf). One of the factors limiting efficiency in the legume seed sector is the lack of policy support for the input and output markets of legume crops at par with staple cereal crops. In general, legumes have not received sufficient government attention in the past and were called 'orphan' crops compared with food security crops, although the situation is changing. Legumes compete for the attention of seed companies against crops that receive stronger policy support. This is besides the already stated facts that legumes are less attractive for private sector investment as it is difficult for seed companies to secure margins from steady seed demand; they do not have strong output markets (especially those linked to a specific variety); and farmers may not have strong incentives to buy legume seed from formal channels on a regular basis.

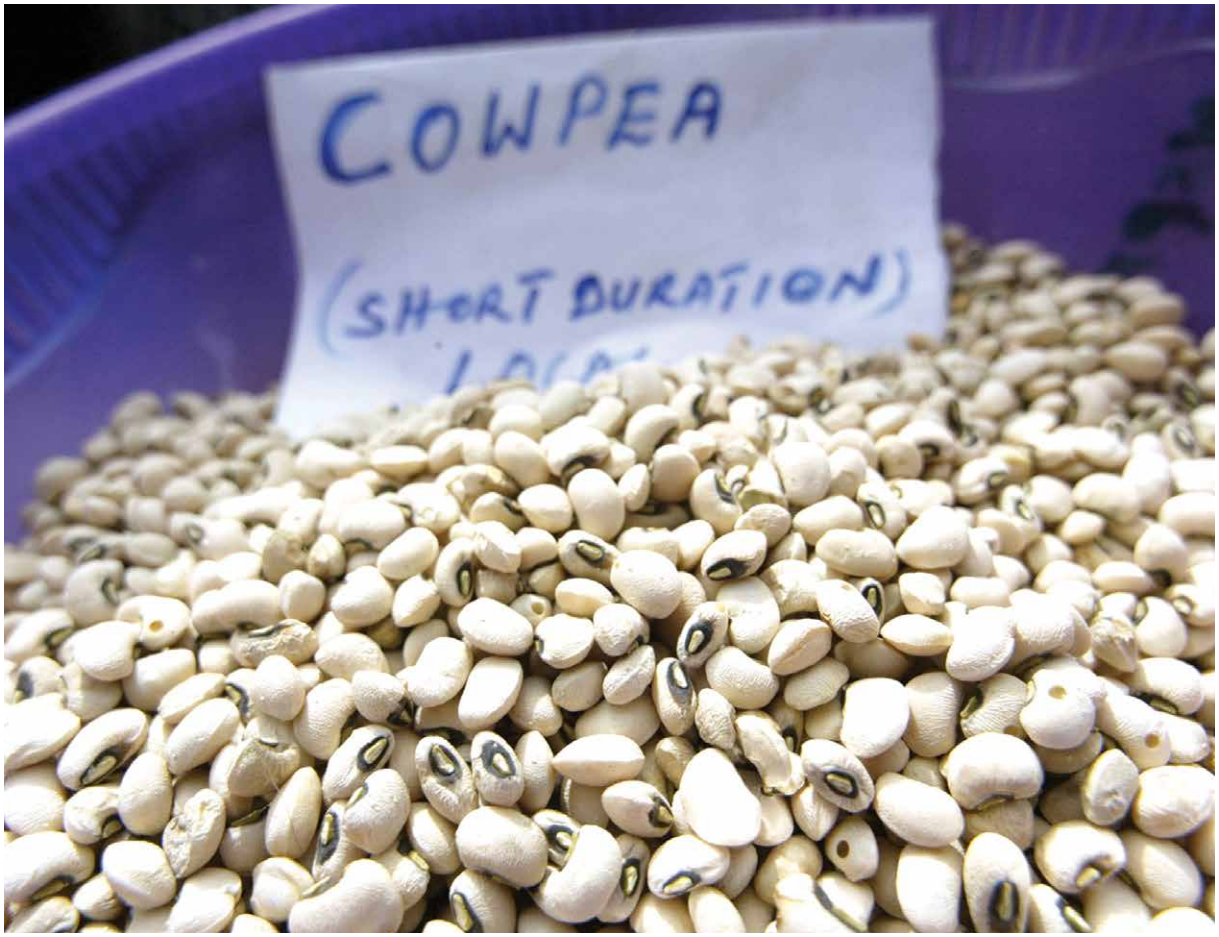
Lack of awareness of improved legume varieties and integrated crop management practices is another barrier. Popularization and demonstration activities for these crops are limited compared with those for food security crops (e.g. maize, wheat). Insufficient farmer awareness of the benefits of new varieties is a perennial challenge. Farmers' knowledge of improved varieties was found to be strongly correlated with the adoption rate for pigeon pea in Tanzania (Amare *et al.*, 2012) and for improved chickpea in Ethiopia (Abate *et al.*, 2012).

Institutional constraints involving both public and private institutions also hamper efficiency in the legume seed system. Public institutions for varietal release and seed multiplication often lack the capacity to efficiently test, release and multiply new varieties

of large numbers of crops, and consequently give priority to the fewest staple cereal crops. Private sector institutions are motivated by profit and need to see some sustainability in terms of demand. Legumes therefore attract limited interest from the public and private sectors in certified seed production and distribution due to a lack of real seed demand from farmers. The self-pollinated reproductive system of most legumes (excluding pigeon pea and faba bean) enables farmers to reuse their own or their neighbour's seed instead of regularly buying fresh seed, reducing incentives for the private sector. A multistakeholder partnership approach and understanding why farmers buy seed is critical for targeting market segments as noted by Hanif and Sperling (unpublished).

Limited availability of early-generation seed (breeder, pre-basic or basic) from NARS is another challenge. Apart from the lack of physical resources (land, irrigation), facilities (farm machinery, processing and storage) and financial resources, priority is still given to other major crops. Compared with major staples such as maize, wheat and rice where one or two species are handled, the diverse legume species, each requiring separate seed production and handling systems, lead to lower volumes of sale. Low seed multiplication ratio and rapid loss of viability in some legume crops, particularly groundnut, soybean and chickpea, are limitations that cannot be ignored.

In the following section some basic principles required to mainstream legume seed systems and thereby legume production and utilization are proposed. These principles include a closer look at the legume seed theory of change, taking note of how the various players help move activities of stakeholders through outputs, outcomes and impacts and how they interact through spheres of action, influence and interest; innovative approaches for early-generation seed (EGS) supply; a connection between EGS and commercial class seed; strong policy environment; strong institutional framework; multistakeholder involvement; linkage to utilization and markets; and the role of legumes in empowering women and youth.



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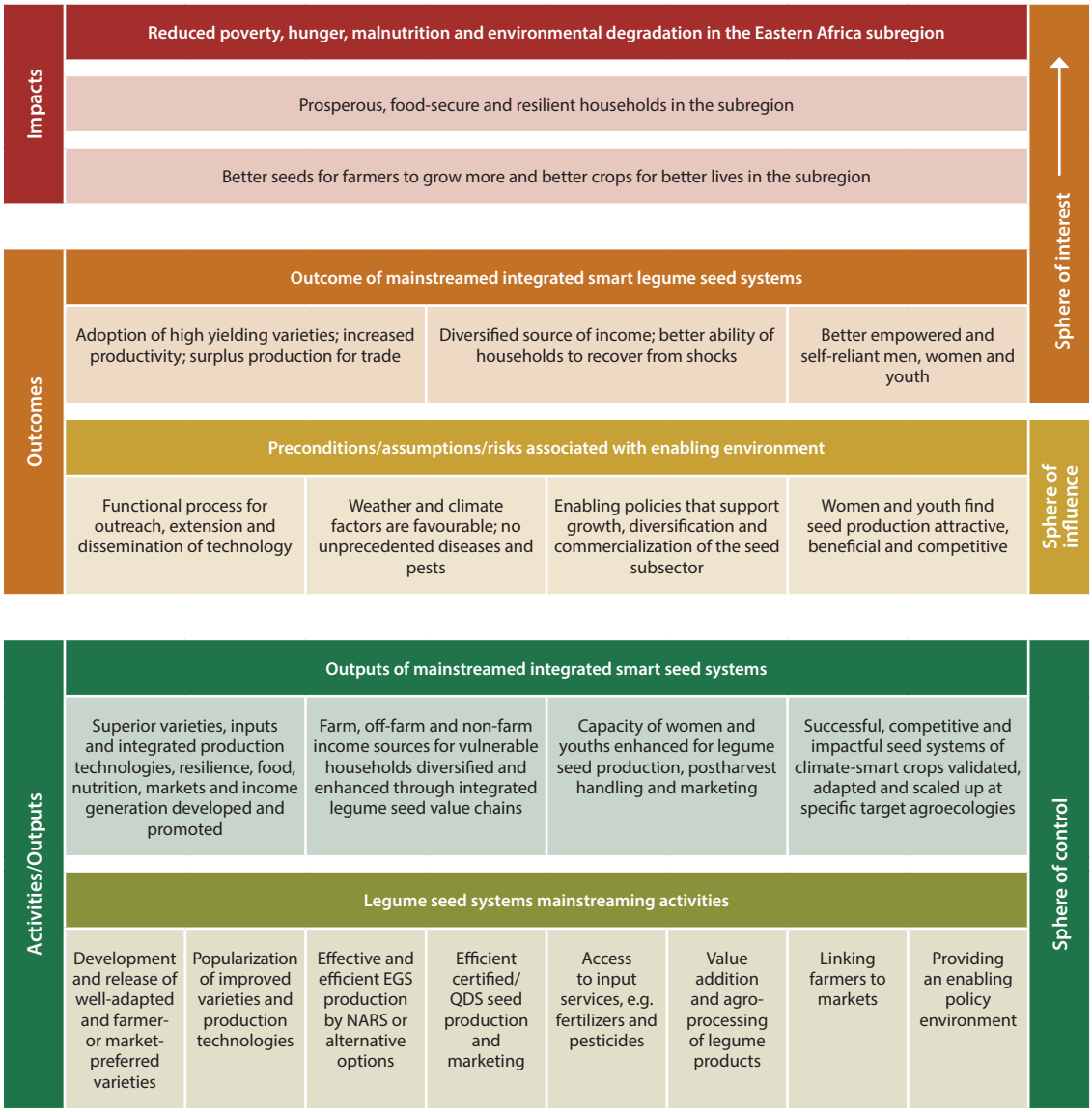
4.1 Principle 1: Mainstreaming the legume seed system requires a clear theory of change

To mainstream legume seed systems successfully, a clear vision of the impact of increased food, nutrition and income security should drive mainstreaming activities. These include the creation of seed producer groups, building their skills in seed production and handling, linking them to seed markets, the provision of source seed (EGS) and the consultative process through farmer participatory evaluation and selection. To achieve this, a clear seed roadmap (area coverage with improved seed taking into consideration the seed replacement rates and varietal replacement rate to ensure adoption of new varieties) should enable better planning of the amount of breeder, basic and certified seed required over a given period. While outcomes such as increased adoption of improved legume varieties and accompanying integrated crop management practices and associated increase in yields are intended, it must be noted that an enabling environment is an important precondition (Figure 9). An enabling environment could also be within the sphere of action of stakeholders such as through promotion and awareness creation of new varieties among consumers, grain traders, processors and value-adders, which then drive the demand for legume seeds.

Within the theory of change there are three spheres – control, influence and interest. The 'sphere of control' indicates what the actors can be held directly accountable for; the 'sphere of influence' indicates what the interventions could influence, but which are influenced by other multiple factors in turn; and the 'sphere of interest' indicates what the direct actors are interested in achieving in the longer term, but which are unlikely to be traced or attributed directly to the activities or influence. The sphere of control of legume seed systems involves actors such as CGIAR, national agricultural research extension systems (NARES) and higher learning institutions (HLIs), which not only work upstream in the development of varieties but are also involved in varietal maintenance and early generation seed production, promotional activities through demonstrations and field days. Elements in the sphere of influence include government policies and regulatory frameworks such as variety-release and seed-certification procedures, infrastructure development, extension and advisory services and political stability.

Many legumes are sold as fresh green pods (common bean, faba bean and groundnut), fresh green grains (chickpea, faba bean, field pea, vegetable soybean) and fetch better prices than dried grains. Innovative approaches in packaging, labelling and freezing fresh legume products could be attractive to the youth. High returns on investment are expected when production is linked to new opportunities for processing, value addition and marketing. Postharvest value-addition is therefore an important element of demand creation that drives legume seed systems.

Figure 9. Theory of change in mainstreaming legume seed systems.



4.2 Principle 2: Mainstreaming the legume seed system is supported by a robust policy environment and regional integration

Policy environment can be a major driver for legume seed delivery and should take diversity into account by avoiding a uniform approach to all crops, given legume-specific challenges. By enhancing efficiency in the legume value chain and creating end-user demand for legume products, there will be new demand for seed and a need for enhanced accessibility, affordability and timeliness of legume seed delivery. National and international policies which are pro legumes as nutrient-dense foods as well as sources of income, thereby promoting legume utilization and enhancing their market demand, are key. Promoting nutrition as a goal will entail different strategies, partners and ways of working compared with having income generation as a goal (Sperling and McGuire, 2012). Either way both are critical selling points for legumes. At country level, seed policies deliberately promoting legume production, trade and utilization, as well as national strategies for specific legume seed supply approaches, must be in place. While a few countries have very crop-specific policies and strategies for the major legumes and well-defined institutional roles along the legume value chains, some countries in the Eastern Africa subregion have not invested sufficiently in human, infrastructural and institutional resources for legume research and development. For example, Ethiopia's ambition to increase productivity through research and development at various stages of legume value chains and through efficient seed and other technology delivery systems is captured in its agricultural growth strategy, dubbed the Growth and Transformation Plan II (GTPII).

Cognizant of the seed sector challenges, appreciating the lack of coordination and to ensure that regional economic communities and countries take the necessary actions, the African Union Commission (AUC) established the Africa Seed and Biotechnology Program (ASBP) to provide a strategic approach for the comprehensive development of the seed sector and biotechnology in Africa[3]. The ASBP is aligned to the Malabo Declaration, which is a set of new goals for a more targeted approach to achieve the continental agricultural vision of shared prosperity and improved livelihoods[4]. The Malabo Declaration, also aligned to the African Union's Agenda 2063, acknowledges broad-based agriculture in terms of mechanized farming and access to production inputs to enhance agricultural productivity leading to the transformation of African economies. This demonstrates the unequivocal role that the seed sector has in the broader goals and targets of Africa's future.

African stakeholders with an interest in agriculture have rallied around Africa's vision through Agenda 2063, seeking to modernize the agricultural sector and consequently the seed system. These efforts are evident through the re-commitment of African leaders to the CAADP and through initiatives run by the Alliance for Green Revolution in Africa (AGRA), the Forum for Agriculture Research in Africa (FARA), the West and Central African Council for Agricultural Research and Development (WECARD), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the New Alliance for Food Security and Nutrition. The above stakeholders are contributing to research and development that will result in the establishment of commercial seed systems. It is important that national governments do not ignore the specific needs of the legume seed sector in the design and implementation of these modernization strategies.

Promoting regional trade to strengthen agricultural transformation is one of the priorities of the Common Market for Eastern and Southern Africa (COMESA). COMESA's Seed Trade Harmonization Implementation (COMSHIP), implemented through the Alliance for Commodity Trade in Eastern and Southern Africa (ACTESA), aims to improve access to quality seed for 80 million smallholder farmers by 2020.

3 African Union, 2011. Communiqué on Integrated Seed Sector Development; African Union, 2013. Second Communiqué on Integrated Seed Sector Development

4 African Union, 2014. Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods, Malabo, Equatorial Guinea, June 26-27, 2014

In Eastern and Central Africa, ASARECA acknowledged that "pulses have relatively high current and expected future demand in the region" in their strategic plan 2006-15. The 2011-15 strategy of Malawi, a country in the SADC region, prioritizes and targets "promoting diversified and enriched foods in complementary feeding programs for maternal nutrition and HIV/AIDS affected people through the use of soybean, common bean, pigeon pea and groundnut as key ingredients".

There are many in-country and regional efforts to bring together players in the seed trade for purposes of harmonizing policies in the seed market. National seed trade associations in Ethiopia (ESA), Tanzania (TASTA) and Kenya (STAK), for example, ensure that the private sector partners can jointly lobby the government on national seed policy under the umbrella of the African Seed Trade Association (AFSTA), which endeavours to promote the development of private seed enterprises in the continent.

Recognizing the role of pulses in food security, nutrition and health, biodiversity and climate change, the 68th UN General Assembly declared 2016 the International Year of Pulses to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed towards food and nutrition security and to encourage linkages along the food chain that would better utilize pulse-based proteins, further global production of pulses, better utilize crop rotations and address the challenges in the trade of pulses.

One of the areas of the policy framework on legume seed systems that would be desirable is a free flow of seeds and varieties between and among countries. Harmonization of regulatory frameworks on the variety release mechanism, plant variety protection, seed certification scheme and sanitary and phytosanitary measures for seed trade would facilitate free movement of varieties and seeds across regional borders to create a common market and attract private sector investment to ensure economies of scale (Bishaw *et al.*, 2008). The East African Community (EAC), SADC, COMESA and the Economic Community of West African States (ECOWAS) are good examples of such regional integration on seed-related matters (https://www.syngentafoundation.org/sites/g/files/zhg576/f/seedpolicy_new_africa_regulation_comparative_analysis_september_2015.pdf).

Regional integration would facilitate (i) common variety release procedures; (ii) free movement/exchange of varieties; (iii) economies of scale through common efforts in the seed business; (iv) expansion of investment in the seed business, thus increasing accessibility; (v) expanded efficiency in quality assurance through shared protocols; (vi) easy access to statistics and information on the value of seed markets (market information); (vii) availability of quality seed; and (viii) capacity enhancement.

Deployment of ICT-based interaction procedures has the potential to reduce transaction costs in implementing the procedures in countries with a harmonized seed sector. Likewise, ICT-based regional trade information platforms have the potential to accelerate the utilization of quality seed of improved varieties, increase the seed trade volumes and guide seed production and supply, thereby increasing the potential and sustainability of both the business and availability of quality seed of improved varieties for smallholder farmers.

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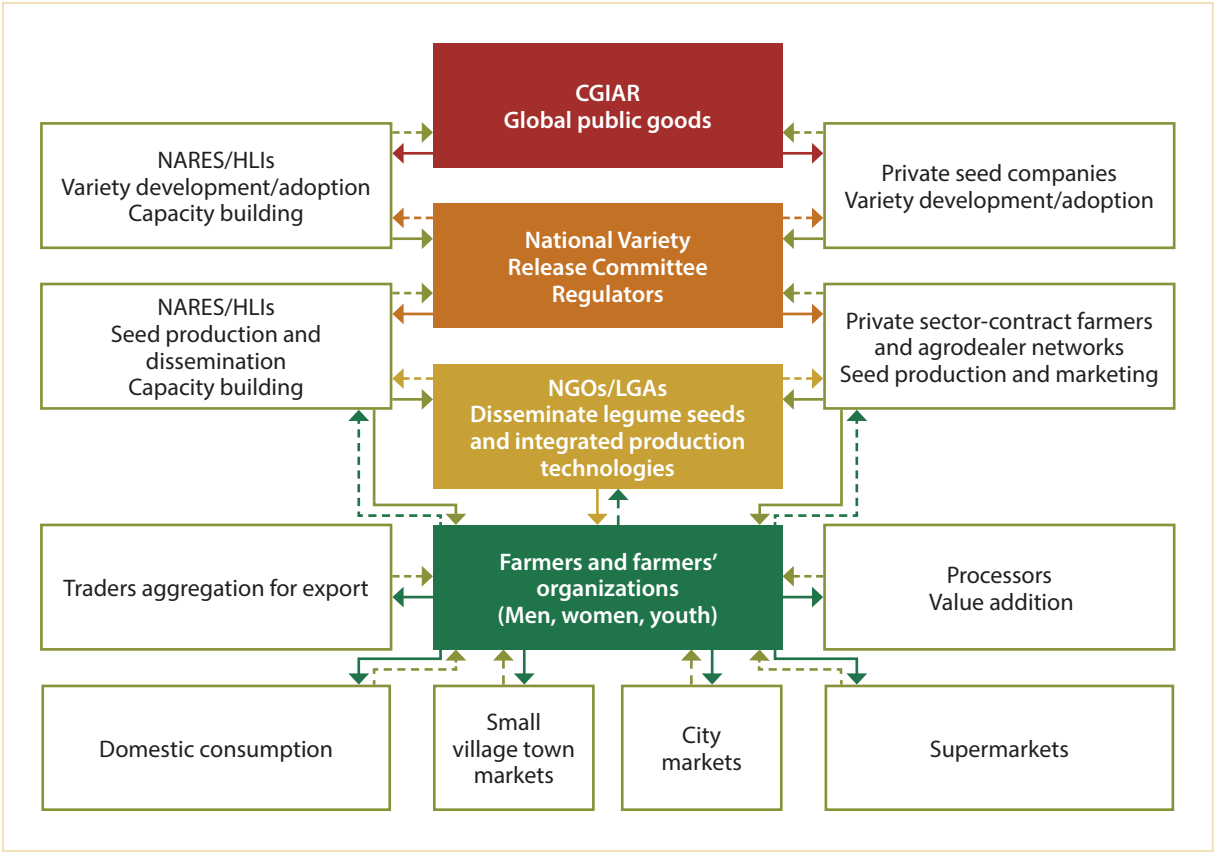
4.3 Principle 3: Mainstreaming legume seed systems is supported by a strong institutional framework

4.3.1 Role of CGIAR centres

CGIAR and regional agricultural research centres – through multilateral or bilateral programmes or projects such as the CGIAR Research Program on Grain Legumes (CRP-GL) and the ICRISAT-led Tropical Legumes Projects (TLI, TLII and TLIII) – are some of the recent research initiatives that bring together IITA, CIAT and ICARDA in the development of improved breeding lines addressing various production and market constraints of legumes. Collaboration with the National Agricultural Research Systems (NARS) ensures that legume research is demand driven and that the legume cultivars developed meet the needs of African farmers while satisfying consumer tastes and preferences. Legume varieties with important traits like high grain yield and quality (taste, nutrition) and tolerant to biotic (disease and pests) and abiotic (heat and drought) stress which are highly adapted and preferred by farmers, industry and consumers are among the most critical in legume production.

The international agricultural research institutions (Figure 10) handle the development of genetic resources (reference sets, pre-breeding, multiple-parent advanced generation intercross and intraspecific mapping populations) and genomic resources (comprehensive genetic maps, whole genome sequences, QTLs and trait-specific markers). CGIAR centers also collaborate with the NARS such as EIAR (Ethiopia), NARO (Uganda), KALRO (Kenya), among others, for integrated breeding approaches including high throughput genotyping and phenotyping platforms, marker-assisted selection (MAS) in pedigree breeding schemes, marker-assisted backcrossing (MABC) and marker-assisted recurrent selection (MARS) to accelerate development of breeding lines. The elite germplasm constituted by CGIAR centers is shared with NARS collaborators for adaptation testing and release in target countries.

Figure 10. Feedback loops of technologies and information from the source of elite germplasm, through legume breeding, seed production and marketing, to farmers, and on to the end-users in an integrated systems approach.



4.3.2 Role of national agricultural research, higher learning institutions (HLIs) and extension systems

In most countries, the NARS have been organized with regional or mandate crop portfolios, which is important for the development of legume varieties to address location-specific production challenges. In most countries, HLIs also have a mandate that cuts across academic teaching, research and community service where knowledge about legumes could be integrated into their curricula. The NARS have the mandate to drive the varieties through official release processes where breeding lines from CGs or national breeding programmes go through several stages of multi-location variety trials.

The elite lines selected from international nurseries received from CGIAR centres or selected from local germplasm or NARS crossing programmes go through observation nurseries and preliminary and advanced yield trials before they are officially submitted for variety release trials. The variety release trials may include performance testing (agronomic merits) and registration testing (for distinctness, uniformity and stability) based on national protocols and guidelines released by the national variety release committees. In Ethiopia, for example, farmer participatory variety evaluation and selections (fPVS) are conducted on a set of released varieties to identify farmer-preferred varieties in specific locations for scaling up. In other Eastern African countries, fPVS data are required as part of the variety release process.

NARS and HLIs have the mandate to maintain the variety, produce early-generation seed and supply basic seed to the commercial seed sector (public and private). For legumes where the private sector is much less involved, the NARS and HLIs also promote the released varieties and integrated crop management technologies through on-farm demonstrations, farmer field days and seed fairs, among others. They moreover assist with the establishment and training of farmer seed producer groups and associations.

In addition to research, HLIs are mandated to undertake training to build human resource capacity. Many universities in eastern Africa have undergraduate and graduate courses on crop improvement and seed technology. In Uganda, the International Center for Tropical Agriculture (CIAT) collaborates with the Faculty of Agriculture at Makerere University to facilitate postgraduate training in agriculture allowing the students to carry out research on bean value chain which fits into the Pan-Africa Bean Research Alliance (PABRA) work.

HLI graduates work as extension agents, development workers, subject matter specialists, teachers, researchers, experts, heads of different offices and consultants, among others (Belay, 2008; Lemma and Hoffman, 2006). Several policy-makers, including ministers or cabinet secretaries and their deputies as well as heads of national agricultural research organizations who can influence policies, are graduates from HLIs. It is therefore important to target HLIs and their training to ensure that such graduates have a positive attitude towards legumes as well as knowledge and practical skills to promote their utilization. In this regard, there should be relevant curricula with competent staff to implement these. HLIs should have adequate infrastructure and facilities for teaching, research and innovation relevant to legume value chain development in general and seed system in particular. Equally important, HLIs are linked to the national development agenda to develop research that is aligned to national priorities and ensure that research findings are actively disseminated to the end users. Regulations and supportive policies may be required to address the challenges in HLIs and enable them to play their rightful role in the mainstreaming of legumes.

4.3.3. Role of seed regulatory systems

Regulatory frameworks guiding variety release, seed certification and cross-border seed trade are neither standardized nor uniform across Eastern Africa and beyond. Where existing, these regulations are mostly based on field crops. The regulatory agencies are involved at several stages of the legume seed value chain (Figure 11) and may require that only officially released varieties and certified seed are commercialized. For example, the Tanzania Official Seed Certification Institute (TOSCI) and the Kenya Plant Health Inspectorate Services (KEPHIS) are responsible for overseeing both the variety release and seed certification, whereas in Ethiopia the Plant Variety Release, Protection and Seed Quality Control is responsible for variety release while the regional seed laboratories are responsible for seed certification.

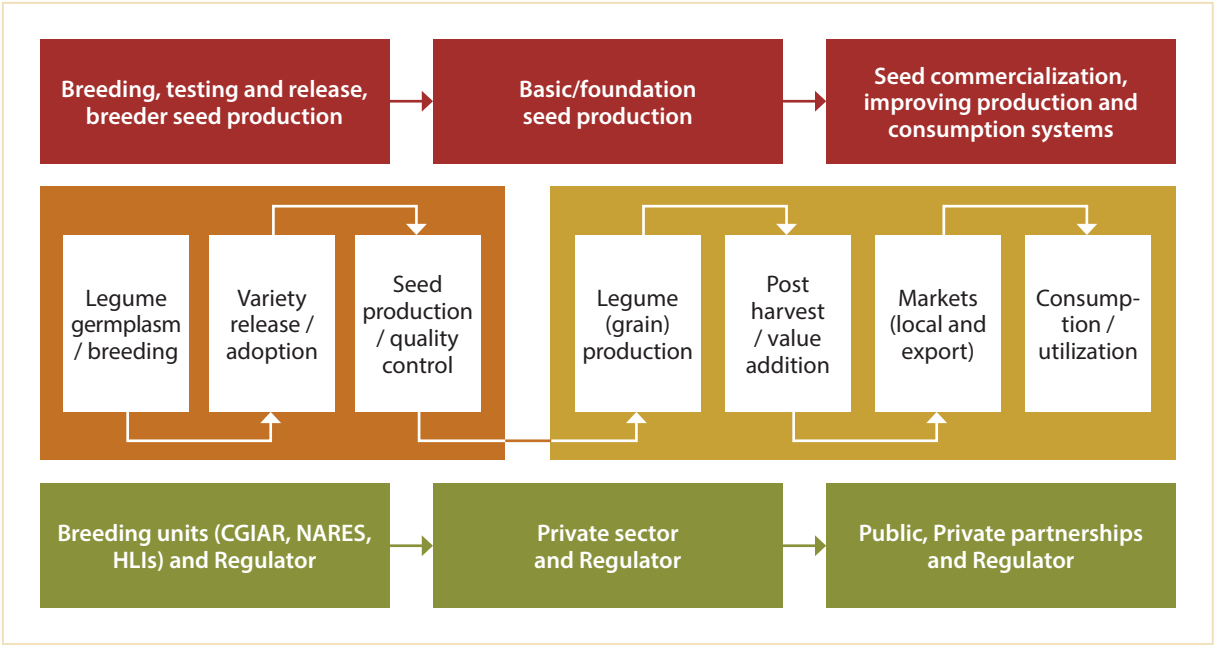
In all cases, the high cost associated with enforcing the release and certification processes is one of the challenges and barriers to private sector involvement in the legume seed sector. Given the limited capacity

of regulatory agencies, new initiatives such as TLII/III and PABRA, among others, have worked closely with these agencies and form all-inclusive innovation platforms bringing together all stakeholders along the legume seed value chain to address the key constraints. Part of the ongoing discussion with policy-makers revolves around approaches to reducing the cost of variety release and certification, but this is a much more complex process at stakeholder and policy levels.

In order to expand the scope of seed delivery, alternative approaches have been designed where QDS production has been recognized and introduced in Ethiopia and Tanzania, though not yet allowed in Kenya. Such alternative arrangements will enable semi-informal small-scale seed enterprises or seed producer groups to emerge and engage in legume seed production to fill the gap created by the absence of the formal sector. Lessons learned from India where truthfully labelled seed (TLS) production is completely free from government certification scheme could help in the case of this subregion and sub-Saharan Africa as a whole. In TLS, no inspection is needed from the government or any other agency at field or at tagging because these functions are performed by the producers themselves. The seed and field standards are equivalent to certified seed. The production procedure is the same as for certified seed. In TLS production all planning, production, postharvest activities and testing for quality control are performed by the producers themselves. The producer provides labels for purposes of marketing TLS. The attributes in the label are the same as those in certified seed. Market monitoring is the only quality testing tool of the TLS. This encourages competition for quality as each producer works hard to be a market leader and to maintain its integrity and trust among seed buyers.

Another model that would be worth emulating is that of the South African National Seed Organization (SANSOR), which regulates seed certification but the process is voluntary (http://sansor.org/seed-certification/). SANSOR uses the services of private inspectors, who though employed elsewhere, are accredited and report to SANSOR. The arrangement has been expanded to include phytosanitary field inspections for seed-borne pathogens. South Africa's seed testing is conducted at both private and official testing stations; however, official testing and issuing of official certificates remain SANSOR responsibilities. For a private laboratory to qualify as a testing station, it must meet regulatory requirements, complete academic and practical training on seed analysis, and be accredited by SANSOR, which exercises control of private seed laboratories through inspections of laboratory facilities and oversees testing of seed samples and spot checks on commercial seed lots.

Figure 11. The role of regulatory authorities at various stages of the legume seed value chain.



4.3.4 Role of public seed enterprises

In almost all developing countries, public breeding is the norm rather than the exception. Therefore, the public sector remains an important and relevant organ in promoting information flow on new, improved varieties. The public sector as custodian of public varieties also ensures equitable availability to the private sector companies, producers and other interested stakeholders. In fact, in some countries, the legume seed sector is dominated by the public sector with fairly limited involvement of the private sector.

In some countries, the public sector is well-established and capable of making a significant contribution to seed supply. In Ethiopia, for example, the Ethiopian Seed Enterprise (ESE), a federal public sector agency, plays a significant role in the production and supply of quality legume seed in the country. In addition, the Amhara Seed Enterprise, Oromia Seed Enterprise and Southern Seed Enterprise which are owned and run by Regional State Governments are also involved in legume seed production and supply. In Tanzania, the Agricultural Seed Agency (ASA) was launched in June 2006 as a semi-autonomous body to take over the responsibilities of the Seed Unit of the Ministry of Agriculture, Food Security and Cooperatives. ASA's roles expanded from foundation seed production to certified seed production to:

- facilitate farmers' access to seed;
- promote increased private sector participation in seed industry development through the establishment of public-private partnerships or joint ventures in seed production and distribution;
- promote increased demand of certified seed by farmers;
- strengthen research capacities for breeding; and
- producing varieties that address farmers' specific demands.

ASA has been instrumental in the production and supply of early-generation and certified seed of legume crops. However, in all these countries, legume seed delivery is a fraction of that of the food security crops such as maize, wheat or rice and not commensurate with the demand. The challenges limiting production and delivery of legume seed by the public sector are similar to those of the private sector. The difference is that the profit motive of the private sector may be less pronounced here where governments may take responsibility to supply seed to farmers through subsidy and loaning approaches.

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4.3.5 Role of private seed companies

Generally, the legume seed business does not attract private sector investment for several reasons:

- The self-pollinated nature of the crops enables farmers to save their own seeds;
- Low multiplication ratio;
- Rapid loss of viability;
- High cost of transportation; and
- Erratic demand.

There are a few seed companies with legume breeding and seed multiplication capacity for some crops. For example, Simlaw Seeds in Kenya has been producing seed of GLP (Grain Legume Project) series of common bean for decades by obtaining elite lines from national and international research institutions in Kenya (ICRISAT and KALRO), Uganda (CIAT and NARO) and Tanzania (Selian), from which they evaluate and propose for release. Other players include, but are not limited to, Dryland Seeds in Kenya, the Integrated Seed Sector Development in Africa's (ISSD's) local seed businesses (e.g. http://issduganda.org/about-us/issd-uganda/), community-based seed multiplication groups, individual seed producers and small seed companies, as well as cooperatives.

As may be expected, most seed companies prefer to trade in hybrids rather than open pollinated varieties. The first and only legume where hybrid varieties have been developed is pigeon pea, but the popularity of these hybrids is just gaining root in India while development of hybrids of the crop is still at rudimentary stages in Africa, with no demonstrated yield advantages.

The promotion of legume crops for rotation with cereals could increase the role of private seed companies in the legume seed business. The private sector may also use the organized seed producer groups as contractual seed producers as they aggregate for bulk marketing. Another possible involvement of the private sector could include postharvest processing and value-addition that could stir up demand. Rubyogo *et al.* (2016a) describe a six-step process towards stimulating private sector interest in the production and marketing of legume seeds. The authors recommended an initial awareness creation about the existence of new improved varieties through field days and seed fairs aimed at displaying and exposing the released varieties to existing and potential stakeholders. The next step involves selecting, building and sustaining partnerships with common interests and commitments for large-scale production and supply of legume seed. The third step involves availing early-generation (basic/foundation) seed of preferred varieties and associated support services (including technical backstopping) to interested and committed certified/commercial seed suppliers. The fourth step involves scheduling activities around variety promotion, seed production and timely distribution to end users in appropriate seed packet sizes for planting. Next is participatory evaluation and performance tracking through an ex-post (qualitative and quantitative) evaluation to assess the effects of the seed distribution and the role of various actors such as seed suppliers, farmers, extension staff, policy-makers and farmers in meeting emerging demand. Finally, the lessons learned are shared through regular interactions and feedback mechanisms around selected themes in verbal (face-to-face as well as media) and written forms of communication.

4.3.6 Role of NGOs

Legumes are mostly grown by smallholder farmers in marginal areas with minimal established infrastructure. Most of the NGOs operate in these remote areas and work closely with marginal and smallholder farmers to help them access quality improved legume seeds, farm inputs, agricultural technologies and markets. CGIAR and NARS partners work with these NGOs for participatory on-farm evaluation and selection of improved legume varieties, promoting proven and integrated crop management technologies, facilitating village-based seed enterprises for seed production and delivery, helping in seed business incubation, enhancing awareness on value addition and processing technologies, and linking farmers to markets.

As part of emergency relief services, particularly during disasters such as droughts or floods, NGOs such as CARE, Food for the Hungry, Catholic Relief Services, Adventist Development and Relief Agency, World Vision, TechnoServe, ACDI-VOCA, Sasakawa Africa, among others, collaborate with international and national research institutions as well as other private and public sector sources of seed to facilitate farmer access to seeds of new and promising varieties to affected households. Some of these NGOs have supported farmer evaluation of new materials, the multiplication of farmer-selected varieties and their subsequent promotion and dissemination. NGOs also participate in capacity building such as

training and the provision of warehouse and other basic infrastructure for seed development (both formal and informal). These important roles of NGOs notwithstanding, it is important to note that NGO assistance can be short-term, and with limited coverage.

FAO and ICRISAT (along with CIAT and ICARDA) hosted a multi-stakeholder workshop on community seed production (CSP) to develop strategies for the enhancement and effective implementation of CSP in developing countries, which will contribute to improved and sustainable crop production, food security and livelihoods of rural farming communities (Ojiewo *et al.*, 2015b). Legume seed delivery featured prominently due to the challenges already mentioned and limited involvement of the private sector.

4.3.7 Role of farmers: Improving on existing indigenous knowledge and diversity

Legumes have been argued to be 'women's crops' because women's contribution in growing secondary crops such as legumes and vegetables is usually greater than in staple crops – rice, wheat and maize (FAO, 2007a, b). Women should play a prominent role in legume research for development by actively participating in technology generation and informing the stakeholders of capacity development needs. In addition, they should receive detailed information on the critical stages of legume value chains pertaining to available new production and crop management technologies, new market opportunities, postharvest handling and value-addition strategies. In many parts of Africa legumes are primarily subsistence crops and women are more visible in the production roles, thereby necessitating a close interaction with them and listening to their voices and concerns such as cooking time, shape, size, colour, taste and market values of legumes (Bationo *et al.*, 2011).

Farmer participation in research programmes must involve a feedback loop to be effective (Figures 11 and 12; http://www.fao.org/docrep/012/i1070e/i1070e00.htm), which includes participatory testing of superior lines, identification of best varieties, and seed multiplication and dissemination. The varietal choices are guided by response to production environments and end user preferences (farmers, consumers, seed companies, traders, etc.). For example, in Ethiopia the Desi types of chickpea are preferred for making

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"shiro", while in Sudan, Kenya, Tanzania and Malawi Kabuli types are preferred. Legume researchers should consult with farmers and use PVS to select the most preferred varieties that are high-yielding, early-maturing, drought-tolerant, easy to cook, responsive to rhizobium inoculation or easier to manage with minimum weeding, fertilizer and water application, and for which there is market demand and better prices.

Particular variety traits such as colour, shape, size, ingredients and even recipes inform the tastes and preferences of a society. Interaction between researchers and farmers/consumers enables the researchers to identify the underlying genetic origins of these traits and use them to develop new cultivars that enhance and complement the particular socio-cultural tastes and preferences. The decision by farmers in a pre-release participatory variety evaluation and selection is a critical consideration for legume breeders. It helps the researchers decide which lines to recommend for official release that will be adopted and produced by farmers. Such "smart" varieties are unanimously agreed on both by the breeder and the farmer or other stakeholders.

Based on specific end-use traits and preferences such as size, colour, taste, aroma, cooking time and shape, farmers may rank a line "very poor" even when the breeders feel that the line was the best due to specific improved traits. Breeders can use the low ranking line as sources of the traits for which they were preferred. Alternatively, the specific preference traits lacking in them can be introgressed. Where there is mutual agreement that a variety is the worst performing on the list, it could be held back from further trials until further improvement is done on it. Sometimes unexpected results are recorded by listening closely to farmers' voices. While the researcher may be hesitant to recommend a variety due to a weakness such as susceptibility to a disease, farmers may demand it due to preferred traits such as high yield, good taste, good colour and good grain size; breeders then propose such varieties for release and commercialization while they work on improving the specific weaker traits.

It is important for farmers to know what consumers want from different legume varieties. Periodic multi-stakeholder workshops, conferences, field days, seed fairs and agricultural shows would inform the value chain players which varieties of legumes people prefer, and why. In addition, innovation platforms help to ensure that researchers on the one hand and farmers on the other, together with the rest of the value chain actors, are contributing to the collective discovery of what works where and why.

Through this interactive process of engagement between researchers and farmers, some farmers have acquired seed production, handling and business skills. In some cases, these farmers have established and registered seed companies. Good examples can be cited for chickpea and common bean in Ethiopia through the TLII project (Box 1).

Box 1. Success stories from Ethiopia

1. Mr Haile Wako, a successful legume seed producer from East Shewa Zone, Oromia Regional State, Ethiopia has been transformed from a small-scale peasant farmer into the owner of a viable commercial enterprise. He started engaging in participatory variety selection trials and demonstrations and gained further skills through various training sessions on the production of quality seed. Using improved varieties and agronomic practices, his production of seed increased. He constructed a warehouse with a capacity of 500 tonnes. Currently Mr Haile owns a Toyota pickup vehicle, an Isuzu truck and a tractor, which he uses for his farm operations. He sells more than 200 tonnes of quality seed each year. To a large extent the progress made by Mr Haile has been due to the technical backstopping and other support through various projects and programmes including PABRA (at early stages) and further technical and financial support through Tropical Legumes II and CRP-Grain Legumes (at later stages).

2. Mrs Temegnush Dhabi, a widow, has been farming for 26 years in East Shewa, Oromia Regional State, Ethiopia. Growing new chickpea varieties with the support of researchers from ICRISAT and EIAR has led to a dramatic increase in her yields. 'I would never have thought chickpeas could bring me such high returns,' says Mrs Dhabi. 'From 1.5 hectares I harvested 42 bags [about four tonnes] of grain. The high yields and market value of chickpea last season meant I could buy a second pair of oxen.' Mrs Dhabi has turned part of her house into a seed store from where she sells chickpea seed to neighbouring farmers.

4.4 Principle 4: Mainstreaming legume seed systems begins with tackling the early-generation seed (EGS) supply challenge

For a sufficient supply of high-quality commercial (certified/quality declared) seed of improved high-yielding legume varieties, whether through the formal (public or private seed companies) or informal (community seed producers, farmers' organizations, individual farmers, etc.) sector, sustainable access to early-generation (breeder and foundation) seed is imperative. USAID and the Bill & Melinda Gates Foundation commissioned a joint study on the early-generation seed sector in sub-Saharan Africa in 2015/2016. The study identified four categories of seed based on public-private sector involvement:

(i) The *Private Sector Dominant Archetype* was identified as 'quality seed of improved varieties that is both attractive for private sector actors to produce and that produces crops the market demands, resulting in robust private sector investment with minimal public-sector involvement.
(ii) The *Niche Private Sector Archetype* is where 'quality seed of improved varieties for crops with niche market demand but which are profitable to produce in certain quantities, are produced by a vertically integrated private sector with minimal public involvement'.
(iii) The *Public-Private Collaboration Archetype* is where 'quality seed of improved varieties for crops with strong market demand but for which the cost of production or demand risk create barriers to private-sector investment and innovation result in public sector involvement'. This is the category into which most legumes fall.
(iv) The *Public Sector Dominant Archetype* is where 'quality seed of improved varieties for crops that are not highly desirable or profitable to produce, are promoted by the public sector to advance a public goal such as food security or seed security'.

Inherent characteristics of the crop and seed biology and associated agricultural practices that impact the design and viability of seed systems in the Public-Private Archetype II under which most legumes fall, include:

(i) Seed is highly labour- or technology-intensive to produce.
(ii) Seed is fragile or sensitive and thus difficult to store and transport to farmers without loss.
(iii) Size or weight of seed makes it costly to transport for production and distribution.
(iv) Multiplication yield rates are low, making the multiplying of seed costly.

The multiplication rates are low (10 seeds/plant for groundnut, 40 seeds/plant for cowpea, 20-115 for common bean) and it is costly to multiply more than once a year where rainfall is monomodal, due to irrigation and input costs, increasing the time and costs associated with multiplying seed. Due to the large size (of common bean, groundnut, faba bean, etc.) and weight of the seed, transportation costs are high, resulting in distribution challenges in areas with poor infrastructure (poor trucking systems and roads).

Economic characteristics of the end market for crops that impact the incentives of various players within seed systems in the Public-Private Archetype include:

(i) Low prices in end-markets depress margins.
(ii) Reuse of varieties for long periods of time in market reduces incentives to invest in breeding new varieties and produce commercial seed. Landraces can be used for 20 to 30 years in-market, creating little market pull for improved varieties.
(iii) Farmers re-use seed for many seasons before repurchasing quality seed of improved varieties. Farmers re-use seed for ~3-5 years depending on skill before repurchasing improved varieties (little rate of return incentive to repurchase improved seed year over year).

A proposed ideal value chain of these crops includes development of new germplasm that has generally desirable characteristics by international research centres (e.g. ICRISAT/ICARDA/IITA/CIAT) in collaboration with NARS; selection of germplasm based on local adaptability and desirability and breeding of first-generation breeder seed by public breeding programmes; maintenance and production of breeder seed by public breeding programmes; public-private partnership or non-profit entity produces foundation seed and licenses it to seed producers on a cost-recovery basis; domestic seed companies manage production of certified seed from foundation seed either through contractual arrangements with outgrowers or on their own plots; domestic seed companies set prices in the market and

either develop in-house marketing and distribution or interface with NGOs, agro-dealers, cooperatives, unions, etc.

Some of the integrated approaches to ensure sustainable supply of early-generation seed are listed below.

4.4.1 Creating an enabling policy environment

Variety release and its commercialization goes hand in hand where the breeders or their agents are responsible for early-generation seed production and supply. While some countries have seed units responsible for EGS production of public-bred varieties, the responsibilities remain unclear and ad hoc in others with no institutional arrangements and technical guidelines. This is exacerbated by a lack of physical, financial and human resources for EGS production. Currently there is no generally agreed criteria for supporting EGS production by the public sector or limiting the same by the private sector. The problem is more pronounced for legumes as compared with cereals. Mainstreaming EGS production of public-bred varieties requires institutionalization of responsibilities with clear mandates in seed production involving both the public and private sectors and ensuring seed quality within the national regulatory framework. Some level of autonomy of the services could be of benefit where EGS production for legumes could be supported by governments through investment loans, provided the economics yield a suitable return.

It should be noted that the multiplication factor for legumes is much less, the demand more erratic, and the returns relatively lower than those for hybrid maize, for example, where there are high costs associated with legume seeds. These are issues worth considering at policy level in the process of mainstreaming efficient legume seed systems.

4.4.2 Decentralizing EGS production

One of the disincentives to engaging the private sector in the promotion and scaling out of public-bred varieties is competition from latecomers after the variety has been popularized. Apart from licensing the public sector to produce EGS, it would be a significant incentive if private companies could be granted performance-based time-bound exclusive rights to produce EGS of selected varieties.

In many countries, EGS production of legume seed is firmly in the hands of the public sector. Experiences from countries such as India, Tanzania and Zambia indicate that decentralizing EGS production and allowing for private sector participation through licensing increases efficiency (Box 2). Furthermore, rather than compulsory certification as a means of quality control, truthfully labelled seeds (TLS) leaves the responsibility in the hands of the private sector and the control authorities only come in to validate that the labelling is truthfully done. This auto-regulates quality and naturally works against companies that are unable to maintain high quality. However, TLS only works when litigation or other enforcement mechanisms are in place. The Eastern Africa subregion may still have a long way to go until such systems are in place.

Box 2.

In 2006, Tanzania established the Agricultural Seed Agency (ASA) as a semi-autonomous body under the Ministry of Agriculture, Food Security and Cooperatives. The main function of ASA is to produce and market basic and certified seeds; to promote private sector participation in seed production; and to strengthen collaboration with research institutes on availability of new crop varieties. However, ASA, being a government agency, has the sole mandate to provide all foundation seed for varieties bred from public institutions; hence it faces a conflict of interest dealing with the private sector. The National Agricultural Policy 2013 has recognized low participation of local and foreign private companies in the seed sector and allowed both to participate in plant breeding and seed production, including multiplication of pre-basic and basic seed.

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4.4.3 Farmer-produced breeder-managed EGS production

One of the lessons learned from the Tropical Legumes project (Rubyogo *et al.*, 2016b), is that farmers can be engaged in EGS production provided close monitoring and supervision is done by the relevant public or private sector breeder. In this arrangement, a farmer would make land, water and labour available, while the institution concerned provides inputs (fungicides, pesticides and fertilizers) and technical support in production (isolation, roguing) and quality control. The farmer would be paid a premium for the seed which is collected by the institute and sold to other seed producers. This has proved particularly successful in India and many farmers, especially women, have benefited. Important at this stage is quality assurance and where the regulation permits, seed quality control agents inspect the seed through the production and handling stages.

4.4.4 Harmonizing regional EGS trade

Discussions on harmonization of the seed trade across regional economic blocks such as the East African Community (EAC), Southern African Development Community (SADC), Common Market for Eastern and Southern Africa (COMESA), among others, have put significant emphasis on certified seed. It should be noted that the best agroecologies and other logistics for production and trade of EGS could be available in some countries and not in others. Encouraging efficient integration of EGS production and trade policies across countries would significantly alleviate shortages observed in some member countries. As discussed under principle 2, numerous discussions have taken place under various frameworks and technical papers and policies on the harmonization of EGS production and trade development. These are currently being domesticated within the countries which are signatories to these harmonized policies. What seems to take a bit longer is the implementation of the documented policies and efficiently putting them into actual practice without hindrances from participating countries which have ratified the common market agreements.

4.4.5 Demand creation through public-private partnerships

This cuts across the entire seed value chain. Consumers need to be sensitized to the nutritional and health benefits of legume consumption and the consequences of a poor and imbalanced diet, including hidden hunger. Farmers should be aware that legumes fetch better prices, which would provide them with a better income, if linked to domestic or foreign market outlets. Farmers would be willing to invest in quality seed if this would guarantee increased productivity and the surplus produce would have a ready market at prices they consider profitable. Therefore, a sustainable demand at the utilization end may stimulate production and sustainable demand for commercial seed and subsequently of EGS. Moreover, extending government subsidies for legume farmers could stimulate production that would fill new demand gaps (Rubyogo *et al.*, 2016a; Box 3).

Until now, low profitability of legumes has been a key obstacle to private sector participation in EGS production. Critical factors for low profitability have been low yields in seed production, high certification costs, and lack of a certified seed demand forecasting system. Lack of demand hinders seed producers from reaching economies of scale without undue risk, which would in turn lower production costs. In order to address these constraints, the public-private partnership (PPP) on EGS would:

- Establish a centralized EGS demand forecasting system.
- Adopt QDS as the preferred class of commercial seed (however this requires that states enact legislation to allow QDS).
- Implement a localized seed production model.
- Stimulate demand for improved varieties and quality seed at the farm level, demonstrating farm-level benefits. In order to stimulate demand, the EGS-PPP includes the following:
  - Expand farm-level demonstration trials.
  - Introduce and sponsor the widespread use of small seed packs.

The EGS-PPP will stimulate demand for quality seed by building farmer trust in the quality seed system. While the EGS-PPP mechanisms and operating principles described above are innovative yet limited in application, the overarching model fits within traditional PPP approaches and existing laws.

4.4.6 EGS revolving fund

Financing EGS through revolving funds that could be government-regulated could also enhance its production. That can work on the principle of loaning. ICRISAT has popularized this approach in Malawi for groundnut, chickpea and pigeon pea, where breeder seed is produced under the supervision of ICRISAT

Box 3. New bean variety dissemination through public-private partnership in Kenya

Until recently, the Kenya Agricultural and Livestock Research Organization (KALRO) was the only organization producing seed of improved bean varieties working with a network of smallholder farmers trained as seed producers. The KK8 bean variety, released in 2008, is resistant to bean root rot, a devastating disease across East Africa. It also gives high yields, matures early, cooks quickly, tastes good and sheds its leaves, putting nutrients back into the soil and making the beans easier to harvest.

A step-change was needed to deliver the variety to more farmers. "We knew we needed to involve the private sector," says Joyce Malinga, Director of the Food Crops Research Institute at KALRO. "Seed companies have the resources, land and dealer networks needed to scale up seed production and distribution." The question was how to attract the private sector, given the assumption that farmers will never buy seed if it is not hybrid. Despite imports of 592 tons of bean seed in 2013, many potential partners felt that there was no local market for bean seed in Kenya. The private sector needed to know that there was a market in order to invest in seed production. But without seed or widespread awareness among farmers that improved varieties exist, there was no proof of a market.

A public-private partnership was brokered by the Syngenta Foundation for Sustainable Agriculture (SFSA) and led by KALRO to get improved bean varieties into the hands of more farmers in western Kenya. While the Bubayi Seed Company tested the new variety for yield and disease resistance, the One Acre Fund tried out the new variety in their nursery and on farmers' fields and selected KK8. The seeds, which are certified by the Kenya Plant Health Inspectorate Service (KEPHIS), are found to be popular. In 2013, Bubayi supplied 100 MT of KK8 seed to One Acre Fund. The following year, demand among One Acre Fund clients grew by eight percent. One Acre Fund is promoting (and demonstrating) an input package which includes credit and crop insurance. This package is conditional on buying the bean seed, a process called 'bundling', where putting together several services in one package may help increase demand. Bundling is one useful idea that should be tried more – it does not guarantee farmers would buy more legume seed, but it might help.

The model, which relies on farmers buying seed on credit as part of a financial package for inputs, demonstrates that farmers are willing to invest in bean seed. It also shows that the inputs are paying off – One Acre Fund does not provide seed to farmers unless the loan-repayment rate is high. Similarly, despite the likelihood that a farmer will only purchase seed every three years, as beans can be resown from the previous season's harvest, Bubayi's investment shows that they see bean seed production as potentially profitable. Partnerships like those between KALRO and Bubayi illustrate that demand is there and rising.

scientists, followed by foundation and certified seed production by contracted individual farmers and farmer associations with a "buy-back system" by ICRISAT and quality certified by the Seed Certification and Quality Control Services Unit (SCQSU). Using the same model, the NARS could be empowered to establish revolving funds to produce and supply EGS.

4.4.7 Government levy

EGS production could be funded through a levy to be reinvested in EGS production (as is done for cash crops in some systems). Bishaw *et al.* (2008) summarized that in Australia all farmers pay a levy based on the gross value of production at the farm gate; in Canada legume growers pay a levy based on the gross value of all pulses sold; and in France farmers pay a fee based on the total legumes produced, which is matched or supplemented by the government or the industry to support scientific research and commercialization.

4.4.8 Variety maintenance

Variety maintenance ensures that the purity and identity of the original variety is maintained through annual multiplication cycles of nucleus or breeder seed. The amount of certified seed that can be produced depends on the amount of EGS seed available, which further depends on the amount of breeder seed whose availability and quality depends on efficient variety maintenance.

4.5 Principle 5: Mainstreaming the legume seed system requires an integrated approach in tackling the commercial seed class challenge

4.5.1 Strengthening the formal seed supply

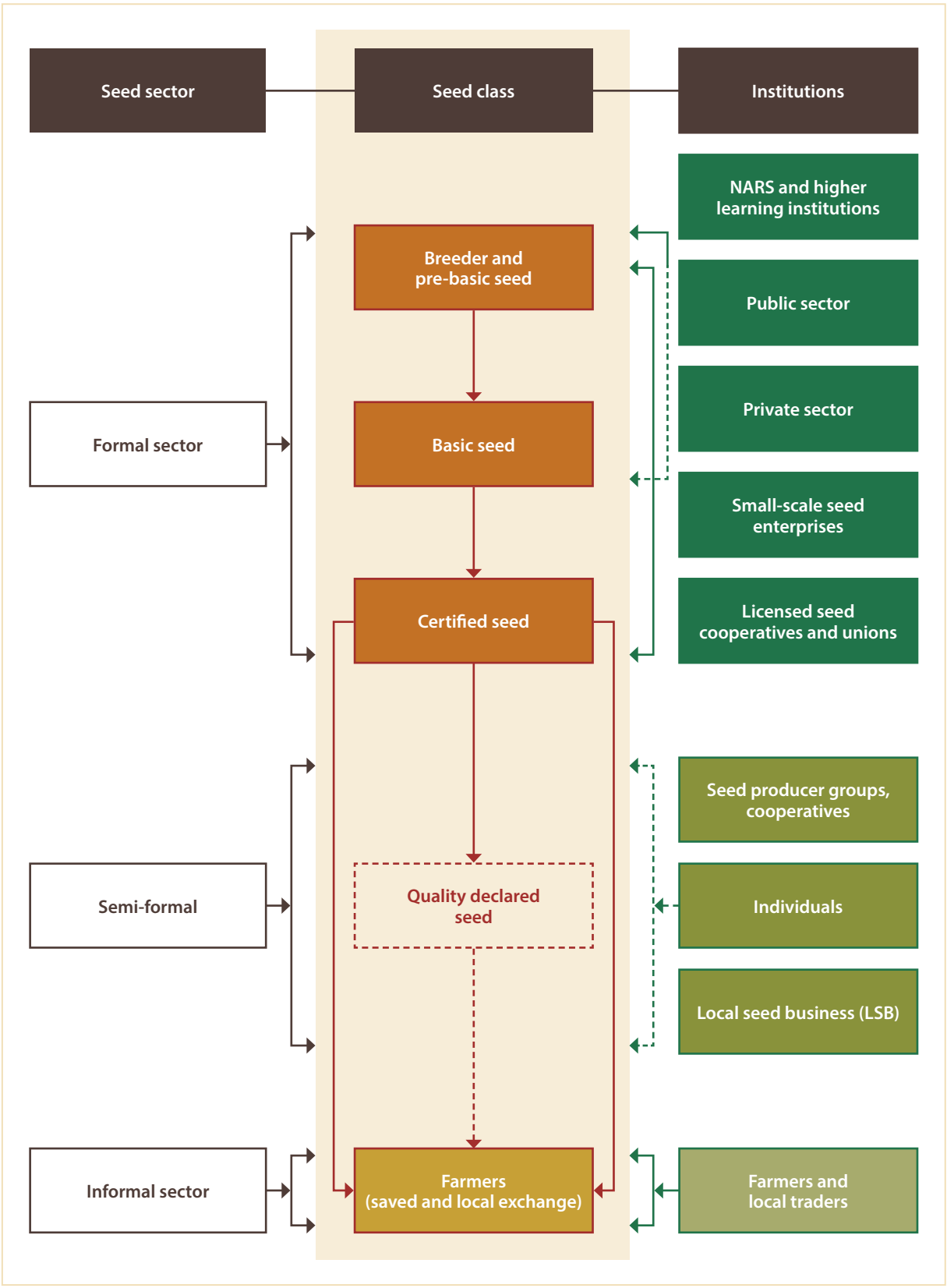
The success of the legume seed industry in developed countries has often resulted from the integration of agricultural research, production technology, input supply, market support and extension information. Byerlee and White (2000) indicated that the success and rapid expansion in soybean production has been attributed to investing in research, mounting wide-scale extension programmes, supporting producer prices and encouraging the industry to develop processing plants and export markets. They suggested that similar efforts are needed for legumes in developing countries. The unique advantages of legumes in farming systems in providing food and nutritional security, enhancing soil fertility and health and as cash crops for domestic and export markets need to be widely demonstrated to farmers and policy-makers to promote and support production. Reforming the public sector and encouraging the participation of the private sector (Figure 12) are among the effective strategies for ensuring the availability of, and access to legume seed through the formal sector and its linkage/extension to initiating alternative semi-formal/informal farmer-based options.

4.5.2 Promoting farmer-based small-scale seed enterprises

In the immediate future, the public sector will remain inefficient in producing sufficient quantities of quality legume seed to meet the demands of farmers. On the other hand, there is no private sector to take up the role and fill the gap. Being profit-oriented and selective in its business strategy, the private sector focuses mainly on profitable high-value cash crops and hybrids. In view of this scenario, neither the public sector nor the private sector is able to provide farmers with an adequate quantity of legume seed of improved varieties. To date, in almost all developing countries, most of the legume seed used by farmers is produced in the informal sector (Figure 12). McGuire and Sperling (2016), in a large sample (2 592 smallholder farmers in six countries), found that only seven percent of legume seed came from the formal or semi-formal (agrodealers, government aid, NGOs, community seed groups) sectors. Therefore, 93 percent came from informal sources, with 64 percent of legume 'seed' purchased from local markets. There is evidence, therefore, that farmers do buy legume seed. However, for various reasons (limited access due to lack of outlets, lack of preferred varieties and high cost of seed from the formal sector), they do not get to buy legume seed from the formal outlets. Most smallholder legume farmers produce and consume or sell all their produce before the planting season to meet their basic needs and are therefore compelled to purchase seed. A few farmers with alternative sources of income manage to hoard their produce for better prices during shortages just before the planting season. The latter group of farmers then sell their grain in the market that is bought by the less fortunate farmers and planted as seed. The greatest concern is the poor quality of the 'seed' obtained from such market sources. The seed often has to be sorted, leading to significant sorting loss, and suffers poor germination, vigour and crop establishment.

Therefore, mobilizing and engaging farmers in seed production and marketing and promoting farmer-based small scale-enterprises is an alternative in the way forward. Several authors have described different forms of farmer-based small-scale seed enterprises which can potentially produce and market seed in a profitable and sustainable manner (Sahlu *et al.*, 2008; Kugbei and Bishaw, 2002, Louwaars and de Boef, 2011). These include individual farmers, groups of farmers, cooperatives, and farmers' organizations or associations (Box 4). To date, there are many variants of farmer-based seed enterprises of different sizes and shapes being implemented across Africa and elsewhere (Ojiewo *et al.*, 2015b). Bishaw *et al.* (2008) identified an intermediary seed sector called 'semi-formal' or 'intermediate' operations, whereby partial quality control is done by regulatory authorities, as opposed to the totally informal sector where seed is produced and exchanged between farmers. Bishaw *et al.* (2008) emphasized profitability and sustainability as core values of any farmer-based small-scale seed enterprises and elaborated the key steps for establishment and operationalization, including group formation and registration, technical backstopping, provision of inputs/facilities, development of business plans, and baseline and seed demand surveys.

Figure 12. A simplified schematic representation of integrated approaches and institutional partnerships in the production and supply of various classes of legume seed through the formal, semi-formal and informal sectors.



ICARDA is promoting an alternative approach by establishing village-based seed enterprises (VBSE) to produce and market quality seed in selected communities for seed delivery, targeting less favourable/marginal and remote/isolated areas where the formal seed sector has no or little coverage (Bishaw and van Gastel, 2008). The main purpose of the VBSE is primarily to mobilize and organize volunteer farmers into local 'seed production and marketing enterprises'. The enterprises are supported by providing training in seed production technology, finance and business management; sourcing seed and other agricultural inputs to initiate production; ensuring seed quality through field inspection and seed testing; and promoting the varieties through field days. The groups will manage all seed production operations and marketing through local contacts or networks. The challenge lies in the sustainability of such groups beyond project life.

Box 4. *Case study 1:* Village-based seed enterprises in Afghanistan

ICARDA is promoting business-oriented village-based seed enterprises as an alternative approach to seed delivery for crops and regions where the formal sector does not operate or exist. Participatory diagnosis of the seed system carried out across Afghanistan and access to seed have been identified as critical bottlenecks. Given the poor infrastructure and the geography, decentralized seed production was a legitimate choice.

A multi-stakeholders process was set in motion including ICARDA, the Ministry of Agriculture and Livestock (MoAL), provincial agricultural development and extension offices and farmers. In each district volunteer entrepreneurial-minded farmers identified, organized and elected group leaders and trained in technical, enterprise and financial management to engage in local seed production and marketing. Farmers were provided with seeds and inputs and closely monitored during seed production. A tractor, a stationary thresher and a mobile seed cleaner were provided for each VBSEs for handling seed production. The VBSEs organized field days and engaged in promoting their products. They became registered and established brand names and were assisted by provincial agricultural development and extension services for seed marketing.

From 2004-06, 21 VBSEs were established that produced 15,049 MT of wheat, rice, mung bean and potato and the total net income generated was US$ 0.8 million in 2004/05 (15 VBSEs) and US$ 2.3 million in 2005/06 (17 VBSEs). Similarly, during 2006-08, 17 VBSEs (12 new) produced 3,856 MT and the total net income generated was US$ 0.2 million (2005/6), 0.32 million (2006/7 and 1.31 million in 2007/08.

Each year, the profitability of the enterprise is analysed and business plans developed to guide and diversify seed production to include wheat, rice, mung bean and potato. District-level VBSEs were organized into a provincial agricultural seed company and eventually became members of the national seed association, which represents their interests. Support over years has led some of the VBSEs to transform themselves into small to medium-sized seed companies.

Benefits and successes emanate from guiding principles which include, but are not limited to, the following:

- Participatory – serve defined target groups mobilizing and involving farmers in less accessible and/or remote areas;
- Decentralization – multiply varieties tested and selected based on farmers' preferences in target areas;
- Market-oriented – link seed demand with production at local level based on farmers' realistic needs;
- Relevant quality – adopt appropriate seed quality standards that meet farmers' diverse requirements;
- Appropriate technology – use low-cost seed equipment to improve quality at farm level;
- Income generation – add value and derive better income from rural farm enterprises;
- Sustainability – institutionalize seed production and marketing by farmers to continue with the seed business without external support.

Box 4. *Case study 2:* Farmer seed enterprises in Uganda – Sonia David; *Agriculture and Human Value 21: 387-397* (2004)

Three bean-growing groups in Uganda were involved – one group, IBFA, had previously produced bean seed and received training, while the other two were trained over five days on pest and disease identification and management, agronomy for seed production, postharvest handling of seed, simple methods for testing germination and moisture content, marketing and promotion, bookkeeping, costing and group dynamics.

Groups were provided with three pieces of equipment – a threshing rack to reduce loss/mechanical damage to seed, a sorter to enable them to clean seed and for work to be done while seated, black polythene sheets for drying. No financial assistance was provided to any group and the equipment and seed were provided on a 'cost share' basis. Producers decided which varieties to multiply.

The project involved two bean varieties (K132 and K131) which were released in the same year that the farmer seed enterprise (FSE) began production with the same varieties. These varieties were identified for production because they had similar characteristics to a widely grown and marketable variety (K20), but with higher on-station yields. Farmers were given the choice of multiplying local land races, but preferred K132 and K131 due to yields with K132 preferred for its higher yield compared with K131. FSE fields were not inspected, but the seed was tested for germination and health to assess pathogen infection levels. FSEs recorded 20 percent higher germination rates and lower pathogen infection compared with seed from other commercial sources, but did not compare germination rates or pathogen levels with bean seed from farmers.

Box 4. *Case study 3:* Successful community-based seed production and dissemination in Uganda

An example of successful community-based seed production and dissemination was reported in the promotion of root rot-resistant beans in the highlands of southwestern Uganda (Opio, 1999). Bean-dependent communities were going hungry owing to losses from this disease complex, but the narrow ecological niche occupied by this farming system generated insufficient seed volume to interest the formal seed sector. The Nyamabale Bean Seed Producers (one of the farmer groups that had evaluated the root rot-tolerant lines) stepped in to fill the gap, registering as a community-based seed producer with support from NARO and the National Agricultural Advisory Services (NAADS). By 2009 this community-based organization (CBO) was producing 15 tons of seed annually of resistant varieties that had been released just three years earlier, which demonstrates long-term sustainability after the establishment of these varieties.

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The authors documented important lessons and factors that contributed to the success of the village-based seed enterprises (VBSEs) as:

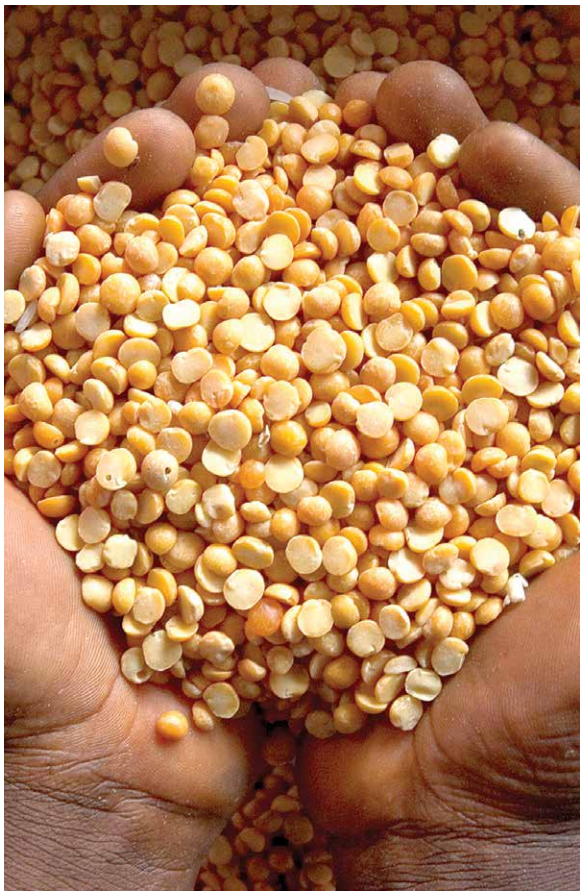
(i) Recognition of the VBSEs as business entities by farmers and other stakeholders enabled them to get access to low interest rural credit services;
(ii) Access to other complementary inputs such as farm machinery acted as a catalyst for development;
(iii) Realization of profits helped to strengthen members' commitment and change of attitude towards commercial production;
(iv) The formation of voluntary groups enhanced the sense of ownership of the initiative;
(v) Effective and regular monitoring and evaluation by peers improved transparency in the farmer-based small-scale seed enterprises.

Srinivas *et al*. (2010) demonstrated that the sustainability of VBSEs depends on technical capacity in terms of the quantity and quality of seed produced and financial performance in terms of enterprise profitability, and that they should be properly organized and supported, linking them to NARS, development practitioners, credit institutions, etc. A similar approach is used in scaling out faba bean and chickpea projects where either existing or new farmer groups are engaged in local seed production and marketing. Khanal (2013) proposed an analytical framework on the sustainability of community seed production to include economic, environmental and social viability. Scaling up/out these lessons requires a sustainable resource mobilization strategy, time commitment by members, frequent assessment of demand and farmers' willingness to pay to support the initiative, and consistency in the ability to make profits. Farmer-based seed enterprises have been promoted by ICARDA (through various projects), ICRISAT (through TLII and TLIII), CIAT (through PABRA) and ISSD (in different formats) in many Eastern African countries. Collectively, these are farmer-based seed-production and marketing schemes that undertake seed business with a view to making a profit (Bishaw *et al.*, 2008).

4.5.3 Supporting emerging seed companies

Farmers in rural areas, primarily women and youth with an ability to learn business skills, can be identified, organized as a group or as individual entrepreneurs, trained or coached in the seed business and directly registered as seed companies (Box 5). These small-scale business groups or individuals can also be linked to major seed companies as contract seed producers. Governments may provide financial support mechanisms or incentives such as loans, tax waivers and subsidies to enable the firms to get established and insurance to protect the upcoming companies from climate and market uncertainties and shocks.

Implementation of this business model may proceed through three trajectories: demand analyses; recruitment of youth and women; training and coaching. The demand analyses will focus on a practical seed demand analysis and forecasting of the 4A concept of Acceptable, Accessible, Affordable and Available (Shayashone Company, unpublished). The selection of the youth and women is based on intensive interviews and recommendation by the local administration and elders. The selected youth and women are trained and coached in practical seed business management of the 3S model of Starting, Scaling and Sustaining a seed business ((Shayashone Company, unpublished). The approach is continuous group learning where people are first exposed to the basic concepts and then a series of group and individual sessions is conducted based on practical problems.



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Box 5. Evolution from individual farmer seed producer to small-scale private seed company

1. Ameha Abraham, a farmer from Adaa district in central Ethiopia, has been growing improved desi and kabuli chickpea varieties since 1995. In 2009, Ameha and his colleagues were supported through the tropical legumes II (TLII) project to form a seed producers' association with 119 member farmers. Ameha and other farmers started by selling seeds individually to seed producers' associations. In 2012, Ameha and a fraction of the association members set up a private seed company – Amuari High Yielding Varieties & Agricultural Products PLC. The initial funding of ETB100,000 (US$5000) was in the form of share capital of ETB10,000 each from 10 founding members.

"Our company has diversified from chickpea and in 2014 we produced teff seed on 57 ha, wheat on 50 ha and chickpea on 31 ha. We estimate that we will get a total of 500 tonnes of seed from four districts. The average chickpea productivity of the company is 3.5 to 4.5 tonnes/hectare, much higher than the national average of 1.9 tonnes/hectare. We dare to grow really big!!"
(Ameha Abraham, CEO)

The company sells seeds to the Ethiopian Seed Enterprise (the federal public seed agency), research centres and buyers from other areas. Currently it rents seed-cleaning machines, but plans to purchase its own machine. Facing a lack of space to store seed, the company recently built a small storage space and is looking to expand. The company plans to tap into the export market once they have sufficient production. Ameha and his team dream of setting up a big company dabbling in seed production, dairy, poultry, apiculture, etc. Besides receiving technical support from Ethiopian Institute of Agricultural Research through Debre Zeit Agricultural Research Center (with technical backstopping by CGIAR Centers, ICRISAT and ICARDA), Amuari PLC also receives market and value-chain support from other programmes such as Integrated Seed Sector Development (ISSD) and financial support from AGRA.

2. Another good example is the Community Enterprises Development Organization (CEDO), a membership agricultural enterprise development organization that is committed to improve agricultural production, incomes, food and nutrition security of farmers and vulnerable groups in Masaka, Rakai, Lyantonde and Sembabule districts in southwestern Uganda. Working with 15 000 households of whom 63 percent are women, CEDO seeks to improve agricultural production through provision of appropriate agricultural technologies; improve incomes of smallholder farmers; improve food and nutrition security of farmers and vulnerable groups; engage farmers in bean seed production, processing and collective marketing; access crop finance and agriculture credit; and strengthen relations between small-scale bean seed producers and other chain actors including agro-input dealers, seed and grain buyers and processors. To achieve its objectives, CEDO interfaces with stakeholders at different levels, thus influencing community dynamics to deliver innovations resulting from research. It addresses gaps in the seed systems through the establishment of learning sites for participatory variety selection; use of palatability tasting for selection of appropriate varieties from research to the end user; and links with other research agencies for implementation of innovations on social economics, seed systems and nutrition.

The collaborative research approach involves cost sharing between CEDO, CIAT and NARO for implementation of projects in terms of materials and resources; as well as development and transfer of improved seed technologies and bean production skills among smallholder farmers. The increased access to improved varieties and enhanced production skills has led to an increase in bean productivity, with improved varieties such as NABE15, 16 and 17 having a yield ratio of up to 1:35. Postharvest losses were reduced significantly from 30 percent in 2006 to nine percent in 2012. In addition, there were significant improvements in household income levels. For instance, in 2012, bean sales accounted for 50.48 percent of household income, while access to credit enabled farmers to reinvest in agriculture, purchase assets and pay school fees. CEDO was then assisted to register as a seed company in 2010. CEDO increased certified seed production of common bean from 50 611 MT in 2010 to 296 082 MT in 2017, which is as good as any private sector seed company would probably do.

4.5.4 Distribution of small seed packs

Grisley (1993) analyzed bean seed production and distribution in Rwanda and proposed alternative strategies owing to the failure of the public and private sectors in providing seed to small-scale farmers. He suggested a non-commercial approach for crops not handled by the formal sector whereby seed packs are distributed to farmers in small quantities to encourage informal varietal diffusion and adoption rather than regular seed production and supply for beans in Sub-Saharan Africa. Small seed packs of about 2 kg are used instead of large 50 kg gunny bags. This small pack model was further explored and systematized in the Tropical Legumes II project involving national programmes and the private sector (Rubyogo *et al.*, 2016b). The approach has been quite successful in Malawi (Chirwa *et al.*, 2007) and Kenya (Box 6).

The small packs approach is increasingly gaining popularity as the most efficient and cost-effective means of reaching more farmers with affordable quantities of seed and a wide range of preferred varieties (Maereka and Rubyogo, 2015). The use of small packs is based on the premise that farmers want access to new varieties and are willing to pay for certified seed at affordable sizes and costs. It also reduces the degree of risk for risk-averse farmers by observing performance of new varieties in small demonstration plots in comparison with their regular varieties. Seed of selected varieties is availed to farmers in starter packs, or at times through sale of small seed packs. This is followed by the training of farmers in integrated crop management and seed production. Small seed packs ranging from less than 1 kg to 25 kg have been extensively used in seed dissemination across several legumes in Africa. It is also possible to link small seed packs with on-farm seed production by clustering the land and organizing and training the farmers.

Box 6: Example of success with small seed packs in Kenya

In Kenya, KALRO initially partnered with Leldet Seed Company and CIAT/PABRA to test the marketing of the small seed packs. A company pickup truck travelled to villages on market days and with a loudspeaker announced the sale of samples of new varieties from the back of the truck. The truck was often mobbed by enthusiastic farmers seeking access to the new varieties, many of whom were women. Leldet became convinced that this presented a significant market opportunity. The price charged per gram of seed for these small packs is in fact higher than for conventional large bags, so profitability is maintained, yet the absolute cost of the seed pack is well within reach of poor women (less than US$0.13/ 100 g) and provides enough seed for homestead cultivation.

As improved varieties become known through this mechanism, more companies joined in. Dryland Seed Company, Kenya Seed Company and KALRO Seed Unit packed and sold more than 89 MT of seed of improved bean varieties in 0.1 kg, 0.5 kg, 1 kg and 2 kg packs. This improved the availability of common bean seed to more than 108 500 smallholder farmers. Additionally, 35 566 and 3 568 smallholder farmers were enabled to access soybean and chickpea seeds respectively through this approach from 2007 to 2013. Public-private partnerships have adopted the small packs approach as a new marketing strategy tailored for smallholder farmers, particularly those living in drought-prone areas. Tanzanian public and private seed companies have progressed from a 50 kg seed bag to 2 kg small seed packs, selling 542 MT of beans in 2 kg packs; up from less than 10 MT three years ago.

Selling seed in smaller packs has both commercial and societal equity benefits as it helps to create greater awareness of the variety available and ensures poorer segments of the society are easily reached. The small packets also help seed companies gain new clients – at least some of the small packet buyers return in later seasons to buy larger packets. Nutrition needs to be made an explicit objective/part of the value chains as consumption is a major driver of utilization and demand creation.

4.5.5 Revolving seed loan and seed fund systems

In this model, local agencies receive initial seed through purchases or grants and, together with the farming community, identify farmers to receive the seed on loan (Box 7). After harvest farmers return one to three times the amount of seeds to the service providers/organizations. Upon receiving the returned amount, the service providers identify additional beneficiaries on a similar loan arrangement. The revolving loan continues for three to four seasons until the variety becomes popular and widespread. The breeder or seed specialist from relevant institutions trains the farmers in quality seed production and provides technical backstopping during the season to ensure that the seed is of high quality. A related model to the revolving seed loan is to revolve cash earned from sales of the seed, rather than revolving the seed itself. Development partners put up the initial cash to establish the seed multiplication capacity, and that cash revolves back following seed sales.

Box 7. Revolving seed loan system in Malawi

ICRISAT has been catalyzing this nonprofit model for groundnut and pigeon pea in Malawi in close partnership with NASFAM. ICRISAT selects outgrowers and gives the seed on credit, funded by the revolving fund; then at the end of the season the farmer sells the produced seed to ICRISAT. ICRISAT pays the farmer the contract price per kilogram of seed using the money from the revolving fund and then sells the seed to seed companies, NGOs and other farmers. Proceeds received from buyers go back to replenishing the revolving fund. ICRISAT tries to limit the sale of seed to those organizations that will further multiply the seed, such as NASFAM and FIPS-Africa.

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4.5.6 Village-based seed bank system

In the remote areas with poor road infrastructure, seed banks were introduced to deliver seed of improved groundnut varieties to farmers. Under the Seed Bank model, producer groups, extension (for training) and agricultural village committees collaborated in the selection of seed beneficiaries who receive seed through a "pass on system" with a seed 'recharge' every four years. Farmers who have been trained as seed producers are encouraged to sell or exchange seed informally within the community. The same farmers or farmers' groups whose capacity has been built for quality seed production are then later used as contract farmers by seed companies.

4.6 Principle 6: Mainstreaming legume seed systems requires institutional capacity building

Strengthening the human resources and infrastructure capacity within the research for development continuum is critical in Eastern Africa. The capacity of African hubs and NARS should be built for modern breeding and seed delivery approaches so that scientists leverage the advances of these tools and technologies. Breeding efficiency, capacity and quality and delivery of innovations through efficient seed systems will be significantly improved if the breeding and seed systems programmes sustainably adopt modern tools and best practices. Each African legume breeding and seed systems programme should strive towards improving its targeting, speed, scale, efficiency and quality (control, precision and accuracy) according to its unique characteristics and resources.

The breeding and seed systems should develop product profiles for key varieties needed for each region, prioritize traits, rationalize resource allocation and ensure the testing best aligned with target environments and markets. This will ensure that the new varieties are adopted with ease and limited promotion as breeding will be demand-driven. Breeding speed could be faster if the programmes have the capacity to obtain additional generations per year, implementing rapid Single Seed Descent (SSD) workflow with appropriate recycling of elite parents in the pipeline and establishing a calendar workflow of key activities on a monthly basis to achieve rapid cycling around the year. The throughput of breeding lines and new varieties could be increased with similar investment if the breeders make more crosses, handle larger populations and evaluate more plots at more sites.

Adoption of digital tools like the breeding management system (BMS) and molecular markers will help to achieve greater scale. Use of modern high-throughput phenotyping and genotyping protocols and platforms would greatly increase the output and allow greater scale and efficiency. Improved technique and operational efficiencies in the breeding pipelines and testing methodologies will allow these increases in scale and precision to be achieved with relatively smaller increases in expenses. Designs that optimize plot size, number of locations and replications per location, increased mechanization and automation (plot threshers, seed cleaners, seed counters, barcoding of seed in storage, electronic data capture) and processes that improve precision and accuracy of data and data handling should be adopted. Improved experimental and statistical designs and methods (e.g. statistical removal of field trends in trials) through BMS, genotyping and analytics for quality control of parents and crosses and

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better trial site land management and other practices to reduce experimental error and increase heritability would all together improve product quality.

It is important for breeders to track pipeline metrics by test stage – numbers of crosses, lines established per cross, lines in initial evaluation and yield trials – in order to track improvements made. Other data quality metrics of these trials should be tracked for trends, for example, CV percentage should be decreasing. It is also important for breeders to track genetic progress and genetic gains of the breeding programme. Breeding progress measures the progress achieved in improving a target trait in a breeding programme and is measured by comparing the finished lines or varieties selected from one year to the next for that trait. Genetic gain is achieved when the selected plants have a better combination of genes (i.e. genotype) that control the traits of interest than the unselected plants. In many research institutions, the role of seed systems, seed health and entomology, seed business, seed extension/promotion, seed physiology and seed production specialists is taken up by plant breeders and general plant scientists owing to lack of capacity.

Breeders should be able to broaden the genetic base by greater use of genetic diversity, either natural or artificial, through induced mutations or targeted genetic modification where policies allow. However, improvements in breeding programmes must match with seed delivery models that are rapid and that support rapid varietal and seed replacement to enhance efficiency. Seed production is a specialized task both in farm operations and postharvest handling of seeds. Special farm equipment (plot planters, plot harvesters, small seed cleaners/treaters) operations and appropriate facilities (e.g. irrigation, cold storage, etc.) for EGS production and processing and storage facilities for large-scale certified seed production may be required. At small-scale farmers' level, Purdue Improved Crop Storage (PICS) bags can be very handy, with proper training on their use and under low moisture conditions. On a large scale, additional technologies such as seed drying beads could increase seed shelf life and reduce the rate of deterioration. Seed treatment with chemicals such as Apron Star is not yet a common practice, especially under informal and semi-formal seed production. Seed production requires specific knowledge and practical experience to produce high quality seed. From the outset, assistance in the capacity development of NARS and national seed programmes is key to enhance their technical and managerial capacity.

Extension and advisory services play a central role in seed-delivery systems and accompanying production technologies. Their internal setup and connection to variety development and end users of quality seed of improved varieties are crucial for successful adoption. Building the capacity of national extension and advisory services requires an understanding of the structure of extension systems. For example, Uganda has a centralized extension system, whereas Kenya has recently devolved with extension duties being assigned to 47 new counties. Ethiopia's extension system has nine regions, but the structure goes even further down to *woredas* (districts) and *kebeles* (wards).

Many agricultural and food research and development initiatives have limited access to technical information on improved varieties and associated technologies and practices. A global survey (SciDevNet, 2012[5]) indicated that 71 percent of well-respected development NGOs did not access science and technology for their work. There is an increasing focus on information and communication technologies (ICTs) such as mobile phones or radio to reach farmers on a large scale. However, ICTs are just tools and studies show that their effectiveness depends on content, context and local knowledge (FAO, 2012[6]). It is unclear to what extent ICT managers and programmers utilize participation, interaction and dialogue with farmers and their communities (including extension agents) at any stage of planning. The deployment of ICT solutions is not necessarily accompanied by open source principles, nor do they aid the flow of crucial and specialized information and content to general populations. For example, the required vocabulary to explain the phenomena of climate change may not exist among key populations targeted with ICT messages. A closer examination using a combination of management, social, linguistic and anthropological approaches may be critical before ICT impacts may be achieved.

5 Ramos, Y.J.R. 2012. *SciDev.Net Global Review* 2012

6 http://www.fao.org/docrep/015/i2701e/i2701e.pdf

There is a need for capacity building among stakeholders, particularly farmers as end users of improved varieties delivered to them through seed. There are also some documented examples in which school-aged children and young adults have successfully acted as conduits for information to their farming families (Bain *et al.*, 2002; Alao *et al.*, 2015). Schools therefore become an important institution to target in capacity building and the dissemination of appropriate information.

The African Forum for Agricultural Advisory Services (AFAAS) has demonstrated the overdue need to improve the Extension and Advisory Services (EAS) in Africa for the dissemination of agricultural innovations (AFAAS, 2016), mostly carried in seeds. The current weaknesses of the EAS in Africa have been related to limited involvement of the target beneficiaries in problem definition and solving, lack of adequate incentives for the extension agents and, importantly, poor linkage between research, extension and beneficiaries or end-users of various innovations (Davis, 2008; Taye, 2013).

In-depth assessment of the gaps in innovation systems is required to improve the EAS and determine priority areas for capacity building. This is in accordance with the findings of USAID's Feed the Future discussions on Agrilink (Agrilinks, March 2016), which has led to the following recommendations after a five-year period of assessment:

(i) need for long-term commitment to modernize and strengthen EAS for sustainable change and impact;
(ii) better coordination of EAS to prevent disjointed approaches and create a model of pluralistic EAS;
(iii) advocate for broader support of EAS through documentation of good extension programmes and impacts; and
(iv) develop state-of-the-art EAS models to inform any decision on the devolution, decentralization and financing of EAS.

Furthermore, lack of access to clear, relevant and action-orientated development communications for use by smallholder farming families and field practitioners has been reported as a key constraint to adoption.

4.7 Principle 7: Mainstreaming the legume seed system is linked to the promotion of utilization for improving food and nutrition security

Most people in Eastern Africa depend on diets made up of cereals and legumes, supplemented by roots, tubers, vegetables and small quantities of meat, milk and fish products. The optimal ratio between cereals and legumes in the average diet is approximately 2 to 1, resulting in an amino acid balance that is near-optimal for human nutrition (Bressani, 1988). While increased intake of major cereals will address hidden hunger to some extent, legumes can play much greater role in enhancing nutritional security across the age, gender and economic groups as these crops have a much higher protein content of better quality than the major cereals, which increases the biological value of combined protein when consumed together. Grain legumes moreover have higher dietary fibre, mineral contents, phenolic compounds as well as some of the vitamins. Besides, legume harvests consumed at home supply the micronutrient and less expensive non-animal source protein needs of farm households and surplus is sold to generate family income. In Ethiopia, legumes become even more critical in supplementing the cereal-based diets, particularly in rural areas and for the majority of the population during fasting periods (for followers of Orthodox Christianity), which cumulatively are more than 200 days a year (Bellete, 2005).

Some approaches suggested to address micronutrient deficiencies include supplementation with vitamins and minerals in capsules, tablets and syrups; fortification of foods that are regularly consumed; control of diseases such as malaria and diarrhea to help the body retain essential vitamins and minerals; and diet education on micronutrient-rich foods (VMD, 2013). Efforts to combat micronutrient deficiencies through biofortification of staple crops or by diet supplementation with vitamins or minerals have been commendable. However, these approaches may target only one or a few nutritional factors, and with potentially significant cost implications. Improving diets through diversification of crop production with legumes; selection of superior nutrient-dense legumes; and improving legume availability, access, affordability and utilization are inexpensive ways of improving the nutrition, health and well-being of smallholder farm households.

A good example is in common bean where iron- and zinc-dense varieties have been developed through selection from available germplasm, released and promoted in Rwanda and Democratic Republic of Congo (Bouis *et al.*, 2011). Due to this nutrient density, some legumes have been used to make ready-to-use therapeutic foods (RUTF) for treatment of acute malnutrition or ready-to-use supplementary foods (RUSF) for daily nutrition support (Box 8). Further efforts at value addition that would encourage legume consumption and make micronutrients more bioavailable would not only improve the nutrition status of the populace but would also spur demand for legume products and, in turn, legume seeds.

Box 8: Ready-to-use therapeutic food

UNICEF started procuring ready-to-use therapeutic food (RUTF) in 2000. The growing number of pilot programmes and the subsequent endorsement of a community-based management approach to acute malnutrition in 2007 by WHO, WFP, UNICEF and the United Nations System Standing Committee on Nutrition (UNSSCN), resulted in the demand for RUTF through UNICEF increasing in one decade from less than 5 000 MT in 2003 to 34 000 MT in 2013. The increased quantity corresponds to the treatment of more than ~2.6 million children in 56 countries and has been driven by recent emergencies and greater programmatic acceptance. It will likely increase further due to greater demand from higher coverage rates, an improved management approach to acute malnutrition, and a growing focus on hunger and malnutrition as a result of the UN's Post 2015 development agenda. A joint study by UNICEF, WHO and the World Bank found Africa remains the only region with increased prevalence in global acute malnutrition, which went from 9.6 million under-five children in 1990 to 13.4 million children in 2011.

UNICEF RUTF suppliers have increased from one (2000-2007) to currently 19 manufacturers (2014), of which 14 (74 percent) are local suppliers based in countries with high concentrations of malnutrition. Some of the companies involved include: Insta Products Ltd, Kenya; Hilina Enriched Foods PLC, Ethiopia; GUTS Agro Industry, Ethiopia; Power Foods, Tanzania; Samil Industry, Sudan; Valid Nutrition, Malawi; Project Peanut Butter, Malawi.

It is important to note that the main raw material for preparation of RUTF has traditionally been groundnut. In the recent past, chickpea-sesame-based RUTF has been developed and tested. Needless to say, the involvement of local companies in manufacturing the RUTF spurs new demand for the specific legume grains used as raw material and in return spurs demand for quality seed. This requires that the local grain produce and the seed too be of good quality.

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4.8 Principle 8: Mainstreaming the legume seed system involves market linkages and income security

At a recent workshop in Nairobi to develop a Seed Systems Strategy for Grain Legumes and Dryland Cereal (GLDC) Crops, attended by more than 70 stakeholders from more than 40 diverse institutions and 20 countries from five continents, participants argued that adoption of improved varieties and use of quality seed from authentic sources depends on the demand and end use of the final product. The value of the final product affects farm-level decisions such as the fraction of resources allocated to a crop, to a variety within a crop and to the source of seed of that variety, as well as the frequency of seed replacement. End-use decisions determine the choice of a farmer to produce one crop instead of another, to produce a particular variety of that crop instead of other varieties, to obtain seed of that variety from particular sources instead of others and also the frequency at which the farmer will replace the seed. A farmer producing for subsistence may be keen on the taste and other traits such as cooking time and flatulence (intestinal gas) but will not care much about the quality or source of seed and may recycle the seed over several seasons. However, a farmer contracted by an aggregator for the export market will be keen to meet the standards required by the market and will carefully select the variety, replacing the traditional one with the specific one demanded; the source and quality of seed that will ensure high-quality produce; as well as seed replacement from season to season to ensure that the produce quality is maintained. This in turn affects the demand for high-quality seed from commercial sources. This was recently observed in practice from field visits in Tanzania (Ojiewo *et al.*, personal observation) where a bean farmers' association allocated 98 percent of their field to a red mottled bean variety production for the Kenyan market and for their subsistence reserved a small fraction of the land for the cultivation of a lower-yielding yellow bean variety causing low flatulence.

Legumes fetch better prices than the commonly traded cereals. |Legumes are moreover in high demand, especially in India which is still a net importer due to vegetarian dietary habits (Alene *et al.*, 2012). Pigeon pea, for example, has substantial regional and international export potential, and India alone imports 506 000 MT annually (Kumar, 2014). Eastern and Southern African countries export about 200 000 MT of pigeon pea grain per year worth $180 million. Farmers in the Central and Northern Tanzanian regions of Babati and Karatu intercrop pigeon pea with maize for its drought tolerance, value as a protein source, fodder for cattle, soil fertility improvement (nitrogen fixation, phosphorus cycling) and income generation. Adoption of improved Fusarium wilt-resistant pigeon pea varieties in Babati has reached 60 percent and the crop contributes more than 50 percent of smallholder farm household incomes (Monyo and Varshney, 2016). Community-based seed production and marketing systems for dissemination of high-quality seed, evolved in pigeon pea producing areas of Tanzania to meet the demand for high-quality seed in response to export demand (Abate *et al.*, 2012). This demand attracted more than 10 big companies/estates producing quality seeds for sale to grain farmers (Ganga Rao *et al.*, 2014). Larger seed companies are expected to enter the pigeon pea seed market, due to ever growing demand for pigeon pea exports.

During the 2014/2015 cropping year, 1.08 million smallholder farmers in Ethiopia produced 458 682 tonnes of chickpea on 239 755 ha of land (CSA, 2015). Out of this, more than 48 700 (10.6 percent) tonnes of chickpea, worth of 22.5 million USD, was exported to 22 different countries (Ethiopian Revenue and Custom Authority unpublished data), while the rest was traded and consumed locally. The local demand and price of chickpea grain is apparently higher than the international market prices. This has raised the price of chickpea seed and stimulated seed growers' associations, seed companies and public seed enterprises to be involved in the production of chickpea seed. Recently, Verkaart *et al.* (2017) reported a 50 percent increase in the adoption of improved chickpea varieties, a 35 pecent increase in the number of households growing chickpea and area expansion from 0.17 to 0.4 ha per household from 2006 to 2014, which are in part a reaction to high demand and prices.

The East African Grain Council and the International Trade Centre recently signed an agreement with India to access its pulses market estimated at USD 4 billion (Daily Nation, Business News, Monday April 27, 2015). There is a huge grain demand-and-supply gap to exploit the potential market. The productivity of these pulses still ranges between 0.6-1.0 tonnes/hectare in Eastern Africa, far below the realizable yield potential of 2.0-5.0 tonnes/hectare of improved

varieties under optimal agronomic practices. The major reasons for these low yields are low adoption of high-yielding varieties, use of poor quality varieties with low productivity and market value, poor access to quality seeds, poor soils, drought episodes in rainfed production, limited use of appropriate production technology such as timely planting, sole cropping and adequate plant population. Weed control and pest management at podding stage and in storage could reduce the potential yield and harvestable and marketable grain. Increases in productivity and lower prices associated with adoption of advanced legume technologies have a positive impact on human nutrition and health and food security. Lower prices of food legumes that are realized through increased production in turn free up income for further diet diversification and purchase of other goods and services, thereby creating demand through economic empowerment, with potential ripple multiplier effects (De Janvry and Sadoulet, 2002).

4.9 Principle 9: Mainstreaming the legume seed system is linked to the role in agricultural and dietary diversification and resilience

With long cropping cycles, the major staple crops tend to be more vulnerable to environmental threats and risk of crop failure. Most legume crop species have shorter cycles, are faster growing, require little space, and thus may be less risk-prone. Production of legumes helps intensify cropping systems by utilizing under-exploited production niches, serving as rotation-, inter- and double-cropping with cereals. Besides, some of the legumes occupy small enough space to fit in the backyard or home gardens with minimal resource application. The fast growth and maturity of legumes not only improves soil-protective land cover, but also helps break pest, disease and weed cycles in cereal cropping systems. Furthermore, diversifying farm activities with legumes reduces risks of catastrophic farm-wide harvest losses, thereby increasing farm resilience to climate change. Legumes have a strong potential role to play in diversification and resilience; establishing this role can help strengthen demand for legume seed. Adaptive R&D and promotion are key steps for identifying and establishing legumes in such roles.

In East Africa some extensively used cropping systems include cereals intercropping and rotations with legumes such as pigeon pea, cowpea and common bean as break crops against pests and disease, water harvesting and use with simple irrigation techniques, use of legumes that can be produced under unique niches such as chickpea on residual moisture, integration with livestock while enhancing feed and fodder quality with legume haulms, and home gardens with legumes and vegetable crops. The ability of pigeon pea to perform well in marginal environments by withstanding drought and other stresses where most other crops fail, and low levels of management and input requirement, make it a particularly ideal crop for smallholder farmers in marginal semi-arid environments where year-to-year variation in seasonal rainfall is a major constraint

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for crop production. In addition, the slow growth during the early stages and deep rooting habit makes it highly suitable for intercropping with cereals or other legume crops and thereby diversifying risk and enhancing stability and household food security. Furthermore, pigeon pea has a wide adaptability to agro-ecological and soil conditions.

The ability of the legumes to fix nitrogen and improve soil health enhances farm productivity and smallholder incomes, while reducing the high costs of production incurred through exogenous application of inorganic fertilizers. The fixed nitrogen is gradually released, thereby improving the soil fertility and making the nitrogen available for the subsequent crop (or intercrop), mostly cereals (Crews and Peoples, 2005). Besides nitrogen fixation, pigeon pea enriches soil by immobilizing fixed phosphorus (P) and making P more available and enriching the soil with leaf fall. It also enhances the soil conditions by improving soil structure, breaking hard pans and reducing erosion, especially on slopes. The subsequent cereal crop will not only give higher grain yields for human consumption, but also higher stover/grain yields for livestock (including poultry) feed. Legume haulm itself is nutritionally rich as livestock feed, improving milk, meat and egg production and quality in crop-livestock farming systems. The livestock manure and poultry droplets go back to the crop production fields to improve the soil structure and fertility and ensure a sustainable land resource management. Thus, legumes support a crop-livestock system that enhances system efficiency and sustainability as well as family nutrition status. Such an interaction therefore not only enhances productivity of the staple crops with reduced inputs, but also diversified diets (legumes, meat, egg and milk) that make those staple foods nutritious (Ojiewo *et al.*, 2015a).

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The Sustainable Intensification of Maize and Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA) project promoted diversification of maize production systems with legumes. According to adoption studies, over 46 000 farmers across SIMLESA sites adopted improved maize-legume technologies in 2013. On-farm exploratory trials, by 2014, found over 68 percent of host farmers were using two or more of these technologies in Mozambique. Across the six SIMLESA districts in Malawi, the use of these technologies increased from an average of four percent during the baseline year to 38 percent in 2013. In 2014, the project reached out to a total of 173 533 farmers, compared with the target of 143 607, accounting for a 21 percent increase in the number of farmers. Adoption of diversified production systems creates fresh demand for legume seeds (http://simlesa.cimmyt.org/simlesa-review-finds-many-successes-and-major-challenges/).

In the Lake Zone of Tanzania, chickpea is grown as a relay crop after harvesting maize or rice. In most areas the crop is primarily grown as a cash crop, particularly after a steady decline in the price of cotton, and only about ten percent is produced for home consumption (CRS, 2001). However, chickpea consumption is also increasing due to the fact that the production of maize and rice has been very unstable during past years owing to repeatedly unfavourable weather conditions. In addition, the fact that many people do not like to consume sorghum despite the fact that it can grow well, increases the chances of expanding the cultivation of chickpeas. Many NGOs, CBOs and seed companies have taken up active seed production, engaging individual farmers or groups of farmers on a contractual basis to produce certified/QDS seed to meet the new demand for seed required for this diversification.

In 1994, ICRISAT undertook a germplasm collection mission in Tanzania and concluded that chickpea production in the vertisols of the Lake Zone was very promising and its potential could be explored further (LZARDI/CRS, 2002). Between 2001 and 2002, eight new varieties of chickpea obtained from ICRISAT were evaluated on-farm with support from the Lake Zone Agricultural Research and Development Institute (LZARDI). The best five varieties released (ICCV 96329, ICCV 95334, ICCV 92318, ICCV 2 and ICCV 92311) were promoted and are now well adopted for diversification of maize and rice production systems.

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4.10 Principle 10: Mainstreaming the legume seed system is linked to women and youth empowerment

Legumes are often described as women's crops, a fact that belies the centrality of the role they play in food production in developing countries. In Eastern Africa women produce up to 80 percent of all the basic household foodstuffs. Legume production as a small-scale enterprise can be a significant money-earner for poor people, especially women with little capital, limited access to land and working under labour constraints (Lewis, 1997). However, only a small fraction of the women have the necessary enablers such as land title, access to credit, input supplies, information and technology.

One of the principal challenges is to bring forth the contribution of women to household income and nutrition through dissemination of improved cultivars, high-quality seed, machinery and equipment that reduce drudgery and increase productivity. For example, although there is evidence that women in Ethiopia are actively engaged in legume production activities on-farm, they do not attend technology dissemination and capacity building training even if proactive approaches are used to prioritize participants' selection criteria in their favour (Njuguna-Mungai *et al.*, 2016). Some of the reasons identified and reported include limitations in their radius of movement and the society's view of a 'good wife/woman' as well as labour burden, and gender of extension agents. Besides, the number of female scientists working on legume research is limited. In addition, the participation and benefits of women in decision-making and the relative level of literacy are low, compounding other problems such as wage disparities and lack of gender-considerate working conditions that address child care, health and transportation issues. This calls for policy intervention to safeguard gains made by women.

There are increasing indications that the management of legume production and marketing is gender based, with women predominating not only in collection, but also in protection, and planting in fields and gardens (Moreno-Black and Somnasang, 2000). In many parts of Africa, women are more visible in the production and marketing of legumes and small-scale processing (e.g. groundnut for home consumption and local sale), while men tend to dominate in the marketing of cereals in the value chain (Bationo *et al.*, 2011). Activities such as ploughing, irrigation, fertilizer and pesticide application are done by men, while sowing, harvesting and trading are done by women (Gockowski *et al.*, 2003). When men leave agricultural communities in search of employment opportunities in the cities, women assume their tasks. Due to women's increasing roles in the cultivation and marketing of legumes compared with staples such as rice, wheat and maize, these crops are generally considered to be women's crops (FAO, 2007b, c).

The cash from legume sales contributes significantly to food security at the household level and enables women to attain a degree of financial independence within the family budget. Attention to women-specific needs and finding a means to ensure that they contribute to, and benefit from, food security programmes and interventions are key to supporting this process. Increasing women's access to land, livestock, education, financial services, extension, technology and rural employment would boost their productivity and generate gains in terms of agricultural production, food security, economic growth and social welfare. Closing the gender gap in agricultural inputs alone could lift 100-150 million people out of hunger (FAO, 2011). Governments, the international community and civil society should work together to eliminate discrimination under the law, to promote equal access to resources and opportunities, to ensure that agricultural policies and programmes are gender-aware and to make women's voices heard as equal partners for sustainable development. Achieving gender equity and empowering women in agriculture are both crucial for agricultural development and food security. This will enable women to play an active role in the marketing and utilization of legumes, thereby stimulating demand for grain and seed in return.

The youth is another category that is largely ignored and excluded from contributing to the economy of their countries and to overcoming poverty, especially through agriculture. Some 87 percent of the world's youth live in developing countries and make up a third of the population in these countries (Population Reference Bureau, 2013). The majority live in rural areas, where 70 percent of the world's poor live, relying on agriculture as a principal source of income and employment (World Economic Forum, 2013). Youth, however, is largely excluded from contributing to the economy of their countries and to overcoming poverty. In 2013, youth made up 40 percent of the world's unemployed; 536 million of employed youth in developing countries were underemployed (estimated 42 percent of youth in developing countries). In 2010, a staggering 341 million youth in developing countries (estimated 27 percent of youth in developing countries) were not in education, employment or training and their number is increasing.

Another challenge is the very rapid growth of the urban youth population, partly due to the migration of young men and women from marginalized rural areas to the cities in search of jobs, which they rarely find. There are rapid changes taking place in today's globalized world that is typified by migration, urbanization, technological innovations, increasing educational levels and aspirations, and the IT and social media revolution linking the young people to global information and change movements.

On the one hand, these changes are leading to new opportunities for better-paid and higher-status work outside agriculture that cream off some of the best talent among the rural young people. However, these changes also create unrealistic aspirations of a better life in the cities that entice other young people to escape their gruelling and often unrewarding agricultural work, especially in the marginal drylands, only to find their dreams dashed.

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They end up in slums, in unsanitary and poor health conditions, risking malnutrition. In a bid to earn a living, they turn to crime including robbery, violence, prostitution, illicit trade and drugs. With the exit of these young people from the rural areas, the agricultural labour force is ageing in many countries, raising serious questions as to how future populations will be fed. There is a need to retain some younger farmers and rural employment as one contribution to providing viable futures for young people.

There is moreover a need for innovative ways to tap and utilize the efforts of agricultural and rural development to contribute meaningfully to national development, and to improved food, nutrition and income security through legume production. Legume breeding programmes should work towards the integration and empowerment of the youths in production, value addition and marketing to meet the rising demand in the cities. This will increase employment opportunities, incomes and consumption of the legumes to address malnutrition among women and youths.

Agricultural research should recognize the potential role of the youth and the need for participatory and youth-responsive approaches to solving the problems of food, nutrition and income insecurity. Traits that reduce drudgery and technologies that are economically beneficial, such as mechanized farm operations (chickpea), herbicide tolerance for chemical weed control, improved and efficient postharvest handling such as simple shelling (groundnut), threshing, dehulling and dhal-making (chickpea/pigeon pea), early maturing sweet varieties for sprout-making and green pea consumption and the use of ICT solutions would all contribute to making legume production appealing to the youth.

Other technologies like smart-phone based apps for disease and pest diagnosis, mobile plant clinics, GIS-based information gathering and extension systems, the Hello Tractor initiative for automation of farm operations such as land preparation, planting, weeding, fertilizer and pesticide application, harvesting, threshing/shelling, winnowing, packaging and labelling would all work together to make legume production look 'trendy' for the youth. Utilization of alternative and cheap sources of energy in the rural-urban continuum, such as biogas from animal waste (and other biomass connected to legume crop-livestock interaction) and solar energy in drying and other processes, would improve the outlook of legumes.

CARE and ICRISAT jointly ran a project in Malawi targeting women empowerment (http://www.careevaluations.org/Evaluations/Malawi%20Pathways%20Endline%20Study.pdf) through agriculture and using legumes as entry point. Through village savings and lending associations (VSLAs), women came together as legume seed producers and others as grain producers. The women were involved at various stages of the legume value chains, creating demand for products at upstream stages. With additional support from NASFAM in legume marketing and quality control, the women emerged as strong actors in the legume value chain, driving the seed demand higher and yet meeting the same demand as community seed producers.

Cross-learning and reference can be made to the WorldVeg's project on 'Empowering the Youth for Market-Oriented Vegetable Production' based on the premise that 'Vegetable-based agriculture holds the prospect of rapid income generation for households but requires a good mastery of production techniques, good access to markets, and a good sense of social responsibility in providing produce that is not detrimental to the health of the consumers'. The project is aimed at disseminating improved technologies and practices, including promotion of co-cultivation of vegetables with staple crops such as banana, which the farmers were more familiar with.

The project focused on the role of young men and women through training in vegetable production and marketing, creating community gardens to solve the challenge of access to land. However, without adequate production and business skills, investments cannot yield a profitable and sustainable return. The project developed a model training farm on-station and enrolled successive groups of unemployed youth trainees. On graduation, the trainees received a seed package, complemented by logistical support, to start their own business. The project provided "after sales" extension and business support to the graduates for a few production cycles before they were ready to continue on their own. Before long, about 20 groups of 20 youths each were trained in quality vegetable production and some of the groups turned into community seed producers for other farmers (Ojiewo *et al.*, unpublished).

4.11 Principle 11: Mainstreaming legume seed systems requires multi-stakeholder involvement

Developing a sustainable seed system should involve engaging multiple stakeholders such as community-based seed producers, individual entrepreneurs and the smaller domestic seed companies and strengthening linkages among the actors so that they recognize the market for legumes and to stimulate and meet the demand by farmers.

Currently, neither the public sector nor the private formal sector is found to be effective and efficient in legume seed delivery across the Eastern African countries. A simple review of the legume seed sector from selected countries clearly demonstrates the predominant role of the public sector (where it exists) and a limited presence of the private sector. Supporting an integrated seed supply system, and recognizing and exploiting the synergy of both the formal and informal approaches, are key for establishing a sustainable seed system (Louwaars and De Boef, 2012).

Governments have an obligation to address key policy challenges to ensure that investments made in agricultural research to generate new improved food legume varieties and associated technologies eventually reach farmers and realize the impacts on food and nutritional security and livelihoods of the rural population. With the research for development continuum, building effective strategic partnerships among NARS, development practitioners, the private sector and donors remains critical in scaling out agricultural technologies.

Innovation platforms that bring these public and private stakeholders together enhance feedback on regional/national knowledge, data and information on legume trends, priorities and expectations. The innovation platform members are involved in various interlocking functions along the seed value chain, enabling public-private interactions (Figure 13). In addition, the networks:

(i) share evidence on best practices, innovative ideas and problem-solving expertise across the legume crops and regions;
(ii) share facilities and services among those best equipped to carry out different tasks;
(iii) coordinate and foster interdisciplinary and cross-crop project collaboration;
(iv) mentor and train young scientists and provide them opportunities for professional development; and
(v) create scientific consensus of opinion to inform policy-making.

In Ethiopia for example, ICRISAT, ICARDA and national and regional seed enterprises (Ethiopian Seed Enterprise-ESE, Oromia Seed Enterprise-OSE and Amhara Seed Enterprises-ASE), NGOs (Sasakawa Global 2000, World Vision, CARE, Catholic Relief Services, Oxfam America), seed growers' associations (Lemelem Chefe, Hawiboru, Biftu, Chala, Megeretu Denkaka, Ude, Memerhager) and private companies (ACOS PLC, Amwari Seed PLC, Guts Agro PLC, Shayashone PLC, GadiEastern Africa Seed PLC) have helped to step up seed availability of various legumes in the country with the support of several projects and programmes such as Seed Scaling-ICARDA, TLII, TLIII, PABRA, ISSD and SSTP, among others.

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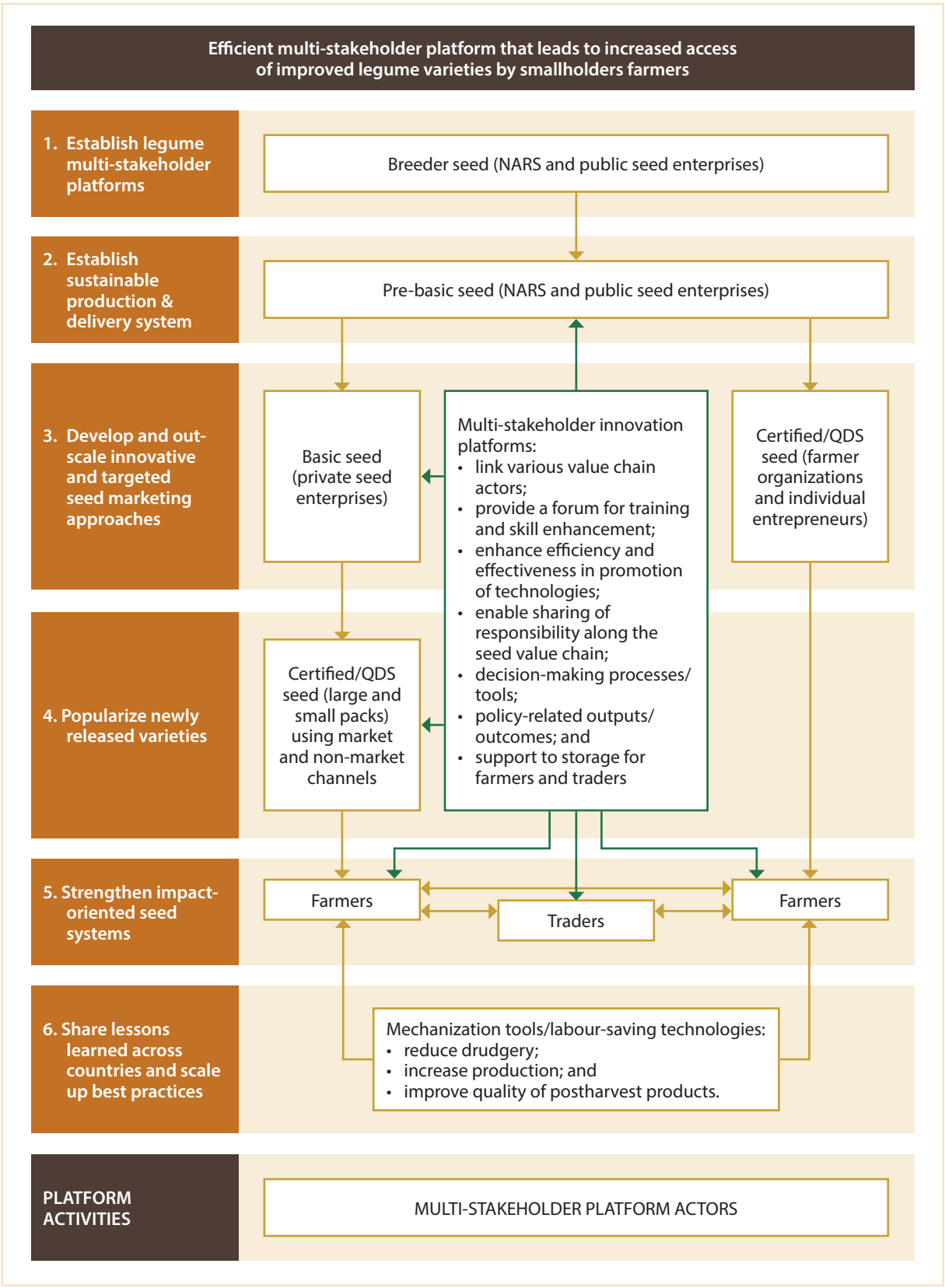
Figure 13. Role of multi-stakeholder innovation platforms in facilitating interactions between informal and formal systems.



4.12 Principle 12: Mainstreaming legume seed systems requires well-defined seed and adoption roadmaps

A seed roadmap is a strategy document that the seed production specialist uses as a planning guide to identify the seed production targets against the objectives. The seed roadmap should be informed by the anticipated seed replacement rate and the potential and stability of existing or new improved varieties which dictate the varietal replacement rates. The seed production specialist may estimate actual seed demand (and grain demand, e.g. for export, processing and local market), target adoption levels in terms of area to be covered or number of farmers to be reached with specific varieties in specific agroecologies (Table 2). The demand forecast for commercial (certified or QDS) seed then determines how much of the EGS is needed. A clear vision for success must be identified and a SWOT analysis done to take advantage of strengths and opportunities while planning improvement approaches on the weaknesses and fallback options in cases of risks/threats.

Critical considerations to make while planning a seed roadmap include the variety characteristics (seed rate, productivity per unit area, resistance/susceptibility to stresses, etc.), target agroecologies (rainfall, temperature, soils, etc.), anticipated constraints and mitigation plans, availability of necessary resources (land, irrigation water, labour, starter seed, etc.), factors motivating farmers' willingness to purchase seed (variety quality, seed quality and perceived value-for-money) and potential partners. Besides the targeted adoption levels, the existing cropping systems (intercropping with cereals, relay cropping, double cropping, rotation, rainfed/irrigated) will contribute to the determination of how much seed is needed.

The market situation, including commodity prices (prices of seed and other inputs and farm costs; cost of growing competing crops) as well as disposable farm income levels (what a farmer will spend on seed; availability of credit and rate or level of adoption of new technology farming techniques will determine adoption levels for new varieties and demand for certified seed. Government policy incentives or subsidies such as price support and credit, extension programmes as well as import or export policy and duty levels will significantly influence farmers' decision to adopt new varieties.

Habits and traditions, such as prolonged fasting in Ethiopia when people do not consume animal products but depend on legumes as protein sources, or in Tanzania where common bean soup is invariably served with every meal, determine the demand for the grain, affecting the demand for certified and EGS classes. The competitiveness of the variety and niche (promotion, price and quality) carved by the seed-producing organization affects the option the farmer has of using alternative varieties and suppliers.

Table 2. A seed roadmap for chickpea seed production in Ethiopia under the Tropical Legumes 2 (TLII) Project

Ecology (Zone)	Demand (ha)	Promising varieties	Yield potential on-farm (t/ha)	Seed rate (kg/ha)	Total area to be covered in ha		Seed production in tonnes						Total seed required to reach 35% adoption (tonnes)
					Zone wise	Variety wise	Breeder seed in 2012		Basic seed in 2013		Certified seed in 2014		
							Area (ha)	Production(T)	Area (ha)	Production(T)	Area (ha)	Production(T)	
Potential	**150 000**	**4**			**52,500**		**16.2**	**25.63**	**205**	**378**	**3 088**	**6 354**	**6 354**
	90 000	Arerti	2.5	120		31 500	3.48	8.7	72.6	181.5	1 512	3 780	3 780
	37 500	Shasho	2.0	120		13 125	2.84	5.68	47.3	94.6	788	1 576	1 576
	7 500	Acos Dubie	1.0	140		2 625	7.21	7.21	51.5	51.5	368	368	368
	15 000	Ejere	1.5	120		5 250	2.69	4.04	33.6	50.4	420	630	630
Moisture deficient	**70 000**	**3**			**24 500**		**8.31**	**14.21**	**118.5**	**203.9**	**1 699**	**2 940.6**	**2 940.6**
	56 000	Habru	1.8	120		19 600	5.81	10.46	87.1	156.8	1 307	2 352.6	2 352.6
	7 000	Minjar	1.5	120		2 450	1.25	1.88	15.7	23.5	196	294	294
	7 000	Yelibe	1.5	120		2 450	1.25	1.88	15.7	23.5	196	294	294
Total	**220 000**				**77 000**		**24.51**	**39.84**	**323.5**	**581.9**	**4 787**	**9 294.6**	**9 294.6**

5. FUTURE PROSPECTS AND OPPORTUNITIES

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The Sustainable Development Goal is to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture[7]". Mainstreaming of legumes in production systems can play a major role in the realization of this goal and the targets set.

While the efforts at policy level in Eastern Africa are commendable, there is limited specific attention to legumes as an alternative source of plant proteins for human nutrition and health, complementing animal protein sources for income and for the environment. There is a need for an integrated approach to create awareness and enhance capacity at various stages in the legume value chain in order to maximize the benefits resulting from improvements in legume technology, especially in terms of variety development and associated integrated crop management practices and scaling up/out of technologies.

Partner institutions engaged in R4D of grain legumes in Eastern Africa have made substantial advances in developing and promoting improved varieties as well as establishing sustainable legume seed systems. Large numbers of varieties have been released in each country, which are high-yielding, resistant to diseases and stress, and have nutritional quality and attributes preferred by the market. Over the past decade, the amount of seed produced and marketed has more than quadrupled, improving access to high-quality seed of improved varieties by smallholder farmers. Technology promotion efforts have resulted in positive impacts in terms of awareness creation and adoption of improved varieties, thereby enhancing productivity and production of legumes. However, such results are often patchy and restricted to intervention areas (low spillover) for larger reach. There is a need for further efforts to exploit available opportunities for achieving larger impacts by enhancing productivity and production of grain legumes.

Breeding efficiency and rate of genetic gain need to be enhanced. There are opportunities to reduce

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the time required in the development of a cultivar by integrating genomics-assisted breeding approaches and rapid generation advancement, thereby enhancing genetic gain. Recent years have witnessed extraordinary growth in the development of genomics resources (structural and functional molecular markers, integrated genetic map, mapping of genes/quantitative trait loci, whole genome sequencing). New molecular breeding approaches like genomic selection (GS) for enhancing genetic gain for development of elite breeding lines for more complex traits could be employed. New advances in phenotyping and statistical tools need to be explored and adopted to enhance genetic gain. Data collection, management and sharing tools such as the Breeding Management System (BMS) of the Integrated Breeding Platform (IBP) offer opportunity for improving the efficiency of breeding programmes.

The involvement of private seed companies in legume certified seed production and marketing is still limited. The informal seed system still dominates as the source of planting seeds for grain legumes. The engagement of community-based seed production and marketing has shown promise to supply seed to smallholder farmers at affordable prices, acceptable quality and in a timely manner. The FAO, ICRISAT, ICARDA and CIAT Community Seed Production (CSP) workshop highlighted the key issues and considerations related to the informal and intermediate seed sector (Ojiewo *et al.*, 2015b), where there is a lack of a general framework for action and where the approaches to CSP vary and are location-specific. To date, available information and the performance of an alternative seed delivery system appear patchy and lack a standardized approach. FAO is addressing this in part through the Seed Toolkits (http://www.fao.org/3/a-i6390e.pdf; http://www.fao.org/3/b-i6396e.pdf; http://www.fao.org/3/a-i6397e.pdf), which are aimed at supporting farmer seed enterprises and those supporting them. Any attempts towards alternative seed delivery may need to address at least the following issues where standardized data need to be collected and analyzed: profitability of certified seed over QDS or farmer saved seed.

Availability of early-generation seed, particularly breeder and foundation seed, remains a challenge. Research institutes mandated to produce early-generation seed have limited human, financial and infrastructural capacity. But maintaining quality in community-based seed production plots has not been without challenge, and seed certification processes are at times lengthy and expensive. Therefore, there is a need for further efforts to engage more private seed producers and enhance the capacity of community-based seed producers. The roles of HLIs in the mainstreaming of legume seed systems need to be recognized and their capacity enhanced to play these roles effectively.

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