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Situating the Grain Legume Agenda in African Agricultural Research for Development Strategies

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About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.
FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).
FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its **mission is the** "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its **Value Proposition is the** "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision.

About FARA Research Result (FRR)

FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access to information generated from research activities, commissioned studies or other intellectual inquiry that are not structured to yield journal articles. The outputs could be preliminary in most cases and in other instances final. The papers are only published after FARA secretariat internal review and adjudgment as suitable for the intellectual community consumption.

Summary

At the household level, legumes have the potential for a triple win - ensuring food security, adaptation to climate change, and mitigation of GHG emissions. Through their potential contribution to ecological intensification and diversification of production patterns in various farming systems prevalent in Africa, they provide sustainable and viable livelihood-enhancing options. This means leguminous crops must necessarily occupy a principal place in the food and nutrition security strategies of African countries. The legume agenda contributes directly to all the three levels of the CAADP Results Framework and should thus be properly situated in country CAADP implementation plans as well as the emerging Science Agenda for Agriculture in Africa (S3A) that seeks to mainstream science as an essential part of agriculture-led social and economic transformation in Africa. The S3A proposes to facilitate collaborative arrangements for pooling and cross-border sharing of infrastructure and human capital to strengthen AR4D capacity of African countries. Landmark advancements have been registered in legume research and development in Africa largely due to multi-country, issue-driven networks typically mediated by the CGIAR. North-South-South partnerships brokered around specific thematic areas have equally contributed to advancement in legume research in Africa. Such models for delivery of legume AR4D need to be fostered to bring to scale available technology and institutional packages. For legumes to play a greater role in human nutrition and economic development, many issues still need research attention. These include technology advancements to improve legume yields and tolerance to biotic and abiotic stresses; screening for susceptibility to storage-induced textural changes; elimination of anti-nutritional and anti-metabolic factors; improving the protein quality and flavour characteristics; expanding the biofortification spectrum; and bioprospecting for more effective Rhizobium strains. Breeding (conventional or using genetic engineering) will be central in addressing many of these challenges, but other downstream value chain competencies (e.g. in processing and postharvest) will also be required.

Introduction

Africa is a region at a crossroads; endowed with great potential but plagued by relentless challenges. Several regions of Africa have been reeling under the adverse effects of climate change. Many countries in these regions will increasingly face huge food deficits due to extreme weather patterns such as the El Nino phenomenon. In 2016, the World Food Program estimated that the lives of about 60 million people in rural and urban areas of the drought-affected parts of Ethiopia, Malawi, Mozambique, South Africa, Swaziland, Zambia, and Zimbabwe were at risk due to food shortage. Other important food producing regions also experienced unprecedented droughts, predisposing the world to another wave of food price hike.

The global food price hike of 2007 – 2011, though partly occasioned by droughts in some parts of the world, was mainly due to high demand for biofuels (especially from grain legume sources) in the developed world, falling world food stockpiles, and increased demand for a more varied diet due to rise in incomes in emerging economies. In Africa, the food riots of Mozambique in 2008 and 2010 are still vivid in our minds; but these were not wholly isolated as such popular citizen mobilization sparked by food deprivation were reported in 30 other countries around the world in the same period.

Persistent hunger and food insecurity in Sub-Saharan Africa emanate largely from inadequate local food production (often exacerbated by erratic weather patterns), inappropriate policies, and lack of the wherewithal by many countries in the region to access externally produced food. Strategic production of local staples is crucial for shelving countries in the region from the vulnerabilities in food supply. Africa abounds in available cropland, water, and fertile soils; yet it is one of the few regions in the world where the food self-sufficiency ratio decreased between 1961 and 2007 (Clapp, 2015). The path to attaining the needed agricultural productivity growth (as well as development of downstream value chains) can only be illuminated by sustained and systematic home-grown research and innovation, being cognizant of the overriding premise that long-term food security in many African countries necessarily hinges on food self-sufficiency. This puts especial premium on investments in agricultural research and development to ensure that more food is produced locally.

The last Pan-African Grain Legume and World Cowpea Conference held in Zambia in 2016 could not have come at a better time and place because grain legumes occupy a prominent place in the African quest for food and nutrition security. Indeed, the conference theme: "Sustainable Grain Legume Systems for Food, Income, and Nutritional Security in a Rapidly Changing Climate" was a very apt interpretation of the United Nations' International Year of Pulses – 2016; a declaration that seeks to solicit high level policy commitments to better position pulses in the global food and nutrition security efforts. Apart from sharing of research ideas and results, the Conference also offered an important platform to lobby for policy action and investments in research and innovation necessary to advance the role of legumes in human nutrition and economic development.

Since the Conference sought "to bring attention to the importance of pulses/grain legumes in improved nutrition and food security, sustainability of cropping systems, and the enhanced livelihoods on the African continent within the context of climate change", one may ask:

1. How can leguminous crops play a greater role in ecological and climate-smart agriculture?
2. What role can legumes play in nutrition-sensitive agriculture?

Some conclusions from the Conference at least furnished common ground regarding tackling such concerns in Africa's agriculture. Equally important is the need for the agreed actions to feed into the prevailing African agricultural development policies.

Why Legumes Matter to Africa

Legumes (especially nodulated food, forage and tree legumes) exhibit adaptability to various agro-ecological zones, drought tolerance, ecosystem services potential, and wide-ranging economic uses. The food legumes provide safe supply of dietary energy, proteins and micronutrients. In some leguminous plants, economic uses can be derived from virtually all parts. For example, cowpea (*Vigna unguiculata*), a native of Africa, is a hardy crop that thrives even in lands with marginal potential and exhibits unique suitability for agroecology. Apart from its use in integrated soil fertility management, both its leaves and seeds are important dietary constituents for many communities in Africa, while the stalks can serve as nitrogen-rich forage for livestock. To the extent that a promotional strapline on the potential of grain legumes for a typical sub-Sahara African farm enterprise diversification could perhaps read thus: "Legumes for food, feed and fertilizer!"

Legumes in the African Diet

From a nutritional standpoint, Bambara groundnuts, beans, cowpea, chickpea, groundnuts or peanuts, pigeon pea, mung bean (also known as green grams), lentils, and soybean are the important grain legumes for the billions of people in semi-arid and tropical regions of many Asian and African countries. Trends over the last 30 years show that pulses are Africa's predominant source of proteins; in fact, the per capita daily dietary contribution has increased markedly since around 2006 perhaps occasioned by rising global food prices (Figure 1). Legume proteins are normally deficient in sulphur amino acids like cysteine and methionine. However, indigenous knowledge systems and culinary cultures evolved over generations made African societies realize the importance of mixing cereals and legumes in the diet. In East Africa, for example, such culinary blends, invariably contain maize and beans of various types. The low lysine content of maize is compensated for by beans and the low sulphur amino acids in beans are in turn compensated for by maize, thereby considerably improving the overall biological value of the meal.

Food grain legumes are also an important source of dietary fiber, antioxidants, vitamins and minerals. They are generally considered to have low glycemic index (and thus suitable for diabetics), and exhibit potency to ameliorate cardiovascular diseases and colonic cancers (Venn and Mann, 2004). There are also indications that grain legumes could help manage HIV/AIDS in victims by increasing the counts of CD4 cells, a primary element of the immune system. Generally, anti-nutritive or anti-metabolic factors in grain legumes such as αgalactosides, trypsin and chymotrypsin inhibitors, phytates, lectins and polyphenols can almost wholly be managed by processing techniques like soaking, cooking, sprouting, and use of food grade additives.

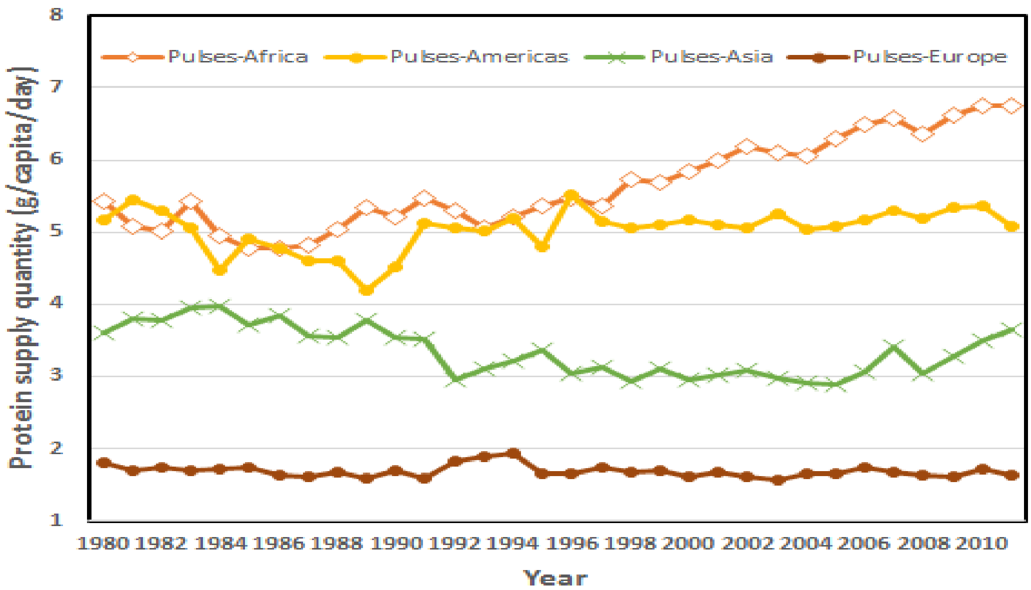

Figure 1: Protein supply from pulses across four regions (Source: FAOStat, 2016)

Recently, grain legumes have proved an important vehicle for fighting hidden hunger in groups vulnerable to micronutrient deficiencies. Biofortification is the development of micronutrient-dense staple crops using conventional breeding practices or modern biotechnology (Nestel et al., 2006). HarvestPlus has successfully launched a variety of biofortified staple foods rich in vitamins and minerals around the world under the CGIAR's Agriculture for Nutrition and Health (A4NH) program. In Africa, farmers in the Democratic Republic of the Congo and Rwanda have widely adopted biofortified beans with enhanced iron content released by HarvestPlus. Elsewhere, consumption of enhanced-iron beans has been shown to improve iron status in Mexican school children (Haas et al. 2010[i]). Indeed, biofortification is fast gaining currency as an effective approach to nutrition-sensitive agriculture. However, there is need for integrated approaches to expand the base of biofortified staples; improve access to biofortified seeds; improve demand, knowledge and practices through extension; expand production; and enhance markets and market access to improve farmers' incomes (Bouis, et al., 2013).

Legumes in African Farming Systems

The individual farm, irrespective of spatial scale, is a basic economic unit with definitive structural characteristics and interactions within the biophysical and socio-economic contexts in which it is embedded and thus qualifies as a system. The farming system concept provides a basis for analysing options and coping strategies to improve household livelihoods and resilience. The FAO has identified 15 farming systems prevalent in sub-Sahara Africa, and legumes are important in at least five of them. These are: forest-based, rice-tree crop, highland perennial, highland temperate, and maize mixed farming systems (FAO, 2001). The importance of legumes in African farming systems is due to their potential contribution to intensification and diversification of production patterns, two key household livelihood-enhancing strategies.

Grain legumes can help achieve these mainly by their use in soil fertility management and livestock feeding. Special tribute goes to the N2Africa - Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa initiative led by Prof. Ken Giller of Wageningen University. The project, now well into the second phase, seeks to increase biological nitrogen fixation and productivity of grain legumes (common bean, cowpea, groundnut and soybean) among African smallholder farmers. Enhanced soil fertility, improved household nutrition and increased household income are some intended outcomes. The project is being implemented in Ethiopia, Ghana, Nigeria, Tanzania, and Uganda under a North-South-South collaborative arrangement. Some elements of the project are also active in the DR Congo, Rwanda, Kenya, Malawi, Zimbabwe and Mozambique. Brazil's Embrapa, the other South collaborating partner has perfected legume inoculant technology that has been leveraged in the project.

Suffice it to say here that biological nitrogen fixation can contribute as much as 300 kg N/ha in a season through in grain legumes or legume green manures and up to 600 kg N /ha in a year through tree legumes (Giller, 2001). Using certain strains of Rhizobium inoculants from Embrapa, on-farm trials by the collaborating agency in Ghana, CSIR-Savanna Agricultural Research Institute (SARI), have reported a doubling of grain yields. SARI has since established a local inoculant manufacturing facility that will go a long way in helping farmers to adopt the technology. In other similar projects implemented in Zimbabwe, introduction of forage legumes - i.e. Mucuna (*Mucuna pruriens* var utilis) and Lablab (*Lablab purpureus*) - in the mixed crop–livestock systems common in this region has enabled farmers to increase their income from high-quality fodder and higher maize yields (Chigariro, 2004 and Jiri et al., 2004). Thus, the technology exists, and evidence abounds as to the efficacy of legume-based soil fertility management strategies. The challenge that remains pertains to the modalities and arrangements for going to scale. Africa still has the enviable opportunity to circumvent the quicksand of the Green Revolution and legume fertilization is one such way.

Legumes and Climate-Smart Agriculture

Adverse environmental externalities (e.g. GHG emissions and associated climatic effects and eutrophication) due to use of high levels of inorganic inputs to sustain crop yields has endeared research towards more ecosystem friendly methods of production intensification. This has given rise to paradigms like ecological intensification and agroecology, the latter also referred to as the ecology of food systems (Gliessman, 2014). Traditional farming systems around the world offer valuable knowledge to inspire ecological intensification in so far as it recognizes the role of local resources and indigenous knowledge systems (Tittonel, 2014).

Climate Smart Agriculture (CSA) refers to agricultural practices that ensure sustainable production intensification without damage to the environment. This includes practices like ecological intensification that nurture natural capital and rely on ecosystem services to replenish soil health. Indeed, ecological agriculture has the potential for both adaptation and mitigation of climate change effects. Legumes, due to their ability to increase soil organic nutrients and reduce the use of synthetic fertilizers, are good candidates for climate smart agricultural practices. However, crop simulation models conducted by CIAT indicate that future temperature rise due to climate change will adversely affect the yields of some leguminous crops like soybean and common bean; but groundnuts will be more adaptable to the higher temperatures. The N2Africa project recommends that in regions dominated by smallholder farmers who are already experiencing climate impacts such as increased drought, flooding or heat waves, the priority is on adaptive measures for reliable N availability to support food security and minimize vulnerability. Combining low inputs of synthetic N fertilizers with practices that increase soil quality through organic matter management and acquisition of N from biological N fixation allows adaptation measures to contribute to GHG mitigation. An example of such adaptation measure is the case of smallholder farmers around the Lake Victoria region who have abandoned maize that is no longer doing well under a changed climate regime for cowpea and pigeon peas crop rotated with sorghum (Kilungu, 2015).

Realizing the importance of climate-smart agriculture in Africa, NEPAD Agency and partners formed the Africa Climate Smart Agriculture Alliance in 2014 to facilitate rapid scale-up and adoption of CSA practices by Africa's smallholder farmers. The Alliance seeks to "leverage existing CSA initiatives and the strengths and capacities of all significant stakeholders to deliver results at scale and drive policy reform." Several countries including Ethiopia, Kenya, Malawi, Niger, Uganda, Tanzania and Zambia are already developing national CSA scaling-up plans. The initiative is supported by the Climate Change Fund, also formed under NEPAD. By COP21, Kenya, Uganda and Tanzania had completed designing their country climate-smart agriculture framework programs (CSA-FPs). Partnerships have been brokered with non-governmental development agencies to pilot the CSA plans in selected sub-national regions in Tanzania. However, key stakeholders with a focus on legume development like the Pan-Africa Bean Research Alliance (PABRA) need to advocate for greater and clearer role of legumes in the national CSA plans based on technical and practical evidence. As the national CSA plans invariably intend to scale out proven CSA practices, the use of innovation platforms (IPs) to rally and facilitate communicative interactions amongst concerned stakeholders is recommended. The IPs have been credited with successful introduction of CSA practices in eastern Africa (FARA, CORAF/WECARD & ASARECA, 2015).

FARA, a founding member of the Africa CSA Alliance, has been mobilizing stakeholders to support the objectives of the Alliance by convening CSA orientation and scaling up workshops. FARA has also conducted situational analyses to determine the state of knowledge on CSA in many African countries including Burkina Faso, Ethiopia, Kenya, Rwanda, Sierra Leone, Senegal, Tanzania, Uganda and Zambia. Results indicate that there exists best bet and success CSA practices in terms of technology packages; risk management through seasonal weather forecasts, index insurance and safety nets; and participatory climate smart mobilization initiatives at village level (Msaki et al., 2015). The available CSA technology packages that are scalable include improved drought tolerant crop varieties and livestock, crop diversification and crop land management, integrated soil fertility management, water harvesting, cross slope barriers, agroforestry, and lowland rice cropping (Kipkoech et al., 2015). Legumes have an overriding importance in crop diversification, crop land management, and integrated soil fertility management.

The Legume Agenda and the Post-Malabo CAADP Results Framework

Since 2003, the Comprehensive Africa Agriculture Development Program (CAADP) has provided the overarching framework to guide concerted stakeholder actions aimed at making agriculture a major contributor to broad-based economic growth of African countries. The CAADP is in its 2nd decade of implementation invigorated by the recommitment to its vision and principles by African Heads of State and Government during their meeting in Malabo, Equatorial Guinea, in June 2014. The outcome of this high-level meeting dubbed the *"Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods"* embodies two resolutions that are relevant to the pan-African grain legume agenda. First, it focuses on commodity prioritization and development of their value chains. In this regard, CAADP implementing countries are expected to prioritize at least five agricultural commodities for focus in the post-Malabo Roadmap and Strategy. I believe majority of the countries will prioritize pulse crops in their revised national agricultural investment plans due to their traditional importance in the African diets. Publicity given to legumes crops by conferences of the Pan-African Grain Legume and World Cowpea Conference magnitude will no doubt go a long way in persuading countries to include them in their priorities. Secondly, it emphasizes collective engagement by stakeholders – much in tandem with the spirit of PABRA and other such regional alliances - to ensure implementation at country level.

The CAADP Results Framework (Figure 1), defined at three levels in a hierarchical cause-effect pathway, seeks to guide program design and evaluation by implementing partners. Its main focus is country-level implementation. Level 1 are the macro-level impacts pitching CAADP's contribution to broader economic growth and development. Building on experiences gained over the last decade, the post-Malabo CAADP's transformative outcomes at Level 2 is pegged to a developed and functional systemic capacity at Level 3.

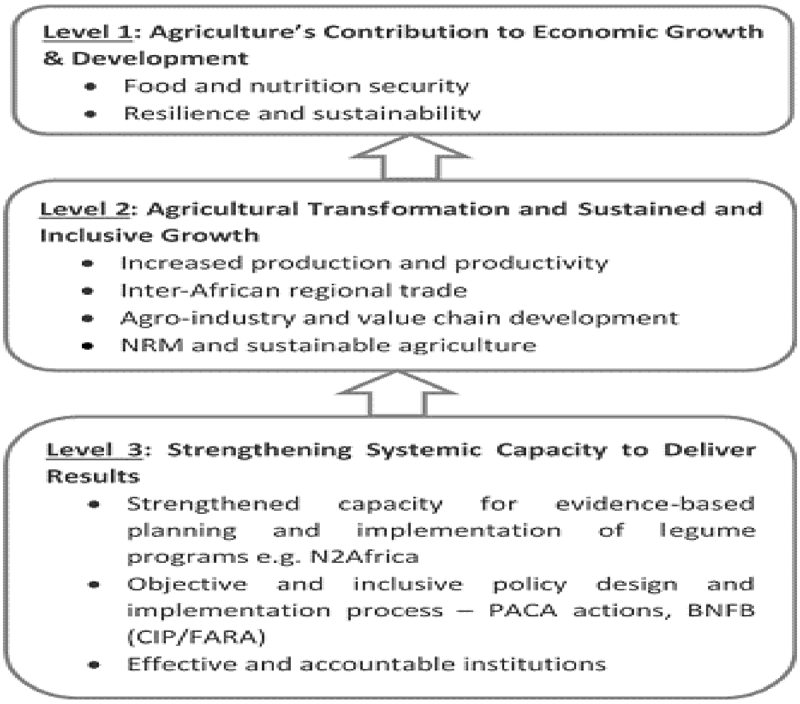

Figure 2: An Adpated CAADP Results Framework

CAADP seeks expanded implementation capacity through alliances and partnerships with various stakeholders. There is also increased emphasis on thematic and commodity focus. Opportunities for partnerships and collaborations abound to align the legume agenda so that it potentially contributes to all the three CAADP results levels. At the impact level, legumes contribute directly to food and nutrition security in so far as they are an important dietary component in Africa. They also contribute to resilience and sustainability due to their positive effects on soil nutrients and climatic adaptability.

At Level 2 of the CAADP Results Framework, the legume agenda has important contributions. For instance, some of us will remember the groundnut pyramids of northern Nigeria and other parts of West Africa. These today are no more and shifts in agricultural policies and lack of markets due non-tariff trade barriers imposed by importing countries have contributed in no small way to obliterating this important economic activity. Focusing the legume agenda on policy advocacy and pre- and post-harvest interventions to eliminate mycotoxins (especially aflatoxins) would go a long way in boosting groundnut production and facilitating trade both within and beyond Africa. The African Union Commission (AUC) and partners have taken lead in this regard by constituting the Partnership for Aflatoxin Control in Africa (PACA) to champion regional efforts to eliminate aflatoxins in Africa's produce.

Moreover, legume-based agro-industries (e.g. oil extraction from groundnuts or soybeans) have great potential to generate demand for the products or raw materials of other industries. The high degree of inter-dependence with backward, forward and sideways linkages (as illustrated in Figure 2) makes legume-based agro-enterprises very key in Africa's quest for industrialization and structural transformation.

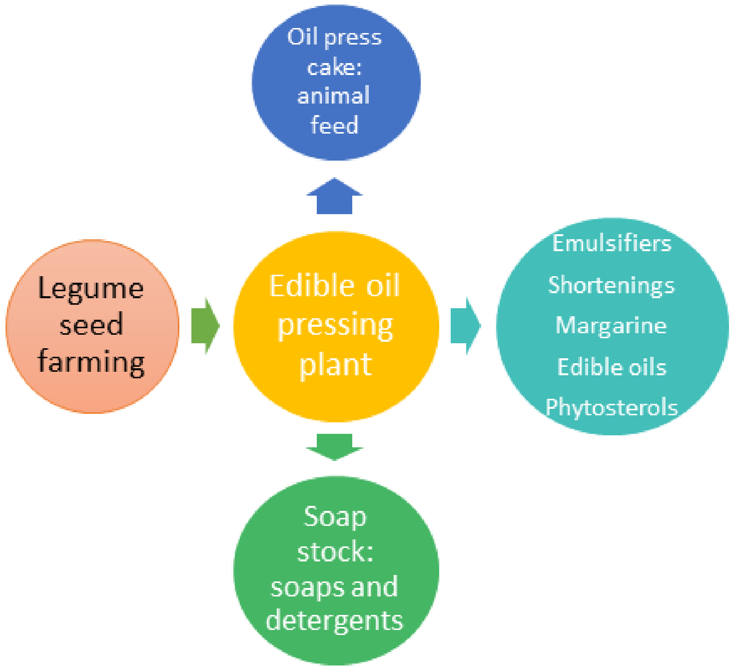

Figure 3: Possible linkages in a legume-based agro-enterprise

Surveys in Ghana under the N2Africa project revealed that farmers in the northern regions store from 20% to 80% of their grain legume residues to feed livestock later in the year. In northern Nigeria, research indicates that adoption of new groundnut varieties is closely tied to the use of haulm as livestock feed (Rekwot et al., 2015). The desired varieties are those with high forage yield and crude protein content. Some studies indicate that high groundnut pod yield and superior haulm quality and quantity are compatible traits amenable to simultaneous breeding improvements (Blümmel et al., 2005). Thus, apart from the oil cake, legume crop haulms are also an important raw material for the livestock industry.

At Level 3 of the CAADP Results Framework, initiatives like N2Africa (Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa) are already fostering partnerships and building needed human capital to spearhead and sustain the legume agenda.

Legumes and the Science Agenda for Agriculture in Africa

The Forum for Agricultural Research in Africa (FARA) is an organization that caters for the interests and aspirations of stakeholders concerned with agricultural research for development (AR4D) in the pan-African context. the. What FARA does is rally stakeholders around a common vision for AR4D. So, advocacy, partnership building, capacity development and intermediation are some of FARA's key functions. FARA's current strategic objective is to contribute to enhancing productivity, competitiveness and integration of Africa's agricultural sector by strengthening the capacity of countries to generate and apply the relevant science, technology and innovation.

During the first CAADP decade, FARA successfully championed the implementation of CAADP Pillar 4 that focused on agricultural research, technology generation and dissemination. In the current CAADP dispensation, FARA has been charged by the African Union Commission and NEPAD Planning and Coordinating Agency (AUC/NEPAD Agency) to develop and lead the implementation of a Science Agenda for Agriculture in Africa (S3A). The S3A was completed and ratified by the African Heads of State and Government meeting in Malabo. Its main objective is to ensure that science plays a greater and rightful role in Africa's agricultural development. Indeed, the S3A has been adopted as the framework to guide implementation of the agriculture component of the Science, Technology and Innovation Strategy for Africa (STISA-2024), elaborated by the AUC's Department of Human Resources, Science & Technology.

The S3A seeks to mainstream science as an essential part of agriculture-led social and economic transformation in Africa and enjoins African leaders to, among other things: 1) ensure a basic science capacity in all countries of Africa, 2) support regional centres of excellence to share knowledge and facilities; and 3) maintain an open flow of people, knowledge and resources among African countries through policies that facilitate exchanges within and beyond Africa (FARA, 2014). FARA is currently mobilizing partners and stakeholders to implement the S3A at country level. In keeping with FARA's role of helping strengthen the African national agricultural research systems, an initial activity in the S3A implementation calendar is mainstreaming the Agenda into the national STI planning, determining the science-readiness of African countries, and facilitating the elaboration of policy and institutional pre-requisites for cross-border sharing of AR4D facilities and deployment of human capital. In this regard, establishing a center of excellence for legume research and development would be an important institutional innovation in the legume agenda. Partnerships like PABRA mediated by CIAT in collaboration with African partners at regional and national levels can help advance such an undertaking.

There have been efforts to align the CGIAR research programs with the CAADP over the last few years through the so-called Dublin Process in which FARA has been an important intermediary. It is instructive to note that currently, the CGIAR has adopted the S3A as the rightful medium to respond to and support the implementation of the post-Malabo CAADP Roadmap and Strategy.

Some Perspectives on Legume Research

The CGIAR research on grain legumes focuses on the following flagship projects: 1) managing productivity; 2) trait determination; 3) trait deployment; 4) seed systems, post-harvest processing, markets and nutrition; 5) capacity building and partnerships; 6) knowledge, impacts, priorities, and gender organization; and 7) tools and platforms for genotyping and bioinformatics. In Africa, the CGIAR research on legumes is led by CIAT and structured through PABRA in close collaboration with national partners in target countries. Figure 4 shows the investments committed to bean research by CIAT over the last 45 years. Changing focus by donors was largely responsible for the progressive decline in funding allocation to bean research between 1990 and 2007. Entry of new donors with interest in genetic improvement of crops explains the apparent increase in bean funding in the recent past. Most of these funds were committed to PABRA research priorities in Africa (Walker et al., 2014). In the 2000s, the frequency of release of improved bean varieties and hybrids in sub-Sahara Africa was only second to maize. This prolific research output is attributable to efforts by the PABRA network. PABRA's bean research and development portfolio focuses on breeding, integrated crop management, nutrition, seed systems, linking farmers to markets, and monitoring and evaluation.

In terms of the rate of adoption of new legume technologies in sub-Sahara Africa, soybean ranks first followed sequentially by pigeon pea, groundnuts and common beans (Walker et al., 2014). Socio-economic, technological and cultural factors impinge upon technology adoption rates. In Tanzania, market access, household characteristics and ICT were found to significantly affect adoption rates for common beans (Letaa et al., 2014). Compared to cereals and root and tuber crops, legumes have a relatively low share of research focus in molecular biology and genetic engineering, tissue culture, postharvest technology, and soil science (Walker et al., 2014). Further, the legume agenda in Africa needs to broaden its scope and depth in the areas shown in Box 1.

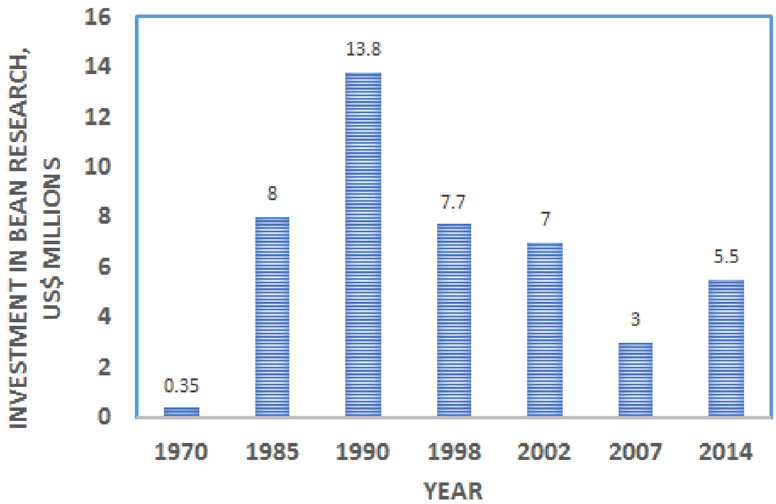

Figure 4: Investment in bean research by CIAT (Adapted from Walket et al., 2014)

Box 1: Suggested areas for more research in legumes

Areas in need of more research focus in legumes
• Narrowing the yield gaps for legumes – yield gaps for legumes are still wide in various agro-ecological zones and farming systems across Africa mainly due to resource and/or technology constraints. Need for conventional and marker-assisted breeding and genetic engineering efforts to develop higher yielding varieties suitable for various agro-ecological zones. • Bean textural changes during storage and their effects on cookability – screening for susceptibility to hard-to-cook defect in different grain pulses and using breeding and biotechnological techniques to determine less susceptible traits. • Breeding for grain legumes with less anti-nutritional and anti-metabolic factors e.g. breeding to reduce flatulence-causing factors and protein inhibitors

- Enhancing the grain legume protein profile - using biotechnological avenues to increase the amino acid profile of legumes; legumes tend to be limiting in Sulphur amino acids like methionine and cysteine
- Enhancing adaptability of legumes to biotic and abiotic stresses – improving temperature and drought tolerance; improving disease and pest resistance
- Enhancing bean flavor characteristics to improve consumer acceptability
- Biosprospecting for more effective Rhizobium strains
- Expanding the biofortification spectrum in beans – e.g. more legumes biofortified with Fe and Zn
- Creating lasting partnerships and building alliances and centers of excellence around legume research and development
- Enhancing the role of legumes in climate-smart agriculture; simulation models to determine climate change susceptibility of legume crops
- Promoting dietary diversification at the household level by developing legume-based recipes
- Embracing innovation platforms in promoting legume technologies for end-user adoption
- The role of legumes in human health – e.g. research on putative health benefits of diets rich in legumes

Conclusions and Recommendations

1. Legumes or pulse crops occupy a principal place in the food and nutrition security strategies of African countries, especially as the region is increasingly ravaged by the effects of climate change.
2. Multi-country, issue-driven networks have contributed significantly to legume research for development in Africa. North-South-South partnerships brokered around specific thematic research topics have equally contributed to advancement in legume research in Africa. Such models for delivery of legume AR4D need to be fostered within the wider regional agricultural development policies and strategies including the CAADP and the S3A
3. Whilst recognizing the important backstopping role of IARCs and the CGIAR, very key is the need to strengthen the national agricultural innovation capacity of African countries as homegrown technologies and innovations are more impactful. Currently, many African countries are constrained by lack of research infrastructure and human capital to drive commodity-specific research and development. This calls for elaboration of collaborative service agreements and partnership protocols to allow capacity pooling and sharing across countries.
4. For legumes to play a greater role in human nutrition and economic development, a number issues still need research attention. Breeding (conventional or using genetic engineering) will be central in addressing many of these challenges, but other downstream value chain competencies (e.g. processing and postharvest) will also be required. Capacity development in these key areas will be essential.
5. A number of constraints at the farmer or household level still need to be addressed to improve absorptive and adaptive capacity of farmers. These may be technological, socio-economic or structural. Participatory approaches to issue identification and solution

building around innovation platforms or taskforces will go a long way in alleviating some of the end-user constraints.

References

Beans on the Iron Status of Mexican School Children. The FASEB Journal 25 (March 17): 96.6.

Blümmel, M., Reddy, C. R., Ravi,. D., Nigam, S. N., and Upadhyaya, H. D. (2005). SAT eJournal, 1 (1): 1 -3. ejournal.icrisat.org

Bouis, H., J. Low, M. McEwan, S. Tanumihardjo (2013). Biofortification: Evidence and lessons learned linking agriculture and nutrition. FAO/WHO.

Chigariro, B. (2004). The Farming Systems of the Zimbabwean District of Wedza and the Role and Adoption of Forage Legumes in Small-scale Crop–Livestock Enterprises. In, A. M. Whitbread and B. C. Pengelly, eds, Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Australian Centre for International Agricultural Research, Canberra, Australia.

FAO (2001). Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO, Rome, Italy. Available at: http://www.fao.org/docrep/003/y1860e/y1860e00.htm#TopOfPage Accessed on: 21 February 2016.

FARA, CORAF/WECARD & ASARECA (2015). Report of the Continental Conference on Research Evidence and Research-Policy Linkages for Adaptation to Climate Change in Africa held 10 – 12th March 2015 in Nairobi, Kenya.

Gliessman, S. R. (2014). Agroecology: a global movement for food security and sovereignty. In, Proceedings of the 1st FAO Symposium on Agroecology for Food Security and Nutrition held 18-19 September 2014 in Rome, Italy. FAO, Rome, Italy.

Haas, J. D., S. Villalpando, S. Beebe, R. Glahn, T. Shamah, and E. Boy (2011). The Effect of Consuming Biofortified

Jiri, O., B.V. Maasdorp, E. Temba and A.M. Whitbread (2004). The Role of Dual Purpose and Forage Legumes to Improve Soil Fertility and Provide High Quality Forage: Options in a Maize-based System in Zimbabwe. In, A. M. Whitbread and B. C. Pengelly, eds, Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Australian Centre for International Agricultural Research, Canberra, Australia.

Kilungu, S. (2015). Tailored success in Nyando: Wycliffe's fresh start and success in farming. Available at: https://ccafs.cgiar.org/blog/tailored-success-nyando-wycliffes-fresh-start-and-success-farming#.VsrYZeaDCSo Accessed on 22 February 2016.

Kipkoech, A. K., Tambi, E. and Bangali, S. (2015). State of knowledge on CSA in Africa: Case studies from Ethiopia, Kenya, and Uganda. Report of a study funded by NORAD. Forum for Agricultural Research in Africa, FARA, Accra, Ghana.

Msaki, M. M., Tambi, E. and Bangali, S. (2015). State of knowledge on CSA in Africa: Case studies from Rwanda, Tanzania, and Zambia. Report of a study funded by NORAD. Forum for Agricultural Research in Africa, FARA, Accra, Ghana.

Nestel, P., H. E. Bouis, J. V. Meenakshi, and W. Pfeiffer (2006). Biofortification of Staple Food Crops. J. Nutr. 136: 1064–1067.

Rekwot, G. Z., Oyinbo, O. and Lasisi, T.O. (2015). Adoption of IAR Improved Groundnut Varieties for Livestock Production in Jigawa State, Nigeria. Biological and Environmental Sciences Journal for the Tropics 12(2):790 – 794.

Tittonel, P. (2014). Ecological intensification of agriculture — sustainable by nature. *Current Opinion in Environmental Sustainability*, 8:53–61.

Venn, B. J. and Mann, J. I. (2004). Cereal grains, legumes and diabetes. *Eur J Clin Nutr*., 58(11):1443-61.

Walker, T., Alene, A., Ndjeunga, J., Labarta, R., Yigezu, Y., Diagne, A., Andrade, R., Muthoni Andriatsitohaina, R., De Groote, H., Mausch, K., Yirga, C., Simtowe, F., Katungi, E., Jogo, W., Jaleta, M. & Pandey S., (2014). Measuring the Effectiveness of Crop Improvement Research in Sub-Saharan Africa from the Perspectives of Varietal Output, Adoption, and Change: 20 Crops, 30 Countries, and 1150 Cultivars in Farmers' Fields. Report of the Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC) Secretariat: Rome, Italy