SC7 Meeting
Agenda item 4
Issued: 31 October 2018

# A Common Bean Flagship for inclusion in the CGIAR Research Portfolio

## Purpose

This document presents a revised proposal for the inclusion of a common bean Flagship, to be integrated into the GLDC CGIAR Research Program as part of the current CGIAR Research Portfolio with effect from 1 January 2019.

## Action Requested

The System Council is requested to:

1. Review the proposal from CIAT for the potential addition of a common bean flagship into the GLDC CRP;

2. Note that in the view of the System Management Board, the revised flagship and proposal meets quality and relevance criteria based on CIAT's response to an earlier review by the CGIAR Independent Science and Partnership Council; and

3. Consider approving the Flagship proposal for inclusion in the CGIAR portfolio according to its proposed arrangements, noting that the indicative funding amounts to be provided from funds from the CGIAR Trust Fund for the approved proposal will be considered by the System Council as part of its discussions on the 2019-2021 multi-year Portfolio Financing Plan ('FinPlan').

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Prepared by: CGIAR System Management Office

## Background

1. The form of the Grain Legumes and Drylands Cereals CGIAR Research Program ('CRP') which was approved at the System Council's 5th meeting in November 2017[1], one year later than other CRPs in the current portfolio, and which responded to the call for a program focused on tropical drylands, did not include activities on common bean breeding and dissemination, largely on the basis of this agroecological focus.

2. CGIAR's Funders and the System Management Board have subsequently considered that common bean improvement activities are a missing element from the CGIAR portfolio given the role that common bean has been shown to play in food and nutrition security for CGIAR target populations.

3. An agreed action from the System Management Board's 8th meeting (December 2018) was that: (i) the System Management Board request CIAT to develop a proposal for a common bean flagship research program; and that (ii) the System Management Office lead consultation and engagement among Centers, relevant programs and the ISPC, to develop a proposal for the optimum location of that work.

4. The System Management Board considered a proposal for a common bean flagship program to be attached to the Grain Legumes and Drylands Cereals CRP at its 9th Meeting (Montpellier, 10 -11 April 2018), receiving a verbal update from the ISPC Chair on the review process undertaken to date.

5. The written commentary of the ISPC received on 23 April 2018, raised several issues in relation to the proposal and labelled it "weak". The Board therefore invited the proponents (CIAT with GLDC) to resubmit a revision of the proposal taking into consideration the ISPC's comments.

## System Management Board recommendation to the System Council

6. A revised proposal for a common bean flagship was received from CIAT on 15 August 2018 (Appendix A) together with a companion document which was submitted in response to the ISPC's earlier commentary (Appendix B).

7. At its 10th Meeting (Nairobi 26-27 September 2018) the System Management Board discussed the revised proposal and accompanying commentary in response to the ISPC's earlier review in the context of other flagship re-submissions and approvals that have been made to the current portfolio since it was first approved by the System Council at its 2nd meeting (25-26 September 2016)[2].

[1] Refer to decisions SC/M5/DP3 (GLDC Agri-food Systems CGIAR Research Program) and SC/M5/DP10 (2018 Portfolio Funding scenario), set out the System Council Chair's Summary: https://www.cgiar.org/wp/wp-content/uploads/2018/03/SC5-11_Chairs-Summary_13Nov2017.pdf

[2] Refer to decision SC/M5/DP9 (Flagship programs resubmitted in 2017 for W1&2 funding in 2018) and SC/M5/DP10 (2018 Portfolio Funding scenario), as earlier referred to in footnote 1 above.

8. In its deliberations, the System Management Board noted the strengthened nature of the flagship proposal - namely:

   a. The inclusion of greater, referenced detail on the historical impacts of the former bean improvement program towards nutrition and climate outcomes; attention to the Theory of Change (based on the extensive first-hand experience of the PABRA bean network[3] with its regional corridors approach in Africa and learning platforms in Latin America), and a better description of program partners and a realistic assessment of opportunities in Latin America.

   b. The components of the flagship are described through its Clusters of Activities (proposal pp 21-25) which show strong potential for linkage to GLDC (outlined in proposal Figure 2) but also to other Agri-food Systems CRPs on other commodities. The proposal notes that interactions with the MAIZE CRP (a potential alternative hosting arrangement for the common bean activities) are most usefully considered through system approaches when maize is the dominant crop. Importantly, the various opportunities for immediate and future linkages with GLDC are described - not least the potential gains from comparative work on legumes and learning on dissemination networks - as well as the management arrangements (proposal section 1.12 starting p 31). The relatively small W1-W2 budget requested by the flagship is to support these integrative management aspects.

9. Overall, the System Management Board determined that the revised proposal makes a strong case for the importance of bean varietal development for food security and nutrition in sub-Saharan Africa and Latin America (through beans in their own right, and through their capacity for biofortification) with a program to combat both climatic and biotic research challenges on the one hand and market, business and distributional challenges on the other.

10. The System Management Board recommends the revised proposal, including the flagship hosting arrangement with the GLDC CRP, to the System Council for its approval so that common bean breeding and dissemination activities are included in the CGIAR portfolio.

## Appendices

A. *Strategic and applied research to meet the demand of beans in Africa and Latin America. A Common Bean Flagship*. August 2018.

B. CIAT response to the ISPC comments on the Common Bean Flagship. 13 August 2018

[3] http://www.pabra-africa.org/ - allowing the common bean proposal to provide an integrated breeding and dissemination Flagship.

Appendix A

CIAT

International Center for Tropical Agriculture

*Since 1967 Science to cultivate change*

# Strategic and applied research to meet the demand of beans in Africa and Latin America

# A Common Bean Flagship

August 2018

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# Strategic and applied research to meet the demand for beans in Africa and Latin America

## A common bean flagship

# Background

The humble common bean (*Phaseolus vulgaris L.*) promises to improve the health, food security and livelihoods of some of the world's poorest people in Africa and Latin America. Beans have been on CGIAR's research agenda since 1973, when a bean program was established at CIAT. The Grain Legumes CRP, launched in 2012, aimed to improve productivity in eight priority crops, including the common bean. Common bean research focused on abiotic stresses, such as drought and low soil phosphorus, heat tolerance and nitrogen fixation. Technical exchanges with other members of the CRP focused on cross-legume physiology and phenotyping derived from that knowledge. As the CRPs moved into a second phase based around the organizing principle of agri-food systems, the Grain Legumes and Dryland Cereals CRPs were merged with the Dryland Systems CRP, giving the research agenda a decidedly dryland focus. The ISPC, and later an expert panel, questioned the relevance of common bean – a crop with greater presence in sub-humid areas – to the new Grain Legumes-Dryland Cereals (GLDC) CRP and subsequently common bean was removed from the program. Nevertheless, the need for more research on common beans remains, as does the potential for collaboration with research on other legumes. Following a December 2017 meeting, the System Management Board requested that CIAT develop a proposal for a common bean flagship and propose the best location for that work. The Directors of CIAT and the GLDC, in consultation with the System Management Office, agreed that GLDC will host the flagship on common bean, building on synergies with other legumes, while respecting the dryland systems focus of the CRP. The advantages and mutual benefits of this hosting relationship are presented in Section 1.12 on flagship management.

## 1.1. Rationale and scope

*The role of beans in agri-food systems.* Agri-food systems extend from production to consumption, including the intermediary steps of marketing, transport and processing, with the ultimate objective of supplying human populations with nutritious and healthy diets in an economically viable way. Edible legumes or pulses have a unique role to play, both in rural diets and in the agri-food systems of urban populations. The United Nations designated 2016 as the International Year of Pulses, and a recent World Bank study highlighted nutrient-dense foods, such as pulses, as an integral component of healthy diets [44]; as a source of protein, complex carbohydrates and minerals (iron and zinc) [29, 41]; and as a preventative measure against obesity [42], diabetes [38], cardiovascular disease [19, 23, 24] and certain types of cancer [28, 43]. Much of the evidence for the health effects of edible legumes is derived from research on common beans (See Annex 1 for numbered references.) The

health benefits of eating beans point to their value for a burgeoning urban population, among whom non-communicable diseases are increasing at an alarming rate. In the food systems of eastern and southern Africa and in Middle America, beans and maize are the foundation of the traditional diet, while in South America, rice is more commonly consumed with beans [18]. Widely recognized as complementary with regard to amino acid profiles, beans and maize have also been adopted by HarvestPlus as important sources of minerals: beans for iron and maize for zinc. In Uganda, genetically improved beans reduce food insecurity and supply 25% of dietary protein [29]. A food system analysis will be carried out in Cluster of Activities 1, with emphasis on production in CoA's 2, 3 and 4, while markets and nutrition are explored in CoA 5.

*Population growth in bean-consuming countries.* Common beans are the preferred grain legume of some 400 million inhabitants of eastern and southern Africa, and another 400 million in Latin America. Several African countries experience population growth of more than 2% per year. Ethiopia and Rwanda have relatively slower growth, but will still experience a population increase of 81% and 74% respectively, by 2050 (see Annex 2). Kenya and South Sudan will double in population during this period; Madagascar and Mozambique will grow by 116% and 122%, respectively, while Burundi, Tanzania, Uganda and Zambia will each grow by a staggering 140%. Overall, the population of bean-consuming countries in Africa will grow by about 116%. As an important source of nutrition in the region, the productivity of beans must improve significantly.

Latin America represents about 40% of world bean production, including in the dryland areas, and is the center of diversity. Beans in Latin America were included in the Grain Legumes CRP, which had a global scope. The CGIAR Strategy and Results Framework (SRF) commits to dedicating 20% of CGIAR resources to poverty hotspots in Latin America, and CIAT leads the CGIAR site integration site in Nicaragua – an important bean producer. Population growth in bean-consuming countries ranges from 4% in El Salvador to 63% in neighboring Guatemala, with an expected average increase of 20% in Central America by 2050. Increases in bean production have lagged behind population growth for several years, and prices are currently prohibitive. Faster yield gains are needed to put prices within the reach of the poor. In both Latin America and Africa, foresight analysis could enable us to estimate future demand for beans and facilitate research planning.

*Levels of poverty and malnutrition.* Africa is a hotspot of poverty and malnutrition, and bean-producing and consuming countries are no exception, experiencing from 40% to more than 70% poverty, characterized as per capita earnings of less than US$1.90 per day (see Annex 3). Anemia rates range from 46–67% in children under five and from 31-49% in pregnant women, due both to iron deficiency and disease load, especially malaria. Stunting in children under five ranges from 27-57%, implying chronic undernutrition, which is often associated with protein and/or zinc deficiency. In Latin America, Guatemala and Honduras continue to have serious public health problems of anemia in children, while Haiti experiences poverty and anemia levels comparable to those in Africa. Stunting is often over 20% in Central America, while Guatemala, Nicaragua and especially Mexico have alarming levels of diabetes. It is urgent to restore beans as a cornerstone of the diet, by increasing availability and lowering prices.

*Policy dimensions of seed and markets*. Policy issues affect bean production and trade and are a necessary element to meet the demand for beans in Africa and Latin America. These include:

- seed trade policies;
- cross border trade of seed and grain;
- regional exchange of genetic materials for research;
- varietal release at both country level multi-country levels;
- agricultural extension policies;
- regulation of pesticides and herbicides;
- post-harvest grain standards;
- nutrition policies.

In previous years, progress was made on seed policy with CIAT's participation, establishing the acceptability of "Quality Declared Seed" in most countries of East and southern Africa, as a viable and legal class of seed and a less expensive option to certified seed; and on the policy to accept regional varietal release when two countries have released a common variety. Other issues require further discussions with decision-makers at the highest level.

*Hypothesis*

We believe that combining better bean productivity with more efficient and accessible markets can bring multiple social benefits, contributing immeasurably to food security, nutrition, health, and farm incomes.

## 1.2. Objectives and targets (what, where, how)

The common bean flagship takes an ambitious approach to developing production technology and improving market linkages. Our approach includes a number of novel components:

- We make our work operational in innovation platforms organized around **production-to-consumption corridors** (see Box 1). This approach streamlines value chains, identifies bottlenecks, strengthens the private sector presence, brings key actors and researchers together and helps them find solutions to their challenges. **The corridor approach applies a geographical vision to value chains and engages actors that are normally outside the circle of the international centers in a participatory mode**.
- **We license new bean varieties** to attract private seed companies. Long practiced in other crops, licensing was not thought practical in a self-pollenated crop like beans. This approach is being promoted with guidance from the Syngenta Foundation.
- **We work with the processing sector** to promote the industrial processing of both normal and biofortified beans in order to increase their nutritional impact. Even rural housewives find the convenience of pre-cooked bean products attractive.
- **We develop new methods to access the genes of the *Phaseolus* genus** to address climate change. Genes in the tertiary gene pool (e.g., *Phaseolus acutifolius*, *P. parvifolius*) have never before been mainstreamed in breeding programs.
- **We explore novel traits to increase genetic gain and yield potential**. Achieving yield increases in legumes has always been a challenge. While most work on yield has often

focused on improving the source, we will pursue crosses to increase sink strength with the *Phaseolus* species mentioned above.

- **We integrate nutrient-efficient cultivars with fertility management**. This has been a long-term goal, but nutrient-efficient bean varieties are only now becoming more readily available and will permit this integrated approach in cropping systems.
- **We open new approaches to enhance dietary zinc in bean as a complement to high iron**. Although this has been a goal since biofortification began, only until now are we seeing significant and stable increases of zinc concentration in beans. This is timely because zinc deficiency is receiving greater attention as a public health problem in East Africa.

**Box 1. Production-to-consumption corridors**

The corridor concept takes the value chain notion a step further by placing it in a geographical context and investigating the people and activities taking place in each location. In studying bean corridors, we ask:

- Who produces beans? Where?
- Who provides bean seeds to the farmer?
- Who eats beans? Where do they buy them?
- Who supplies beans to the markets? How do they get there?
- Who sells the beans?

A corridor may run from a farm in western Uganda, to a warehouse in Kampala to a trucker who takes beans to a supermarket in Nairobi, where they are bought by an urban housewife.

The corridor approach permits us to identify problems and solve them by bringing together people in innovation platforms along the corridor. For example, putting farmers, traders and researchers in the same room enables them to express their needs and jointly consider how they can be met. With facilitation from PABRA and the national bean program, the corridor approach empowers people to solve their own production, transport and marketing challenges. It highlights the role of the private sector in bringing dynamism to the value chain. It cultivates trust among actors and fosters stable and sustainable business relationships that promise better employment opportunities for women, men and young people.

## Expected impacts

Based on our experience in Phase 1, which reached 3.3 million households with improved varieties, crop management practices and new bean products, we expect impacts to accelerate, especially given the wider participation of the private sector, which is now producing almost 80% of certified bean seed in Africa (with the potential to cover 6-8% of bean area planted). Although still modest, this is significantly more than a decade ago, when certified seed covered much less than 2% of the area planted.

See contribution to SRF system level outcome (SLO) targets in Annex 4.

**Contribution to SLO 1: Poverty reduced, by 2022 …**

- … there is at least a 5% reduction in poverty prevalence among female- and male-headed households in targeted segments of bean corridors in Africa.
- … three million farmers are linked to profitable markets.
- … 25 small-to-medium enterprises (SMEs) trade in bean products.
- … six million households access seed (60% of seed recipients being women) of high yielding, nutritious, climate change-resilient and marketable bean varieties and ICM.
- … ten thousand women participate in the development and delivery of climate-smart technologies and information.
- … Farmers have access to heat tolerant bean varieties, thus expanding options for production in marginal environments.

**Contribution to SLO 2: Improved food and nutrition security for health, by 2022 …**

- … there is a 5% reduction in food and nutrition-insecure households in the targeted corridors.
- … nutritious bean and dry bean products are consumed in nine million households (consumption disaggregated by gender )

## Overview of expected outcomes

The SRF of the CGIAR defines its mission in terms of three broad system-level outcomes of poverty reduction, nutritional security and health, and natural resources and ecosystem services. These in turn are sustained by the respective Intermediate Development Outcomes (IDO's) and sub-IDOs. The bean flagship contributes explicitly to at least five of these sub-IDO's, the outcome narratives of which are described below; milestones can be found in Annex 5.

1. Outcome 1: *Enhanced genetic gain* on station and on farm through bean varieties with greater yield potential (sub-IDO 1.4.3.);
2. Outcome 2: *More efficient use of inputs*, including fertilizer-efficient varieties that maximize the return on investment (sub-IDO 1.3.4);
3. Outcome 3: *Reduced pre- and post-harvest yield losses (including due to climate change)* with varieties that confront drought, excess rainfall, and/or higher temperatures, and the accompanying biotic constraints (sub-IDO 1.4.1);
4. Outcome 4: *Diversified livelihood opportunities* through the production and creation of new bean varieties and bean-based products that have market-ready potential and meet consumer and food industry demands (sub-IDO 1.3.1.);
5. Outcome 5: *Increased availability of nutrient-rich food* through the creation and dissemination of varieties that have greater nutritional value and serve as raw products for processed foods (sub-IDO 2.1.1.).

## Outcome narrative

*Outcome 1. Enhanced genetic gain on station and on farm through bean varieties with greater yield potential*

Achieving genetic gain in legumes has been less successful than for cereals. This suggests that we need new approaches to yield improvement and a coordinated effort to test yields under farming conditions. Making progress in genepools that have already been subjected to many cycles of selection will be gradual, since the important genes for yield (the 'low hanging fruit') already dominate, and, pending the identification of key yield genes through pre-breeding, further gains will depend on the accumulation of minor genes. This will require an agile and accurate system of phenotyping across a range of farming environments. Phenotyping networks that link communities of breeders in similar agro-ecologies and with similar grain-type requirements can contribute to this objective when the breeders all speak the same breeding language and use comparable methods. In Africa, the PABRA regional programs use existing relationships to build more effective collaborative breeding programs, while in Central America, long-term regional cooperation on beans makes coordinated early generation testing schemes a logical step in pursuing steady genetic gains. Genetic gains must address performance in a range of production environments, both stressed and favorable. While genetic gain for yield is often thought to conflict with breeding for stress tolerance, research has demonstrated that traits for stress tolerance, such as enhanced sink strength and better grain filling, also contribute to yield increases under favorable conditions [1, 35]. Regional phenotyping networks will address this issue more fully.

*Outcome 2. More efficient use of inputs, including fertilizer-efficient varieties that maximize the return on investment*

Closing the yield gap requires integrated soil fertility management (ISFM) to combine the judicious use of plant nutrients (organic and inorganic and soil amendments) with high-yielding, healthy planting materials [46]. Plant micronutrients have been shown to increase bean yields by as much as 25% in PABRA's experience [27]. Elements such as molybdenum, boron and zinc should complement N-P-K (nitrogen-phosphorus-potassium), and 'designer fertilizers' that address more specific plant nutrition needs will be formulated. In addition, we will draw on other sources of knowledge for ISFM and integrated crop management (ICM) techniques, for example, the experience of the Maize CRP's work on conservation agriculture, and will promote these techniques through our partnership networks as a complement to genetic improvement. Treating soil with lime and fertilizer at the recommended levels is often prohibitively expensive for smallholder farmers, and fertilizer recovery from soil by crops is typically very low. Inputs, either chemical or organic, applied at moderate – and affordable – levels should be complemented by cultivars that make efficient use of those inputs through improved uptake or superior use efficiency. Significant genetic variability is being tapped for tolerance to acid soils, and for roots with longer root hairs that will recover more nutrients, for higher yields and better return on investment [7]. Preliminary data from Nicaragua suggest that enhanced nutrient efficiency can increase yields by as much as 400 kg $ha^{-1}$ over an elite cultivar [16]. A nutrient-efficient line is at the point of release in Mozambique. Interspecific lines yielded 34% more in low phosphorus trials and 49% more under aluminum stress trials than did the elite control variety.

*Outcome 3. Reduced pre- and post-harvest yield losses (including due to climate change) with varieties that confront drought, excess rainfall, and/or higher temperatures, and the accompanying biotic constraints.*

Efforts to enhance food security with common beans [29] will require alleviating current yield constraints. CIAT and its partners have long since demonstrated that improved bean cultivars can increase the productivity of small producers. In the first ten years of CIAT's bean research in sub-Saharan Africa, farmers using CIAT-improved varieties increased their productivity by 400 kg per hectare [25]. Genetic improvement work by CIAT and partners in Africa has continued to boost bean yields in the region. By 2011, yield productivity in Rwanda and Uganda had increased by 14% and 11% respectively, due to CIAT-related improved bean varieties [29]. Nevertheless, in spite of important productivity increases, average yields in Africa are still one half those in other regions of the world [17], and are bound to suffer severe reductions as a result of climate change [36]. Drought-tolerant bean varieties have been released in a dozen countries, and heat tolerance is now a major breeding objective [5]. Pest management also has a role to play in addressing yield constraints. Simple post-harvest technologies for seed storage, such as air-tight plastic bags (e.g., the Purdue Improved Crop Storage system), are a reliable and time-tested method.

Phenotyping for abiotic stress tolerance is backed up by studies of physiological mechanisms – an important point of interaction across legumes in GLDC.

*Outcome 4. Diversified livelihood opportunities through the production and creation of new bean varieties and bean-based products that have market-ready potential and meet consumer and food industry demands*

Looking ahead, it is clear that opportunities for marketing beans can only increase. By 2050, urbanization will surpass 70% in most countries in Latin America, and will reach 50% in East Africa, implying that more people will rely on purchased food. Bean production in Central America and Africa is dominated by small-scale farmers who produce beans for both home consumption and for market. Some 86% of farmers in Nicaragua cite beans as their first or second most important source of income. An estimated 40% of the beans produced in Africa enter market channels, with the number of bean-growing households that sell beans ranging from 25% in Rwanda, DR Congo and Zimbabwe, to 76% in Ethiopia. The markets may be local, regional, or international. Ethiopia has been particularly successful in tapping international markets.

It has been estimated that using improved CIAT varieties increases the probability of being a net bean seller by 14% [45]. Climbing beans have grains with high commercial value; they have the potential to triple the yields of bush beans, and provide an important opportunity for expanded market participation [21]. Snap beans are finding wider usage. Beans also have potential as a raw material for processed products, since the food industry continues to seek sources of vegetable protein. In Africa, a budding food industry is finding opportunities for marketing bean-based convenience products, such as weaning foods that cook in a matter of minutes.

*Outcome 5: Increased availability of nutrient-rich food through the creation and dissemination of varieties that offer greater nutritional value and serve as raw products for processed foods.*

In 2011, it was determined that the use of CIAT-related improved bean varieties reduced household food insecurity by 16% in Rwanda and 2% in Uganda. The study used a dietary diversity score as a measure of food security [29]. Beans have been found to provide 24% of the daily protein requirement in Uganda [29]. CIAT, together with HarvestPlus and other partners, has promoted the adoption of high-iron bean (HIB) varieties since 2010, starting with a pilot project in Rwanda. High-iron bean cultivars have been released in at least seven countries. By 2015, it was estimated that around 350,000 households were already growing HIB varieties. A recent study showed that the consumption of beans had a positive effect on the iron status of Rwandan women aged 18 to 27, and women who ate high-iron beans bred had significantly higher hemoglobin levels [20] and better memory and attention span [33] than women who ate standard beans. High iron and zinc levels are breeding objectives for four legumes in GLDC FP 4. Breeding for high iron has both opportunities (e.g., tapping certain segments of the genetic resources for the high mineral trait) and pitfalls (e.g., inadequate selection criteria), and the experience with HIB will likely be of value to other legumes. GLDC's FP 3 proposes a comparable outcome of nutritional impact.

## 1.3. Theory of change and impact pathway

### Impact statement

Food and nutrition security, greater wellbeing and the alleviation of poverty in sub-Saharan Africa and Latin America has been and will continue to be enhanced through exploiting the genetic diversity

of the *Phaseolus* genus, the application of crop management practices, and improved market linkages.

### Theory of Change

This flagship attends to multiple issues of climate resilient production, income generation through marketing, and human health, in an agri-food system context. Production technology for beans continues to be developed as in past years, and further evidence of the healthy effects of bean consumption is emerging. But a more systematic approach to link production and consumption through a dynamic marketing sector is increasingly recognized as a key component to satisfy both ends of the value chain. Therefore, in our work we raise the profile of the **private sector at the center of the value chain and in linking production and consumption.** It expands on a successful track record in seed production and dissemination with the private sector through engagement platforms, variously called innovation platforms (in Africa) and learning alliances (in Latin America). Some of these are rapidly evolving into business platforms in which seed businesses continue to play a role in disseminating new, productive and nutritious varieties, while platforms are drawing in other business sectors as well.

The success of the Pan-African Bean Research Alliance (PABRA) is based on these engagement platforms. PABRA is a consortium of 30 countries in sub-Saharan Africa within which the facilitation and participation of CIAT play a key role (see below and section 1.7 Partnerships). PABRA unites sub-regional networks in east-central, southern and west-central Africa to coordinate regional cooperation in the development and dissemination of bean technologies. As long ago as 2014 the external review of the Grain Legumes CRP (CGIAR Research Program), Phase 1, found the alliance set up to be well established and confirmed the value of its platforms:

> "Linkage of participatory research to innovation platforms is creating positive impact (for example through the Pan-Africa Bean Research Alliance-PABRA). Such systems approaches are to be recommended across all seed enterprises. Different modalities for seed dissemination have been carried out effectively in an "action research" mode (e.g. marketing in small seed packets at low cost and permitting farmers to experiment with low risk; seed-for-grain models; standard private sector production; decentralized local production of Quality Declared Seed (QDS) with small NGOs and CBOs; and value-chain development). This work has revolutionized the impact pathway and opened multiple channels to reach farmers, both outcomes of the effective partnerships within PABRA."

These platforms allowed PABRA to reach 3.3 million households (an estimated 16 million bean users) with improved bean varieties, bean products, and crop management practices between 2012 and 2016 (see Section 1.5 Building on successes and lessons). While historically bean innovation platforms have focused largely on seed dissemination, **crop management practices** are shared as well. In the evolving model of the platforms, the role of seed production has been increasingly assumed by the private sector. In 2017 small and medium sized seed businesses produced about 80% of the 21,000 tons of QDS and certified bean seed in Africa (Annex 6), reaching an estimated 4 million farmers in one year. This vastly increasing rate of dissemination is a testimony to the capacity acquired by PABRA and its partners in dealing with the private sector, and in business development (to which a full PABRA staff is dedicated).

Seed business platforms have led naturally to involvement in diverse bean markets (grain for local use; grain for different regional markets; grain for international markets; snap beans). In the bean corridor approach, platforms have been convened for grade traders among other participants

(researchers, extension agents, farmer groups, credit providers or representatives of the food industry). Face-to-face meetings are held every six months or yearly. Regular communication is a key to success. PABRA maintains an agile M&E system to monitor distribution seed and other technologies, including gender disaggregation of recipients.

This flagship's theory of change is based on CIAT's and its partners' rich experience in convening and coordinating engagement platforms with national partners. Three key aspects of these engagement platforms merit emphasis because they enable our delivery promise:

First, because these engagement platforms are **co-convened with a national partner**, they have the potential to be sustainable beyond an eventual exit by CIAT. Among domestic institutions in developing countries, the entity that is attached to the Ministry of Agriculture has the prestige to convene such platforms and to serve as an honest broker, even in cases where public resources do not permit vigorous intervention. Lead business partners also contribute to stability of the platform. For the national research program also, the experience with seed systems and seed businesses has been an opportunity to learn to deal with the private sector – a relationship that has permitted, for example, contractual relationships for the production of breeder and foundation seed by private companies under supervision of the breeder. Increasingly the relationship with the private sector is one of a mutually beneficial partnership, with potential to stand the test of time.

The case of navy beans in Ethiopia – cited above – points to a second dimension of innovation platforms and learning alliances: **market-pull transformation**. Bean yields were well below a ton per hectare in Ethiopia, comparable to other African countries. Thanks to an innovation platform involving researchers, farmer cooperatives, extension agents, traders and exporters, farmers gained confidence in the market, and were informed about improved agronomic practices and market requirements. This led them to invest in and adopt technologies, including fertilizer, weeding and new varieties, with the confidence that they would earn a return on their investment. The bean deficit in the large regional African market suggests a major opportunity to stimulate adoption of technology and to induce changes in productivity. Foresight analysis can help us to focus our efforts on those market opportunities with the greatest pay off.

A third aspect of these engagement platforms is that **they grow organically**. Bean production, trade and consumption exist already in all target countries, and existing systems are the foundation and the seedbed for systematic, organic growth and improvement. For example, the navy bean trade in Ethiopia existed prior to the innovation platform, but the platform facilitated more dynamic relationships among the actors who were empowered to chart the course of the platform. The organic nature of the evolving relationships is evidenced by the bilateral agreements that often result without the involvement of either the national program or CIAT.

### The role of CIAT

Clearly, CIAT's work with national partners contributes to innovative research to **exploit genetic diversity** as described in detail in section 1.6. below (cluster of activity 2: Germplasm studies, trait discovery, pre-breeding and enabling technologies; and cluster of activity 3: Breeding pipelines for stress-tolerant, market-ready beans). But beyond research and technology development, the role of CIAT in the engagement platforms (see also section 1.7. on partnerships) is three-fold, enhancing social capital, and with some aspects predating even the CRP system:

- To assist national agricultural research programs (typically a branch of a country's Ministry of Agriculture) to **foster communication between the suppliers and demanders of technology**, especially but not exclusively bean seed. The role of CIAT in innovation platforms is not exclusive but supportive. The presence of an international institution tends to augment the prestige of the national partner, and facilitates cross-border learning. CIAT staff have more than ten years' experience in facilitating platforms, and bring this depth to new challenges. CIAT's success is largely thanks to investing in this bridge-building function, and to mentoring of national program colleagues. The relationships between actors must be nurtured at each step along the impact pathway to ensure the development of mutual trust, the sharing of available technology and of feedback on the nature and magnitude of the demand for technology.
- To **evaluate models** that enhance the effective and more rapid dissemination of technologies. For example, at one time action research led to testing the marketing of bean seed in small packets of as little as 200 grams. The cost of such a small packet was within reach of any farmer, and permitted the farmer to experiment with new varieties with practically no risk. While the profit margin for seed companies was small, some viewed this as a promotional technique that paid for itself, and that could induce farmers to return to buy larger quantities.
- To give **intellectual leadership** to the consolidation of production-to-consumption corridors, through data compilation and analysis. Since corridors cross borders, this implies an international function that falls outside that of national program staff. A market economist has assumed this task, and is completing the characterization of corridors in terms of volumes of production, routes of movement of grain, and grain traits preferred by the market. This has brought a far more quantitative perspective to the task of structuring interventions.

**Assumptions**

The following major assumptions underpin our Theory of Change and will be validated in the course of implementation:

- **There is a significant unmet demand for beans.** While we recognize that yield increases alone are insufficient to meet development goals, the current deficit in beans requires us to increase productivity. Latin America is a net importer of beans, with Mexico and Brazil experiencing large and expanding deficits. Modeling exercises indicate that bean production is under short-term threat from climate change throughout Latin America [15, 31]. Kenya imports 40% of its required beans. In Africa, the bean deficit can only grow in light of population growth.
- **Consumption is also limited by purchasing power**. The results of Living Standards Measurement Studies (LSMS) in Uganda and Tanzania indicate that bean consumption in lower income families is scarcely 40% of that in higher income brackets (see Annex 7). Combining greater availability with lower prices would increase total consumption.
- **Greater consumption of beans will lower food insecurity and improve nutrition and health.** Many of the world's poorest people face a double burden of undernutrition and so-called overnutrition, consumption of high calorie diets that give rise to obesity, diabetes, cancer and heart disease. Latin America suffers an estimated cost of US$65 billion per year due to diabetes [3], and this may foreshadow public health problems in other regions. Bean consumption can lower risk of these non-communicable diseases, and reestablishing beans as a regular dietary component would be an important preventative measure [38].

- **Ample genetic variability is available** to improve bean productivity, both by alleviating yield constraints and enhancing yield potential. Cultivated common bean has two major genepools [6, 8], as well as secondary and tertiary genepools with the potential to tackle yield traits, extremes of climate and soil constraints.
- **Market channels exist and bean value chains can be strengthened to serve both rural and urban consumers more effectively.** Beans are a well-established crop that both farmers and the markets know and appreciate. Survey data in Africa confirm that urban consumers continue to eat significant quantities of beans. A significant proportion of the bean crop is already marketed on both continents, and beans are being viewed as a business opportunity.
- **Marketing beans can contribute to farm income and prompt the adoption of improved production technology**. In Ethiopia, a marketable product – navy beans – and reliable markets combined to improve crop management, doubling bean yields over a decade [17]. We foresee the potential for replicating this experience in eight existing but poorly organized market corridors to serve a growing population. Foresight studies can guide and focus this effort for the greatest benefit, identifying the most lucrative future markets and most competitive production zones.

### Impact Pathway

Figure 1 illustrates the anticipated impact pathway for the flagship's theory of change delivery.

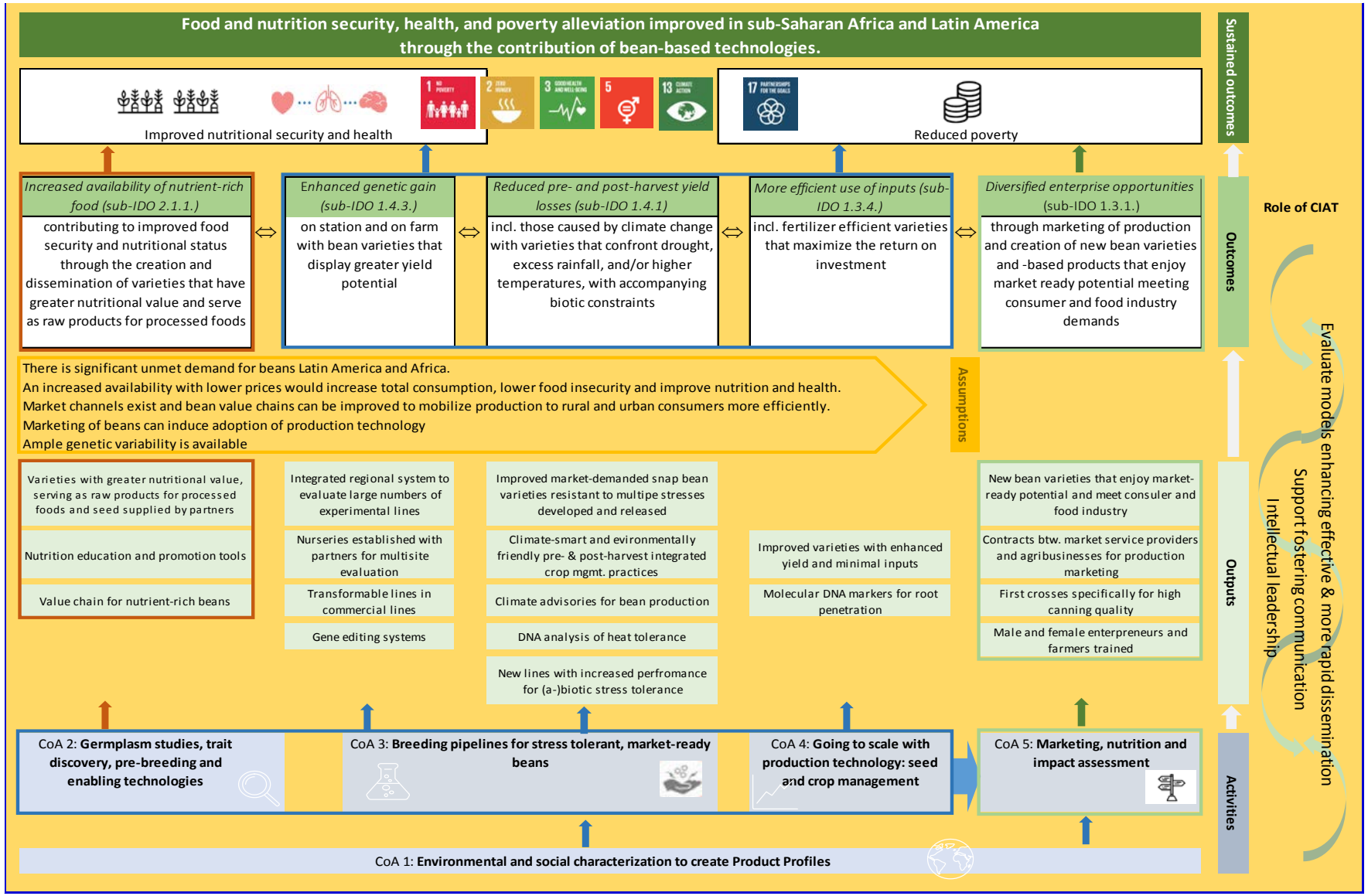


**Figure 1: Impact pathway, assumptions and CIAT's role**

## 1.4. Science quality

CIAT's Bean Program communicates its research outputs regularly through peer-reviewed journal articles in the areas of genetics, genetic resources, applied breeding, stress physiology and seed systems. Many of these articles appear in the reference list of this paper, and a complete list of CIAT publications (2013–2017) is available at http://bit.ly/2BgMT82. CIAT research has resulted in more than 500 bean varieties in Latin America and more than 400 varieties in Africa: cultivars that respond to the challenges of soil degradation, climate change and nutritional demands. In the last External Program and Management Review (EPMR) in 2008 it was stated that:

> The 6th EPMR Panel believes that CIAT's bean improvement program is by any measure the leading program in the world. It has a very high level of output of finished varieties and advanced lines for use in Africa and Latin America, produces important basic knowledge, is a leader in developing and applying biotechnology tools in bean improvement and is the primary source of capacity building in national bean programs. The program has strong linkages with ARIs, NARSs and other researchers in developing countries. These linkages keep the program on the cutting edge of science.

## 1.5. Building on success and lessons learned

Economic impact assessment analyses show that the adoption of CIAT-related varieties, either with lines created directly by CIAT or through breeding with CIAT germplasm, has generated benefits in Latin America and Africa estimated to be worth **US$17.4 billion**, with a return on investment of **US$3.22** per dollar invested. The benefits arose from a combined research expenditure by CIAT and partners estimated at US$5.3 billion [14]. CIAT's portion is only about 12% of the total but potentiates the investments of national partners, demonstrating excellent value for money. Between 2012 and 2016, the Bean Program and its partners in Africa reached an estimated 3.3 million households, 2.2 million of which received new bean varieties (51% of recipients were women), 0.76 million were trained in new crop management practices (55% women), and 0.38 million received bean products such as pre-cooked beans (45% women). The business platform approach is already scaling up these successes (see section 1.3. Theory of Change).

Important lessons for the current proposal have emerged from CIAT's work and that of the wider research and development community and these are presented below.

*The importance of beans for nutrition and health*. Besides reducing risk of chronic diseases, beans are also an important source of iron and zinc. CIAT's Bean Program has participated in the HarvestPlus program on biofortification since 1994. The development of beans with high iron are one of the banner successes of the program. HIB improve hemoglobin status [20] and have a positive effect on memory and cognitive ability [33].

*The need to exploit the potential of bean biodiversity*. Climate modeling [5, 15, 31] highlights future challenges of heat and drought for which the evolution of common bean did not prepare the crop. Sister species (both wild and domesticated) in the bean's center of origin in Latin America evolved in extreme environments and are invaluable sources of hardy genes that can confront the challenges of drought, high temperatures, excess rainfall, resistance to certain diseases, and edaphic constraints (phosphorus, aluminum [11, 12]). These species may also be able to contribute genes for yield potential and nutritional quality. Improved methods for tapping the diversity of these species have been developed [2] and are being complemented with genomic analysis.

*Relationships with development partners.* A key to creating impact lies in the dedication to building relationships with development partners. Too often interactions of international centers with partners are sporadic and limited to the scope of short-term projects. Instead, networking needs to be someone's long term 'day job' and their primary responsibility. CIAT staff working in PABRA (see below) have taken on this task, essentially by facilitating linkages between the suppliers and the recipients of technology through platforms, while exploring novel institutional relationships, such as licensing bean varieties to private companies (see text box).

*Dramatic success stories.* Climbing beans have dramatically raised yields in Rwanda and, in a place where hunger previously loomed large, beans are now being exported. A second success story illustrates the potential for markets to motivate improved crop management practices. In Ethiopia, a combined market and training program prompted farmers to invest in crop management and quality control, doubling yields over a ten-year period [17].

*Possible unintended consequences.* Increased productivity runs the risk of lowering prices due to oversupply. While both Africa and Latin America currently have ample deficits to absorb production, gluts can and do occur locally and at harvest time. Here, the role of market access takes on importance, together with the issue of storage capacity to enable farmers to sell their products at a favorable time. These issues can be addressed through the efforts of market corridor platforms. Another unintended consequence of increasing productivity may lie in the promotion of trade. Will poor consumers find themselves competing with regional and international markets, with less access to beans as a staple food and negative health consequences? CoA 5 will address this question.

**Box 2. Case study: Innovative partnerships.**

Bubayi Seed Company, a family-run seed business in Western Kenya, initially sold just maize seed but saw an opportunity to sell bean seed, albeit with great uncertainty. Many seed companies shy away from bean seed business because of low profitability due to self-saved farmer seed after one-off purchases. However, Bubayi opted to take the risk, buoyed by the fact that farmers needed bean seed, which was unavailable in local shops. In 2015, Bubayi and the Kenya Agriculture and Livestock Research Organization (KALRO) entered into a bean variety licensing arrangement supported by Syngenta Foundation for Sustainable Agriculture and CIAT. Varietal licensing greatly encouraged Bubayi and, since 2014, their certified bean seed production has grown from 6.1 tons to more than 160 tons. This model of public- private partnership bodes well for engaging more private companies in a budding market.

## 1.6. Overview of clusters of activities (CoA)

The activities in the common bean flagship will be organized into five clusters that follow the private sector business model promoted by the Excellence in Breeding platform (EiB). The first cluster refines understanding of the socio-economic setting and contributes to the design of product profiles (characteristics sought in new varieties); clusters 2 and 3 deal with trait discovery and pre-breeding; and mainstream breeding, respectively. Seed scaling activities – as described under CoA 4 – will be implemented continuously based on established and evolving strategies in PABRA, HarvestPlus and the Grain Legumes programs. CoA 5 is concerned with markets, nutrition and includes components

of gender and youth employment. Figure 2 represents the links between clusters of activities and the bean flagship outcomes on the one hand, and on the other hand, the links of these same CoA's with the corresponding activity clusters in the GLDC.

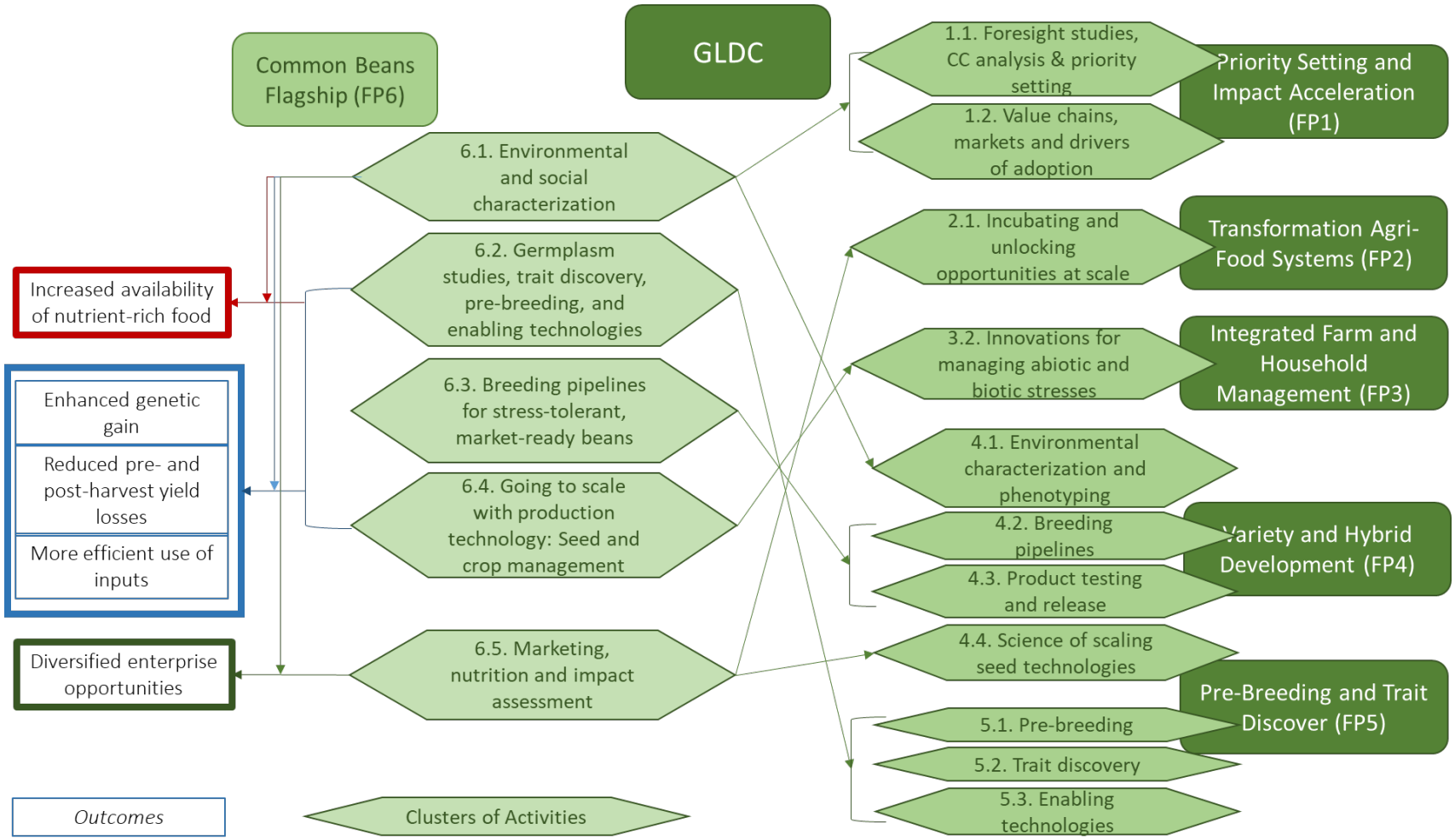


**Figure 2: Clusters of activities in the bean flagship and their relationship to bean outcomes and to GLDC clusters of activities.**

## CoA narratives

*CoA 1. Environmental and social characterization to create Product Profiles*

Designing interventions in an agri-food systems approach requires understanding the multiple steps from production to consumption, the relationships that link one step to another, the economic viability at each step, the ultimate effectiveness in nourishing a population, and the requirements of different actors. The geographic distribution, character and magnitude of demand (gender disaggregated) must be estimated as population growth and urbanization transform food habits and consumption. Foresight analysis will seek to estimate demand in local, regional, and international markets and value chains in production-to-consumption corridors. Gender differentiation of trait preferences has been practiced in the Bean Program for many years, but is subject to the dynamics of a changing social environment and will be updated through surveys. Varietal development is being aligned with the concept of demand-led breeding ~~(DBL)~~ in collaboration with CoA 5.

A priority-setting exercise carried out in 2012 identified climate change, soil constraints and biotic limitations as the key targets for genetic improvement (GL CRP Phase 1 document; see also [47]). That exercise will be refined -- using statistical analyses of climate and soil data – to develop Target Populations of Environments (TPE)[1] in support of CoA's 2 and 3. One approach used the MaxEnt model (maximum entropy) to characterize environments for the cultivation of climbing beans [21]. Temperature, soil pH and cation exchange capacity (CEC) emerged as determining factors. The MaxEnt method can be used to evaluate the effects of climate change at mid-century and at end-of-century. The context for business platforms will be determined, and opportunities for youth employment will be identified, in coordination with CoA 5. On the consumption side, data on health parameters, especially anemia and stunting, will be incorporated where possible, although these data often are available only at the national level (see Annex 3). Zinc is emerging as a higher priority than iron in some countries in East Africa [22] and targets must be refined accordingly in consultation with HarvestPlus. The surprising receptivity – even among rural women – to easy-to-cook infant foods suggests that the processed food market merits further study. These activities will contribute to refining the product profiles for different production regions as facilitated by the CGIAR Excellence in Breeding Platform Module 1 – Optimizing Breeding Schemes, and enhancing the likelihood of adoption.

*CoA 2: Germplasm studies, trait discovery, pre-breeding and enabling technologies*

Faced with extreme climates in the future, pre-breeding with sister *Phaseolus* species promises superior adaptation to harsh environments (Outcome 3), although in the past these species have scarcely been touched in varietal development programs. *P. coccineus* and *P. dumosus* evolved in humid environments, while *P. acutifolius* evolved in hot, desert-like regimes. Interspecific variability is a key to accelerating genetic gain (Outcome 1). Our experience with breeding for abiotic stress sheds light on the role of photosynthate transport to grain in both stressed and unstressed environments [1]. *P. acutifolius* (tepary bean) is especially efficient in this regard and can serve as a genetic model for yield improvement [35]. *P. acutifolius* offers tolerance to drought, heat (at least 28$^{o}$ C nighttime temperatures), and some pathogens and insects (Outcome 3). Lines derived from *P.*

[1] A TPE identifies the environments to which a new variety developed by the breeding program must be adapted.

*acutifolius* showed a 468% production increase over the common bean parent under heat stress and a 12% increase over the best elite line. In the past, breeders made little use of this species due to the need to culture young embryos in the laboratory. The recent discovery of interspecific bridging genotypes, which are cross fertile with both species, opens vast new opportunities for breeding common bean [2]. *P. acutifolius* accessions from the genebank will be examined extensively to determine what other traits they may offer.

*P. coccineus* has ample genetic diversity that has never been characterized. This species has unique root traits that, if transferred to common bean, could improve access to soil water and nutrients [7, 11, 12] and improve the recovery of fertilizer (Outcome 2). Superior interspecific lines are already moving into the mainstream breeding program, while others are being developed. Understanding the genetic systems of these species will permit the design of common beans through gene editing or genetic transformation when these methodologies are perfected [32].

Markers for key disease resistance genes have been tagged with single-nucleotide polymorphisms (SNP), and this work continues (Outcome 3). In-house capacity exists for selecting SNPs using the melting temperature differential technique, but prospects for high volume, low cost outsourcing of genotyping are also being explored. Increasingly, the sequencing of key genotypes is helping us to identify unique, linked polymorphic loci [30]. Traits derived from interspecific crosses offer higher probability of unique polymorphisms in relation to *P. vulgaris*; thus, sister species should be sequenced strategically, for example, to reveal markers for heat tolerance in tepary bean (Outcome 3) and root traits from *P. coccineus* (Outcome 2). Recombinant inbred lines (RIL) segregating for iron concentration have been phenotyped and are ready for genotyping and marker development (Outcome 5). Prospects for gene editing are good, as the obstacle of recovering plants from tissue culture has now been overcome [32]. Rapid cycling of generations combined with reliable selection criteria in each generation will lead to faster genetic gain as favorable alleles are recombined in each cycle (Outcome 1). This will be especially useful in climbing beans, which have a long growth cycle of four-to-six months or longer. The use of novel phenotyping tools, for example to evaluate photosynthetic traits or in situ root distribution in soil, will be explored.

*CoA 3: Breeding pipelines for stress-tolerant, market-ready beans*

Common bean breeding must meet specific grain characteristics for color, size and shape to comply with regional demands. Based on the current networks of CIAT researchers and NARS partners in PABRA and in Central America, we will create efficient professional breeding networks around commercial classes of bean, using a common system, methodology and following the same metrics. The bean trait dictionary is a step in this direction and has been implemented. New germplasm developed at CIAT stations in Colombia and Africa will be shared with NARS partners in regional communities of breeders, who will evaluate regional nurseries of several hundred lines planted in ten to twelve sites per region. National partners in Central America recently agreed jointly to establish such a system, and the PABRA network will facilitate this in Africa. The aim is to obtain adaptation data early in the testing and release process and to facilitate the rapid release and use of lines (Outcome 1). The breeding network will use a stage gate system (systematic joint decision taking at key steps) to facilitate information flow, estimation of genetic gain, transparency, quality assurance and optimal budget allocation. Organized data feedback from NARS will permit us to explore genomic prediction for breeding at a distance.

Bean breeding has long highlighted resistance to biotic constraints (fungal and viral pathogens) and the selection of several important resistance genes is now facilitated with SNP. Many grain types are common to Latin America and Africa, facilitating breeding across continents. Most production constraints are also similar, with major exceptions of gemini viruses in Latin America, and the bean stem maggot (*Ophiomia* sp.) in Africa. However, climate change will alter patterns of insects and diseases, and bring abiotic constraints to the forefront, especially drought and heat stress [5], requiring creative approaches to stress physiology. If photosynthetic traits measured by the MultispeQ tool prove to be related to yield, data can be compiled in real time over entire regions in the PhotosynQ cloud database. Several drought-tolerant varieties have been released already, while breeding for heat tolerance is more recent (Outcome 3). Stress-tolerant lines are components of climate-smart agriculture (CSA) in CoA 4. Lines derived for adaptation to infertile soils and nutrient uptake are being incorporated into mainstream breeding programs (Outcome 2), to be combined with integrated crop management (ICM) practices in CoA 4. Market demands for grain types, industrial traits (e.g., canning quality), and traits preferred by consumers (e.g., cooking time, taste) [4] must be included in phenotyping platforms. Market traits have dominated the criteria for release of varieties in Latin America for two decades, and Africa is rapidly moving in this direction. Breeding methodology for improved micronutrient concentration (iron and zinc) is developed and piloted in HarvestPlus under the Agriculture for Nutrition and Health (A4NH) CRP and mainstreamed in the bean flagship [9, 10] (Outcome 5), while biofortified lines are distributed to countries beyond the HarvestPlus mandate of Rwanda, DR Congo, Uganda, Nicaragua, and Guatemala. Climbing and semi-climbing beans will offer farmers high yield and excellent commercial value (Outcome 1). The creation of new varieties requires support from auxiliary disciplines of physiology, pathology, entomology and virology, to reveal mechanisms of stress tolerance, elucidate host-pathogen relation, and to develop selection criteria for the breeding program.

*CoA 4: Going to scale with production technology: seed and crop management*

Seed dissemination: Scaling up seed-based technologies involves seed production, distribution including marketing, and messaging. Multiple strategies have been devised, tested and implemented, particularly for legume seed, as alternatives to high cost certified seed. The Tropical Legumes II and III projects promoted creativity in seed systems in collaboration with CIAT's seed experts in PABRA, who led the seed component of those projects. A major key to success has been the innovation platforms, many members of which are self-financed and are anxious to access new varieties. Through direct communication, demand for seed is channeled from seed users to seed enterprises who use this information to respond appropriately to supply the quantities required (Outcomes 1 to 5). As noted above, the Phase I external review of the Grain Legume CRP noted several strategies for scaling up seed dissemination, including "marketing in small seed packets at low cost and permitting farmers to experiment with low risk; seed-for-grain models; standard private sector production; decentralized local production of Quality Declared Seed ~~(QDS)~~ with small NGOs and CBOs; value-chain development". In addition, the wider involvement of the private sector in production and marketing, in novel legal arrangements for production of large amounts of breeder and foundation seed, or in licensing of new varieties has been very successful and will be encouraged. In Central America, seed dissemination occurs through multiple mechanisms: public extension services (all countries), local community seed banks (Nicaragua), and more than 100 local

farmer research committees (Honduras). The participation of the private sector in limited, but is being explored.

This activity is integrated with GLDC CoA 4.4 under the Tropical Legumes-III project.

Crop management practices: Integrated soil fertility and pest and disease management practices must accompany the scaling up of bean varieties across diverse production environments, including the judicious use of organic, inorganic and foliar fertilizers. Site-specific fertilizer recommendations that emphasize balanced plant nutrition and micronutrients will contribute to more nutritious grain (for example, to increase zinc concentration). The adoption of simple-to-use post-harvest labor saving technologies like bean threshers (e.g. in Ethiopia and Tanzania) is increasingly important as youth migrate and farm labor becomes scarce. This is a long-term reality in Central America and is also occurring in parts of Africa. Climate-smart agricultural practices that improve water and nutrient use efficiency, such as conservation agriculture, require greater attention. Climate risk assessments will provide accurate and timely climate information to inform farm decision-making and operations. CIAT and its partners have carried out CSA profiles to estimate risks from climate change in nine countries in Latin America and the Caribbean and seven countries in Africa (Kenya, Rwanda, Senegal, Mozambique, Tanzania, Zambia and Uganda), together with climate risk profiles downscaled to a sub-national level in 31 counties in Kenya.

These activities relate to GLDC CoA 3.2. Innovations for managing abiotic and biotic stresses.

*CoA 5: Marketing, nutrition and impact assessment*

Regional corridors: PABRA takes a regional corridor approach to addressing beans in a food system context. Ongoing analyses reveal the existence of corridors of unstructured major flows of beans between areas of production and consumption, connected by poorly organized distribution networks. Eight such corridors have been defined by PABRA (see Annex 8), and the characterization of major corridors in eastern, southern and western Africa is well advanced. What is unique about this approach, in addition to its participatory mode, is that it provides a detailed quantification of these flows, and information on service providers such as sources of credit, insurance, and ICTs. The objective of this activity is to strengthen the efficiency of the three interlinked corridor hubs—production, distribution, and consumption – on the pathway to markets. Production hubs are sites or regions where large volumes of beans are (or can be) produced in response to market needs by: targeting the development and dissemination of varieties demanded by the market; improving productivity and production through good agricultural practices (GAPs) including CSA and ICM; developing and sustaining seed systems; and strengthening the capacity of farmers to collectively market their products. Distribution hubs include product aggregation centers, distribution centers, warehouses, storage points and commodity exchanges where beans are distributed to consumers. Consumption hubs are major market outlets in rural, peri-urban and urban areas (in or outside of production areas) and include processing units, supermarkets, and bean dealers.

In section 1.3. in our Theory of Change we describe the role of the private sector in linking production and consumption. Engaging with the private sector in the corridors takes place through bean business platforms (a variation on the innovation platform theme) that foster relationships among leading firms in the seed and grain businesses. Platforms based on lead firms are coherent and sustainable, and facilitate market channels to which smallholder farmers can link, replicating the experience of Ethiopia whereby smallholders doubled their yields in response to market pull. To date

business platforms have been established in Ethiopia for navy beans, in southern Tanzania and Zambia for sugar bean, in Uganda for the Nairobi market, and in Rwanda for precooked (including biofortified) beans. Business platforms in corridors will create employment opportunities for young people. For example, youth are taking the lead on IT applications in the Rwanda platform. Improved production technology can open up opportunities for small businesses for young people (for example, in crop spraying). Linking these opportunities to the wider business context offers greater likelihood of sustainability than isolated efforts to generate work for youth. The corridors will help to create market-driven, rural agricultural transformation by linking all members of the bean value chain across the corridor, while strengthening linkages to support services such as credit, insurance, and ICT among others, as potential members of the platform.

A corridor perspective sets product profiles developed in CoA 1 in a specific regional context. Markets increasingly reflect what consumers want and determine what farmers grow. This has been a reality in Central America for nearly two decades where the market demands small red beans of a specific pinkish tone, while in East Africa, the vast on-farm diversity of grain mixtures used a generation ago is being reduced to half a dozen types. Focusing interventions around corridors offers a context for enhancing the inclusion of women in value chains (Outcome 4), and for evaluating the impact of interventions. Nutritional outcomes (e.g., of biofortified beans) can be measured by monitoring the volume of grain moving through the corridor (Outcome 5). Bean-based products (flours, porridge) are developed in collaboration with food processors and commercialized in the consumption hub to create new markets for nutritious food options (Outcomes 1 and 5). These activities relate to GLDC CoA 2.1. Incubating and unlocking opportunities at scale

Policy discussions: PABRA's work plan includes the following output: "policies and constraints that affect trade in beans reviewed, advocated and harmonized at national and regional levels." To date, various policies affecting bean production and trade have been reviewed in Uganda, Rwanda and Tanzania, and discussions have been held with ministerial-level functionaries in Malawi and Burundi. Decision-makers will be kept informed on the vision and progress of the corridor approach. Governments in net exporting countries have already embraced the opportunity to commercialize bean and have classified bean as a tradable commodity for further promotion.

Nutrition: A strategy that promotes marketing of beans raises questions regarding nutritional impacts. How will increased marketing of beans affect domestic consumption, especially in poorer households, which are sometimes net buyers but will now have to compete with consumers in regional/international markets? Will moves to commercialize beans increase malnutrition and create a heavy health burden on poor consumers and on their governments, or will the returns to trade have positive social gains? A previous study examined this question in Rwanda, and it will be studied further under CoA 5. Bean-based porridge for children found ready acceptance among mothers, and promotion of bean-based products in local communities will continue. An on-going project looks at potential for nutrition-sensitive value chains, and a major project on promotion of biofortified beans is due to initiate soon.

Impact assessment: PABRA has a full-time impact assessment economist with attention to adoption, especially under the Tropical Legumes III project. The economist works closely with the seed specialist, market economist and nutritionist to set adoption in a context of development goals. Extensive analysis on data derived from the Living Standards Measurement Study (LSMS) in Uganda and Tanzania has confirmed a vast gap in bean consumption among lower economic classes.

## 1.7. Partnerships: Jointly funded collaboration

*Networks with national partners*. Agro-ecological regions and agri-food systems cross political borders, making regional cooperation in networks a cost-efficient way to address current and future challenges. CIAT has a long history of creating regional networks with partners (Annex 9), first in Central America, and later in the African Great Lakes region and eastern and southern Africa. The Central American network has not functioned formally since the mid-1990s, but governments in the region pursue formal structures of integration that make regional cooperation a natural outcome, and collegial relations among researchers facilitate the exchange of germplasm and research results among countries with similar agro-ecologies and grain preferences. Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua regularly share germplasm, with follow-up on testing of breeding lines financed by the national research institutions. CIAT works closely with the Pan-American School (Zamorano) in Honduras, which plays an important role in coordinating regional trials. An annual meeting of agronomists (the Central American Cooperative Program for the Improvement of Crops and Animals –PCCMCA according to its Spanish acronym) facilitates coordination of activities and is supported financially through HarvestPlus.

The Pan-African Bean Research Alliance (PABRA) is a self-governing consortium facilitated by CIAT and comprising 30 countries, among which Cameroon, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda are the largest bean producers. Our researchers (breeders, economists, seed experts, nutritionists, a gender expert) work closely with national program partners who constitute the three sub-regional networks of PABRA (in East, West and southern Africa). National bean program leaders are the formal national representatives of PABRA and sit on the steering committees of their respective regional network, with decision making power on research priorities. However, other collaborators such as representatives of the private sector frequently attend coordination meetings. Annual meetings permit information-sharing and joint decision-making on priorities and governance. An external review of PABRA highlighted the benefits of such a networking model:

> PABRA represents a model for how a continent-wide crop network can function for the benefit of smallholder farmers. The efficiency and effectiveness of PABRA are demonstrated by the potential for communication and cooperation in bean research and allied areas among 30 African nations. PABRA is becoming increasingly relevant with changes in African agriculture and market development across the continent. [37]

Regarding CIAT's role in relation to PABRA, the review noted:

> PABRA has benefited enormously from its partnership with CIAT, and CIAT's support has kept up with changing circumstances in the member countries of the network. The PABRA network, in essence a multifaceted partnership, contains some strong countries whose bean production is being commercialized or is at the point of being so. It also includes countries that are aiming to supply domestic, regional, sub-regional and international markets… If CIAT were not available as a partner in PABRA it is likely that only few countries could continue to develop their bean breeding, bean production and related activities…CIAT is a mainstay of the PABRA network and will continue to be so into the future. [37]

In most countries the greatest active collaboration has been in the breeding and seed sectors, although this is rapidly expanding to the business sector under the corridor approach. Within PABRA, three CIAT scientists are responsible for breeding for locally-important traits, and they also coordinate the introduction of germplasm from CIAT-Colombia from the two breeders based there. CIAT scientists interact with their peers working on other legumes through the Tropical Legumes III

project, funded by the Bill & Melinda Gates Foundation and led by ICRISAT. PABRA leads the seed component of this project, whereby successful experiences in seed dissemination have been shared and applied to other legumes in GLDC, illustrating the benefits of the cross-legume cooperation that will be nurtured by this flagship.

The current 2018 Bean Program budget for CIAT activities and for national partners is broken down by CoA in Figure 3. PABRA also leverages additional bilateral funds that flow directly from donors to partners and are not presented here. Budgets for 2018 to 2022 broken down by CoA are presented in Annex 10. CoA 1 and CoA 2 are currently not funded but discussions are underway to secure bilateral funding.

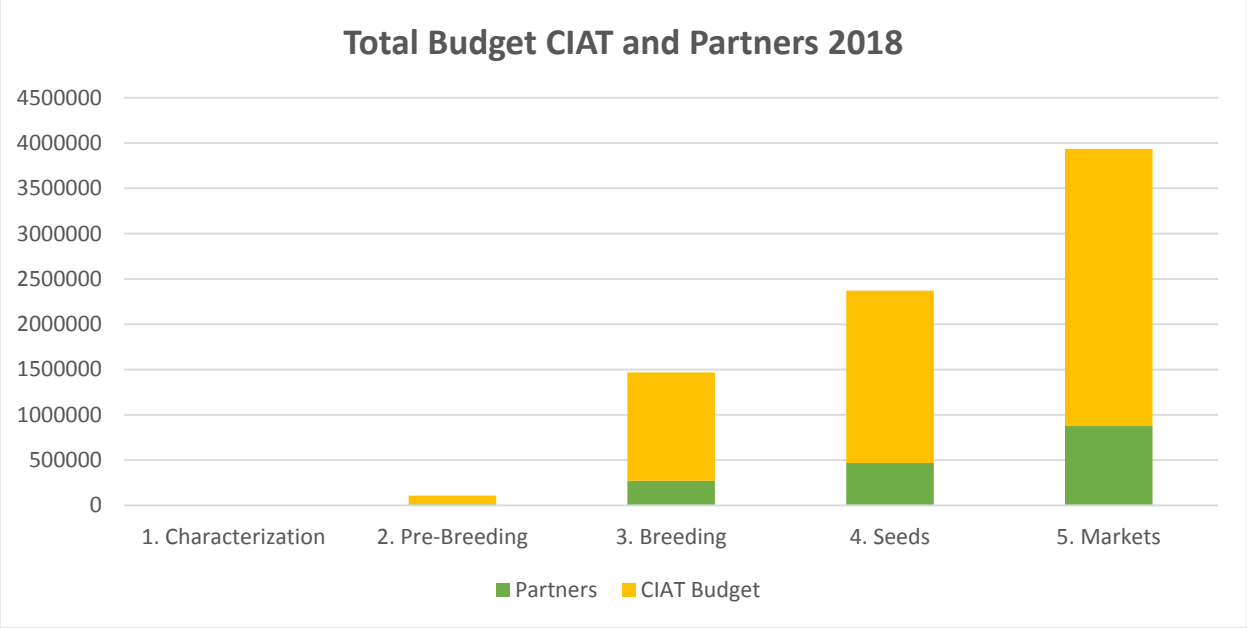


**Figure 3: Assured funding for CIAT and partners for 2018 by clusters of activities,.**

*Upstream partners*: The largest bean research community in the developed world is found in the United States, where the genome sequence of common bean was developed. Partners in advanced research institutions (ARIs) often choose to include CIAT in projects given its track record of scientific excellence. A joint project focusing on breeding for abiotic stress tolerance is funded through the United States Agency for International Development and administered by Pennsylvania State University. The project fosters interactions between colleagues in three USDA stations, and in the University of Puerto Rico, North Dakota State University and Zamorano (Honduras), as well as in Mozambique, and on topics as diverse as stress physiology, breeding and genomics. Cooperation with Michigan State University has focused on soil pathogens, processing characteristics of bean, and photosynthesis research. Work with the University of California at Davis is looking at drought and heat tolerance physiology. CIAT's role in collaboration with advanced research institutions includes providing unique germplasm, interpretation of our own genomic data, joint QTL analysis, understanding and exploiting genetic resources, and physiological studies in tropical environments. We anticipate opportunities to develop cooperation on nutritional and health with partners such as Michigan State University, Colorado State University, and Washington University. Cooperation on heat tolerance and modeling is on-going with institutions in the UK: with Reading, Rothamstead and Leeds Universities.

*CRP linkages*. The unusual context of this flagship requires maintaining strong linkages to the A4NH CRP and the HarvestPlus program on biofortification, where beans have been one of the leading success stories. In the realm of production systems, bean has the closest affinity with the Maize CRP, with which we have collaborated in East Africa and in Mexico in the MASAGRO program. Beans have been shown to benefit in particular from conservation agriculture, which CIMMYT (under the SIMLESA collaborative project) has promoted widely. The CCAFS (Climate Change, Agriculture and Food Security) CRP, is based at CIAT and conversations are ongoing around the analysis of future climate scenarios and their implications for common bean production.

## 1.8. Climate change

To address the challenge of climate change, crop-specific analyses are needed to identify the geographic scope, nature and frequency of future climatic constraints. Interaction with CIAT experts in agro-ecology has consistently indicated that heat stress will be a major limitation in many bean-growing areas [36]. Drought tolerance has long been a priority in the breeding program and has resulted in the release of more than 20 tolerant varieties, and the potential benefits of drought tolerance have been estimated through a modeling exercise [13]. CoA 3 on breeding highlights the use of interspecific crosses with sister species in addressing these challenges. Continuing collaboration with climate experts in the UK will help to identify selection sites that can mimic future stress environments, and to target traits for climate resilience more effectively. As mentioned above, CSA profiles and downscaled climate risk profiles have been developed in collaboration with CCAFS.

## 1.9. Gender and youth

Empowering women is a central CGIAR value and it holds a special significance for beans, which are widely considered a women's crop in Africa. This means that CIAT has both a responsibility and an opportunity to exploit the potential of beans to benefit women and their families. It is well understood that putting income in the hands of mothers brings greater social benefits. For this reason, the socio-economic impact of our work on beans must be measured through a gender lens. An extensive survey in several regions of Uganda showed that women are particularly active along the bean value chain, including in marketing. They also influence how income is used in the household (see Annex 11). Nonetheless, as beans gain in commercial value, men are becoming more involved in cultivation and marketing [34]. This situation merits monitoring and/or active intervention to build the capacity of women to engage with evolving markets and new technologies (Gender sub-IDO: Gender equitable control of assets and resources). The involvement of women in participatory varietal selection contributes to the choice of lines to advance, but the exercise also needs to influence breeding objectives, considering trait preferences by gender and including these in product profiles. The gender analysis of preferred traits has been central to the bean breeding program since the 1990s [39, 40] and has been updated on occasion to monitor possible changes [26, 34]. Some studies have shown that men and women have different preferences (for example, women cited cooking time as important and this is now a breeding objective!), while other studies show little difference between men and women. Most importantly, gender disaggregated participatory evaluation of germplasm has been incorporated routinely into collaborative work with national research institutions, more than half of which use such evaluations as their standard operating procedure (see Figure 4). Production-to-consumption corridors will have new implications for trait preferences, as markets –near and far –set standards for varieties grown by farmers. This will require monitoring the impact of new commercial relations on gender roles in bean production and marketing to ensure that women and youth benefit.

Gender disaggregated evaluations must also be included in the development of non-germplasm products such as easy-to-cook foods (bean flours or other processed bean products) (Gender sub-IDO: Technologies that reduce women's labor). In their role as caregivers, mothers are responsible for deciding what their children eat. Weaning foods and other products aimed at improving the health of children will not succeed if they are not approved by the mothers. Beans are an especially nutritious option for improving the growth and health of children, but fulfilling their potential will depend on engaging with mothers.


**Figure 4: Left: Farmers in Kenya prepare to rate breeding lines using colored strings to mark preferences. Right: Gender disaggregated data are extracted from string colors.**

CIAT's gender consciousness is reflected in the gender balance in the Bean Program, where 40% of the scientific staff are women, covering a range of disciplines: breeding, economics, nutrition and food science, monitoring and evaluation, and gender analysis. A full-time gender expert based in East Africa assures rigor in issues of gender analysis and will work with the gender expert of GLDC.

Our approach to youth is based on the hypothesis that the corridor approach, with its production-to-consumption focus, will open up business opportunities for young people in bean value chains, either as small business entrepreneurs or as employees. Such opportunities could include providing services in production such as crop spraying; mechanical land preparation, planting, harvesting and threshing. Youth groups may be organized for the joint acquisition of costly machinery. Opportunities in distribution and marketing include collecting produce from farmers, and linking farmers to aggregation centers with support from mobile based ICT tools. For example, the older leaders of the bean business platform in Rwanda prefer to hand over some tasks – especially the ICT-based work and logistics – to young people. Streamlining the bean value chains opens up new opportunities in agricultural employment, especially on mechanized farms; grain trade and logistics; processing, sales and distribution of products; and developing appropriate ICT applications for agriculture. PABRA is evaluating how to support the establishment of youth employment/labor groups within the platforms: a proposition that has been well received by agribusinesses. There are plans to test the notion towards the end of 2018 as a source of employment for rural youth with insufficient land for agricultural production.

## 1.10. Capacity development

CGIAR suggests ten areas of intervention that develop capacity in agricultural research for development (for the full list, go to: goo.gl/Lk4y7z). Two of these are especially relevant for this proposal:

- *Develop CRPs and centers' partnering capacity and strengthening institutions.* As stated in the CGIAR capacity development framework, it is important to "face the challenge to move from research partnerships to broader, strategic and effective multi-stakeholder partnerships […]." This includes partnerships with local organizations, NGOs and institutions adept at developing capacity, particularly among producers and other stakeholders. The PABRA structure is just such a model and provides a prototype for cross-country, cross-institutional learning and empowerment whereby results and experiences can be quickly shared. Indeed, PABRA goes a step further in implementing participatory decision making across a region. An important challenge already assumed by PABRA is how to innovate in public-private partnerships to deliver products at scale.
- *Develop future research leaders*. There is a continuing effort to enhance and modernize the breeding programs of the international centers. The CGIAR Excellence in Breeding (EiB) platform will support research leadership capacity through updated knowledge on techniques and data analysis, among other services. The Breeding Performance Assessment Tool (BPAT) will facilitate a program-by-program analysis of strengths and weaknesses to guide this process. CIAT's Bean Program is actively engaged in the BPAT analysis and the broader EiB process. Considerable effort has been dedicated to formal post-graduate training for national program staff. Over the past 20 years, PABRA has trained 86,880 people, a third of which have been women. While this will continue, a greater effort should be made to build capacity at the level of field and laboratory technicians who are the backbone of research programs. The bean flagship will cooperate with GLDC on capacity building and on developing curricula for technicians. Breeding programs everywhere depend on well-trained technicians who are responsible for day-to-day operations.

The bean flagship will address the following capacity development sub-IDOs as stated by the CGIAR strategy:

- enhanced capacity to deal with climate risk and extremes;
- improved capacity of women and young people to participate in decision-making;
- increased capacity of beneficiaries to adopt research outputs;
- enhanced individual capacity in partner and research organizations through training and exchange;
- increased capacity for innovation in partner research organizations.

## 1.11. Intellectual asset and open access management

CIAT abides by the CGIAR Principles on the Management of Intellectual Assets (CGIAR IA Principles) and their Implementation Guidelines. Results and outputs of research and development activities of the bean flagship are international public goods and will be disseminated widely to maximize impact for farmers and consumers in target countries. CIAT will manage its intellectual

assets with integrity, fairness, equity and accountability. Scientific articles will be published in reputable open access journals.

In keeping with the CGIAR Open Access and Data Management Policy (OADM), research data, tools and associated information generated under the bean flagship will be made open via FAIR principles (Findable, Accessible, Interoperable, Re-usable) to enhance innovation, impact, and uptake. The CGIAR Big Data Platform framework, principles and tools will be used for timely dissemination of data-related products for use and reuse by others through the CIAT Dataverse. In addition, the bean flagship will use other specialized and shared databases such as the Breeding Management System (BMS) to make available its results to the global research and development community. For example, CIAT established a trait dictionary that serves as the 'lingua franca' of bean research. Pedigrees are maintained in the IPHIS program (a *Phaseolus* adaptation of the International Crop Information System-ICIS, and now a part of BMS) and are web accessible. Internally, CIAT has developed software for managing seed inventories. More effective management of phenotypic data is a high priority for the near future.

## 1.12. Flagship management

The Directors General of CIAT and ICRISAT, in consultation with the System Management Office, have agreed that CRP-GLDC will host a flagship program on common bean. The critical contribution of common bean research to improving smallholder farming systems in target regions will contribute positively to achieving the targets of the CGIAR Strategic Results Framework. However, due to differences in rationale and scope, the full integration of common bean in the GLDC was not possible. Hence, a separate flagship program is proposed with its own administrative arrangements. GLDC has agreed to support this hosting arrangement with the assurance that any extra requirements for GLDC staff or operations will be funded by the flagship program.

There are some inherent differences in perspective between the bean flagship and GLDC with regard to agro-ecological focus and the conceptual approach to research. First, the ISPC and later the expert panel of the SMB questioned the appropriateness of bean within the dryland focus of GLDC, given their perception that bean is cultivated in environments that are not relevant to the GLDC. Beyond this, the GLDC takes an ecosystem approach within which crops are a component, while the bean flagship initiates with a product line approach that addresses the system context (production, marketing and consumption) around a single crop. Nonetheless, these two philosophical approaches are complementary and can both benefit from co-learning. The former offers a broad system vision with its potential trade-offs and agricultural options, while the latter offers greater detail in a single value chain and can help identify key sensitive intervention points.

So what is the nature of a 'hosting' arrangement, and what is the role of the 'guest'? This merits a review of the components that make this a mutually beneficial relationship, especially in Africa where the target domains overlap.

- Seed systems: The TL-II and TL-III projects have worked to develop creative approaches to legume seed systems. PABRA has led the seed work in these projects which are on-going, and this collaboration will continue.
- Gender and youth: Gender specialists for PABRA and GLDC are based in Nairobi, and can interact very positively. This can be an especially powerful team for developing a firmer knowledge base for grain legumes, which are often considered 'women's crops.' Both GLDC

and PABRA have well-conceived plans for addressing the role of young people in agriculture.

- Training: While often focused on post-graduate training, a healthy component for training research technicians is included in GLDC. Many talented technicians must assume the day-to-day running of research programs when researchers are absorbed by administrative duties (a very common phenomenon). A joint effort in this area would strengthen staff in both international centers and partner organizations.
- Physiology: GLDC crops by their nature are cultivated in stressful environments, and genetic improvement for stress tolerance is a priority for both GLDC and the bean flagship. Physiologists of ICRISAT and CIAT are already acquainted and work well together. Their approaches are complementary (vapor pressure deficit; photosynthate translocation capacity, respectively) and can facilitate co-learning on essential production limitations in the tropics. GLDC reports that no genetic variability has been found for tolerance to low soil phosphorus, but promising results with bean can offer insights for other crops.
- Biofortification: Bean was the first legume to be considered in HarvestPlus and has become one of its banner successes. A 24-year history of research has revealed many lessons and pitfalls. This understanding can be useful for other crops as these crops initiate efforts on the objective of nutritional improvement.
- Markets and the corridor concept: This is an attractive field of study, but it needs to be approached cautiously, since market channels may or may not be largely crop-specific, especially since highly productive bean areas will often have greater rainfall and thus be outside of the GLDC dryland domain. Nonetheless the learning experience of PABRA has evolved over some three decades and can offer insights on methodologies for platform development. Indeed, there might be opportunities to participate across platforms, if some actors (e.g., grain traders) deal with multiple crops.

*Knowledge transfer*: The points of interaction that are described above imply that a governance structure must prioritize and facilitate effective communications between the bean flagship and the other components of GLDC. The management principles for maximizing this relationship and its synergies will be as follows:

- To address the priority of effective communication, the flagship leader will participate in, and provide information and technical input to the Research Management Committee (RMC) and the Independent Advisory Committee (ISC), as requested. S/he will serve as a channel for receiving similar information about other legume crops from other members of the GLDC. Seminars on topics of technical interchange will be promoted, under the auspices of the RMC, to generate further information exchange.
- Members of the GLDC will be welcome to attend PABRA technical and sub-regional network meetings, and/or business platform meetings, first as observers, but with the potential to establish useful contacts in the business and development worlds. A representative of GLDC will be welcome to participate in the annual PABRA Steering Committee forums. In some countries, a single legume coordinator is responsible for all legume research, on beans and on other species within GLDC. Meeting at the PABRA coordination meeting will facilitate interactions with national partners on multiple crops.

*Future development of this relationship*: Knowledge transfer will be the point of departure for the relationship of the bean flagship and the rest of GLDC.

- The value and future direction of the relationship will be reviewed annually with regard to the effectiveness of interchanges around the development of platforms and the potential for experience sharing.
- We request W1/W2 funds to finance participation in the administrative functions of the RMC, or any other coordination meeting. If GLDC requires additional services from the bean flagship to GLDC, or if unscheduled research on beans is needed that is of wide interest to the legume community of GLDC, this will require additional W1/W2 funds. The funding gap will be addressed through bilateral fund raising.
- An initiative to strengthen genetic improvement is being coordinated by the System Office. It remains to be seen how this will fit within the existing CRPs and what reporting standards will be put in place, or if this will influence in any way the relationship of breeding programs to their homes in the CRPs.

*Governance arrangements*:

- The flagship will be managed by the CIAT's Bean Program leader, Stephen Beebe, a bean researcher with 40 years' experience. Beebe has produced seventy publications in various areas of bean science: genetic resources, pathology, nutrition, and, especially, abiotic stress tolerance (drought, aluminum toxicity, low phosphorus and high temperatures). He has been an invited speaker at international symposia on stress tolerance. Beebe led the Bean Program from 1996 to 1998, and from 2000 to the present. He represented the Bean Program in the Grain Legumes CRP for its duration. His scientific contributions include understanding the limitations of domesticated bean in the context of its evolution from its wild ancestor.
- PABRA is coordinated by a bean pathologist, Robin Buruchara, who has more than thirty-five years of experience in African agriculture. Buruchara is widely recognized for his administrative capacity and has represented CIAT in many fora in Africa and Europe. He was instrumental in the implementation of the sub-Saharan Challenge Program – Kivu site, which was the banner success of that initiative. Much of PABRA's documented success can be attributed to his ability to open PABRA's program to new initiatives on markets, nutrition and gender.
- Beebe as Flagship Leader, and Buruchara as coordinator of PABRA, lead a team of 16 scientists (see Annex 12).
- CIAT will be responsible for monitoring financial and research performance of the flagship. CIAT will seek to cover its funding gap through W3 and bilateral sources.
- As noted above, the bean flagship program leader will participate in the RMC which, as stated in the GLDC proposal, "is primarily responsible for the establishment, execution and monitoring of the CRP research portfolio, strategy, work plans and annual budgets." The strategic function of the RMC will permit reflection on the interaction of the flagship and the other components of GLDC.

- The flagship will use CIAT's monitoring, evaluation and reporting system –MARLO – a platform that is used by eight other CRPs. CIAT-MARLO is comparable with the MEL system used by GLDC. MARLO is undergoing a process of interoperability with the MEL, which will allow the CRP director to have access to key monitoring information. PABRA employs a monitoring and evaluation specialist who systematically follows milestones and outputs, and the collection of data on seed distribution is an established procedure, including gender disaggregation. A report will be made to GLDC management annually as per normal CRP standards.

## 1.13. Budget summary

The funds dedicated to gender, youth, capacity building and other line items are normally reported at the level of the CRP, but since this flagship is being developed after GLDC has already declared its investment in these areas, we provide this information below in Tables 1 and 2, followed by the standard flagship budget in Table 3.

**Table 1: FP management and cross-cutting budget (USD)**

| FP management budget Items | 2018 (USD) |
|---|---|
| Administrative support (financial services) | - |
| Flagship leader and CoA leaders admin management: 0.1 FP, 005 CoA time allocation | 53,327 |
| Gender, youth, capacity development coordination (1.0 FTE) | 209,956 |
| CRP RMC operating costs: 2-3 meetings pa; travel | 15,000 |
| Monitoring & evaluation, impact assessment (2.0 FTE) | 245,683 |
| Foresight analysis (0.5 FTE) | 75,000 |
| Internal audit & external review: programmed as required | - |
| Communications: 1.0 FTE website, publications, briefs. | 148,400 |
| **Total** | **747,366** |

**Table 2: Estimated annual average operational budgets for cross-cutting activities**

| FP Cross-cutting items | 2018 (USD) |
|---|---|
| Gender, youth | 40,000 |
| Capacity building | 150,000 |
| Monitoring & evaluation, | 245,683 |
| Impact assessment | 100,000 |
| Communications | 65,000 |
| **Total** | **600,683** |

**Table 3: Overall budget estimates for the Bean FP, 2018-2022**

| | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
|---|---|---|---|---|---|---|
| **Funding needed** | | | | | | |
| W1+W2 | 15,000 | 15,500 | 16,000 | 16,500 | 17,000 | 80,000 |
| W3 | 4,088,883 | 4,293,327 | 4,507,993 | 4,733,393 | 4,970,062 | 22,593,658 |
| Bilateral | 6,825,329 | 7,166,595 | 7,524,925 | 7,901,171 | 8,296,230 | 37,714,250 |
| Other sources | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 10,929,212 | 11,475,422 | 12,048,918 | 12,651,064 | 13,283,292 | 60,387,908 |
| **Funding secured** | | | | | | |
| W1+W2 | 0 | 0 | 0 | 0 | 0 | 0 |
| W3 | 1,458,523 | 0 | 0 | 0 | 0 | 1,458,523 |
| Bilateral | 4,081,724 | 3,901,940 | 1,673,498 | 1,623,047 | 0 | 11,280,209 |
| Other sources | 0 | 0 | 0 | 0 | 0 | |
| Total | 5,540,247 | 3,901,940 | 1,673,498 | 1,623,047 | 0 | 12,738,732 |
| **Funding gap** | | | | | | |
| W1+W2 | 15,000 | 15,500 | 16,000 | 16,500 | 17,000 | 80,000 |
| W3 | 2,630,360 | 4,293,327 | 4,507,993 | 4,733,393 | 4,970,062 | 21,135,135 |
| Bilateral | 2,743,605 | 3,264,655 | 5,851,427 | 6,278,124 | 8,296,230 | 26,434,041 |
| Other sources | 0 | | | | | |
| Total | 5,388,965 | 7,573,482 | 10,375,420 | 11,028,017 | 13,283,292 | 47,649,176 |
| **Line items** | | | | | | |
| Personnel | 3,854,964 | 4,047,712 | 4,250,098 | 4,462,603 | 4,685,733 | 21,301,110 |
| Travel | 742,581 | 779,460 | 818,158 | 858,766 | 901,379 | 4,100,344 |
| Capital equipment | 72,399 | 76,019 | 79,820 | 83,811 | 88,001 | 400,050 |
| Other supplies and services | 2,591,679 | 2,721,263 | 2,857,326 | 3,000,192 | 3,150,202 | 14,320,662 |
| CGIAR collaborations | 0 | 0 | 0 | 0 | 0 | 0 |
| Non-CGIAR collaborations | 2,586,000 | 2,715,300 | 2,851,065 | 2,993,618 | 3,143,299 | 14,289,282 |
| Indirect costs | 1,081,589 | 1,135,668 | 1,192,451 | 1,252,074 | 1,314,678 | 5,976,459 |
| Total | 10,929,212 | 11,475,422 | 12,048,918 | 12,651,064 | 13,283,292 | 60,387,907 |

# Appendix B

Annex B

## CIAT response to the ISPC comments on the Common Bean Flagship

"*Strategic and Applied Research to meet the Demand of Beans in Africa and Latin America*"

**13 August, 2018**

The ISPC gave comments on the proposal that was submitted to the CGIAR System Management Board (SMB) in March, 2018. Comments were organized around themes of: Strategic relevance; Theory of change and impact pathways; Science quality; Comparative advantage and partnership; Cross-cutting issues; and Budget. These comments have been taken into account in the revision of the proposal, and a point-by-point response to the comments follows.

### Strategic relevance

**Positive:** A compelling argument for retaining a research focus on common bean within the CGIAR related to its importance in Eastern/southern Africa

> We appreciate greatly that the ISPC has taken note of the importance of common bean within the CGIAR portfolio, and trust that this implies the need to find a satisfactory mechanism to address this need.

**Negative:** "Lack of evidence to document the impacts of common beans on diets and nutrition in Africa and Latin America"

> While the ISPC notes a "compelling argument for retaining a research focus on common bean," it is true that impacts to date have been measured most often in terms of yield improvement and income generation. These published results were cited in the description of the outcomes, and more recent analyses indicating 17 billion dollars in impact are being prepared for publication. However, impact on diets was in fact documented in terms of reduced days of food insecurity and dietary protein contribution (LaRochelle et al, 2015) and was cited. Nutritional impacts on iron status fall within the domain of A4NH (HarvestPlus) and require directed studies, first in controlled populations for bioefficacy (documenting the potential effect), and then in bioeffectiveness trials (in which a population deploys a technology in uncontrolled "natural" settings). Two publications on bioefficacy of beans bred for high iron were cited indicating positive effects on iron status (hemoglobin; Haas et al., 2016) and cognitive ability (Murray-Kolb et al., 2017), and positive effects in school children were reported earlier (Haas et al., 2011). While very promising, a trial for bioeffectiveness is pending. A trial with HarvestPlus in Guatemala has been delayed by technical issues, including a severe drought that led to consuming stock seed instead of replanting the high iron variety. Other evidence cited in the references is derived from epidemiological data from bean consuming populations, such as the effects in reducing cancer and cardiovascular disease. A recent novel study with far-reaching implications in Malawi demonstrated a positive effect of bean consumption on gut health of children (Borresen et al. 2017). This is research on the frontier of human nutrition.

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## Theory of change and impact pathways

**Positive:** Building on success of PABRA in seed production and dissemination for technology upscaling in sub-Saharan Africa

> Again, we appreciate that the ISPC has recognized the strength of PABRA in dissemination of technology, and that this represents valuable experience for expanding the scope of work.

**Negative:** "ToC is not well-articulated; FP lacks an agri-food system approach. Most Clusters of Activity (CoA) focus on genetic resources enhancement."

> We recognize the weakness of the ToC, which has been changed in the current proposal (see the summary illustration at the end of this document) to reflect more the integration of the activities of the proposal, although we still emphasize the relationships that are cultivated in the business platforms as the real keys to change.
>
> There is no one formula for an agri-food system approach. We argue that the production-to-consumption corridor approach within well-defined geographical areas and with discrete products is as coherent and viable as any other, and integrates production and markets as a system approach must (see a schematic representation of production-to-consumption bean corridors in Eastern and Southern Africa at the end of this document) . On the consumption end, a current project in collaboration with A4NH and funded by BMZ contributes a perspective of nutritionally sensitive value chains including beans. Collaboration on biofortification with HarvestPlus similarly contributes directly to this end. A project soon to be funded by the African Development Bank will likewise strengthen nutritional work in the dissemination of biofortified beans.
>
> In the restructured proposal, three of the five CoA, while not divorced from genetic enhancement, go far beyond breeding. CoA 1 is a broad-based contextual analysis including foresight that will impinge on any technological development, not only breeding. CoA 4 focuses on production technology including seed systems for varietal dissemination, but also contains a strengthened component of agronomic management, with attention to soil fertility and "designer fertilizers" with micronutrients. CoA 5 actually dwells on developing market channels in a production-to-consumption corridor context, with a focus on business platforms, and with added reference to policy issues. CoA's 2 and 3 focus on "Trait discovery" and on breeding, and are common with other crop-based CRPs. While there is a modest research component on crop management, collaboration with the Maize CRP addresses this more amply (see discussion on this below). With these considerations, the structure of this flagship is not radically different from those of entire CRPs.

**Negative:** "Impact pathway appears to be aspirational; expected impacts for 2022 are very ambitious and need to be placed in the context of what has been achieved during phase I CRPs. Clear pathways to market have not been identified or demonstrated."

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**Impact pathways**: The ISPC notes that a strength of the impact pathways is "building on the success of PABRA in seed production and dissemination…" This is very true and is now explained more explicitly in how the seed business experience is being broadened to include other aspects of business, particularly grain marketing. External reviews of PABRA have confirmed the success of PABRA's strategies. As noted in the proposal, 3.3 million households were reached in the previous five years, and currently the participation of the private sector is increasing rapidly, to the point of producing almost 80% of seed. Last year 21,000 tons of seed were produced, which could represent from 6 to 8% of total bean area in Africa. As farmers normally purchase modest amounts of seed (no more than 5 kg), we estimate that just this year more than 4 million farmers received improved varieties. We fully expect this tendency to gain further momentum, "building on the success of PABRA in seed production and dissemination…". PABRA maintains an agile M&E system with partners to monitor seed distribution, including gender disaggregation of seed recipients. In this light the goals and impacts surrounding seed dissemination we consider to be feasible. Furthermore, experience with seed systems, their institutional dynamics, and partner relationships is the core around which other impacts are being built.

**Market pathways:** This effort is led by a PhD–level market economist. The comment of the ISPC about "the success of PABRA in seed production and dissemination" is relevant for the topic of market pathways, since much success in the area of seed is with small and medium-sized seed businesses, dealing with issues of marketing of seed. Indeed, one of the two seed experts works specifically on the seed business development. Business platforms for beans as grain mirror those pre-existing platforms for seed production and marketing. Market pathways are defined in broad geographical terms by the corridors, and have been refined in terms of key actors, with multiple models emerging that respond to specific local needs. For example…

- The Ethiopian business platform is the oldest example of an organized and proven platform and in a sense is a model for current work, to the extent that it is centered on supporting large players with organizational capacity to maintain value chains, with options for smallholder players to link in. It is based on a system of cooperatives organized under a cooperative union that aggregates grain, seeks out markets, sources loans for its members, and pays producers promptly. For example, the Ras Gayint Union in North West Ethiopia, has 67,000 members. The union is exploring the use of ICT technologies to search and connect with potential buyers around the world.
- Published documentation of impact was cited for Rwanda. Building on this, a two-tier platform combines an "aggregator" and a "processor", with the aggregator integrating producers who are organized in cooperatives. An elective governance structure assures gender balance. Scale: 11 district-level platforms.
- In Uganda one of the central actors initiated as an NGO, and evolved into a seed company, and then into an aggregator. The platform is experimenting with IT under a project with Mastercard Labs to facilitate payments for services. Scale: 4,000 MT, projection to grow to 20,000 MT in 3 years.
- In southern Tanzania a trade logistics company, Raphael Group Ltd has aggregation centers in six districts in the region. However, the company has not been getting its desired volumes of grain due to insufficient seed system. The platform facilitates

contact of farmers with a seed company, Afri-Seeds Ltd, to provide quality seed. Scale: 4,000 MT, targeted to grow to10,000 MT.

- In Zambia two business platforms are planned for the export of cream-and-red speckled (sugar) beans – a type that is not popular locally but is consumed in neighboring countries. This implies strengthening research for a grain type that has not received attention.

These results are currently emerging from the corridor approach and will continue to grow, adapting the platform approach to each situation and local needs.

## Science quality

**Positive:** Research proposed for crop genetic enhancement based on CIAT common bean breeding track record and recent advances in the subject

CIAT's success in crop improvement is documented in both reviewed journal articles and in on-going impact assessment, which is cited in the document and which is being prepared for formal publication.

**Negative:** "A major assumption in the FP rests on "*improved productivity of bean, linked to better functioning markets*"; but too little understanding is demonstrated of the policy dimensions of market development"

Again, PABRA's experience in seed has included dealing with issues of markets. Within the workplan of PABRA, one of its outputs is "Policies and constraints that affect trade in beans reviewed, advocated and harmonized at national and regional levels".
The PABRA annual report 2017-2018 reports that to date various policies that affect bean production and trade were reviewed in Uganda, Rwanda and Tanzania. Those found to be critical are:

- Seed trade policies
- Cross border trade of both seed and grain
- Regional exchange of genetic materials for research
- Variety release at country level as well as across countries (Multi country variety release)
- Agricultural extension policies
- Regulation of pesticides and herbicides
- Post-harvest grain standards
- Nutrition policies

In previous years contributions were made by PABRA on seed policy, establishing "Quality Declared Seed" as a viable and legal class of seed; and on the policy to accept regional varietal release when two countries have released a common variety. In the past year policy makers were engaged in selected countries. In Malawi, discussions were held with the Deputy Minister of Agriculture, Water and Irrigation Development, on the need for Malawi to prioritize beans as a major commodity in the national agricultural diversification and nutrition strategies. In Burundi, field tours to bean production sites were organized for policy makers, and discussions were held with the President on the need to subsidize post-harvest technologies such as use of the PICS bags.

Annex B

**Negative:** "The project lacks novelty; Agronomy, crop management and farming systems research seem to be reduced to a small component of CoA 5, mainly concerned with upscaling of existing technologies"

Novelty in this proposal is based not on totally new concepts for scaling out, but rather in developing multiple applications for basic concepts of business relationships, in an action research mode. Operationally this involves multiple components: governance structures; compilation of detailed quantitative information on demand and supply of different bean products; models for information sharing including IT under a project with Mastercard. The characterization of value chains in a production-to-consumption corridor context is being carried out in much greater detail than is normally done, in a crop as complex as common bean with multiple production contexts and with many visibly distinct products of grain classes. Furthermore, action research is participatory, and is a learning mode for all actors. The integration of multiple dimensions within a business-driven model is itself novel for much of the CGIAR experience.

Even within the scope of crop development, ample exploitation of the tertiary gene pool (*Phaseolus acutifolius* and close relatives) to the point of mainstreaming this activity is a novel approach. While interspecific crosses with these species are not new, these have largely remained in the domain of academic studies, with essentially only two traits (bacterial resistance and storage insect resistance) successfully transferred to common bean. The availability of bridging genotypes opens the opportunity to exploit far more traits –a particularly timely opportunity in light of climate change and extreme environments. Improvement of yield potential has been a long term frustration in the breeding of legumes, as genetic gain has lagged behind that of cereals. Experience with breeding for drought tolerance has revealed essential bottlenecks in bean yield potential, and traits for improved partitioning to grain will be explored in these same interspecific crosses that have potential to contribute to enhanced yield across a range of environmental conditions.

Agronomy, crop management and farming systems research have been strengthened in the current proposal but are admittedly still relatively small components. Recognizing that crop management is a major contributor to closing the yield gap, experience demonstrates that market pull can induce improved crop management practices of weed control and fertility management. The question remains: What are the relative roles of research in crop management versus application of known simple technologies? Most beans cultivated by our target audiences in Africa and Latin America are produced in regions where maize is the major field crop. In this context, the comment of the ISPC is highly relevant: "The work in the FP currently has stronger interface with the Maize CRP." It will be more cost-effective to explore agronomic management (especially soil conservation and fertility management) through linkages with the Maize CRP than through independent research. This is coherent with the strategy proposed for the CGIAR in the 2016 Winsor meeting, whereby cropping systems work should develop around the major crop in the system. Such collaboration has occurred between bean and maize researchers under the SIMLESA project in Africa.

**Negative:** "Track record of the FP leadership team is not presented, except the name of the FP leader"

> The flagship leader is a bean researcher with 40 years' experience, and with more than seventy publications in various areas of bean science: genetic resources, pathology, nutrition, and especially on abiotic stress tolerance (drought, aluminum toxicity, low phosphorus, and to lesser extent high temperature). He has been an invited speaker at international symposiums with emphasis on stress tolerance. He has been the leader of CIAT's Bean Program from 1996 to 1998, and from 2000 to the present. He represented the Bean Program in the Grain Legumes CRP for its duration. His scientific contributions include understanding the limitations of domesticated bean in the context of its evolution from its wild ancestor.
> PABRA is coordinated by a bean pathologist with more than thirty-five years' experience in African agriculture. He is widely recognized for his administrative capacity and has represented CIAT in many fora in Africa and Europe. He was also instrumental in the implementation of the Sub-Saharan Challenge Program – Kivu site, which was the banner success of that initiative. Much of PABRA's documented success can be attributed to his ability to open PABRA to new areas of markets, nutrition and gender.
> These data have been incorporated into the proposal in section on flagship governance.

## Comparative advantage and partnership

**Positive:** The CIAT common bean program well-established; part of the CGIAR research portfolio for over 45 years; Partners add value in terms of scientific contribution and enhance the probability of impact; some activities in breeding and upscaling are jointly funded

> External reviews have confirmed this observation: the partnership model practiced by the Bean Progam has been especially effective in exploiting the synergies of different actors and permitting partners to "add value" and to "enhance the probability of impact."

**Negative:** "FP relies heavily on strategic partnerships with ARIs and NARS partners; bean researchers seem to play a minor role in the research process and platforms as facilitators and "bridge-builders" "

> This is simply a misconception. The value that CIAT places on partnership should not be construed as being a passive bystander. Indeed, it is difficult to understand how the reviewer drew this conclusion (which is at variance with the comment on the positive effects of partnership adding value to CIAT's work), given the recognition of CIAT's track record on the ground as a "well established" program, and our scientific publications. As to CIAT's role as a "bridge builder", the external review of PABRA came to a different conclusion in saying that "PABRA has benefited enormously from its partnership with CIAT…CIAT is a mainstay of the PABRA network and will continue to be so into the future." Most CIAT staff are directly or indirectly involved in promoting platforms. For example, on p 14 it was stated explicitly that:
>
> > "*Relationships with development partners:* In reference to the suggested impact pathway, a key to creating impact has been to dedicate staff time explicitly to building

> relationships with development partners. Too often the interaction with these partners [has been] sporadic and limited to the scope of short-term projects. Impact needs to be someone's "day job" and their primary responsibility. CIAT staff working in PABRA (see below) have assumed this task, essentially facilitating linkages between the suppliers of technology with the demand for technology through platforms,…"

The staff referred to in the paragraph above is Jean Claude Rubyogo, widely recognized throughout the region for his facilitation abilities, and Enock Maereka, who came to CIAT from AGRA and specializes in giving support to bean seed business development. Eliud Birachi is the market economist who is directly involved in promoting the business platforms.

The presence of CIAT staff in the different activities has been clarified in several places in the text. For example, in CoA 4, the text now reads "Especially for legume seed, multiple strategies have been devised, tested and implemented as alternatives to high cost certified seed, with significant efforts under the Tropical Legumes II and III projects, in collaboration with CIAT's seed expert in PABRA which led the seed component of those projects."

**Negative:** "Proposal is silent with regard to bean partners in South America, e.g. Colombia, Brazil"

This is true and was an oversight. Current funding realities do not permit wide collaboration with more developed countries in Latin America, such as Colombia, Brazil and Mexico. However, we have modest interaction with Colombian institutions under HarvestPlus (with the national research agency, AgroSavia (formerly CORPOICA); with the grain growers association, FENALCE; and occasionally with local farmer associations). With EMBRAPA-Brazil we are exploring a possible joint venture with the private sector, but this is in the very early stages of discussion. With Mexico we have a long term relationship with INIFAP, but have no currently funded work. We have included an Annex 10 that presents a list of our primary NARS partners, although many other partners participate through the platform structure.

## Cross-cutting issues

**Positive:** Clear consideration for gender mainstreaming in the FP; Strong commitment to develop institutional and individual capacity; Recognition of importance of enabling environment

These observations are much appreciated. In particular, the partnership model has supported an "enabling environment."

**Negative:** "The strategy for youth engagement is very thin; no explicit mention of any research questions focusing on youth issues"

We cite the text from the proposal, which we consider to be quite concrete and coherent with the rest of the corridor strategy, where the youth strategy parallels that of "gender mainstreaming." Indeed, a youth component is being integrated into the corridor approach,

under the hypothesis that assuring that a broad based effort will offer youth a wider gamut of opportunities than more limited initiatives with a narrower focus. This integrated approach offers a greater likelihood of sustainability than activities focused exclusively on youth but isolated from a larger context.

The corridor approach with its production-to-consumption opens business opportunities for youth in bean value chains, either as small business entrepreneurs or as employees. Business opportunities include provision of services in production: crop spraying; mechanical land preparation planting, harvesting, and threshing. Youth groups may be organized to acquire the more costly machinery. Opportunities in distribution and marketing include produce collection logistics, linking farmers to aggregation centers and supported by mobile based ICT tools. For example, within the bean business platforms in Rwanda, the elder platform leaders have preferred to hand over some tasks- especially the ICT-based ones and logistics - to the youth. Streamlining the bean value chains opens new employment opportunities in: agricultural employment, especially on mechanized farms; grain trade and logistics; processing, sales and distribution of products; and developing appropriate apps for agriculture. PABRA is evaluating how to support the establishment of youth employment/labour groups in the platforms—a proposition that has been well received by agribusinesses in the sector, and plans to test this with the sector towards end of this year as a source of employment for rural youth with insufficient land for agricultural production.

## Budget

**Positive:** The funds requested for the breeding pipelines (CoA 4) and upscaling (CoA 5) relative to the expected outcomes seem appropriate

**Negative:** “The sharp decline in the secured budget after 2018 can be a concern; no funding has yet been secured for 2022. The overall funding gap for the 2018 to 2022 period is US$ 47.65 million, which represents 79% of the required funding to support the activities outlined in the proposal. Small amount sought from W1+W2, which raises questions regarding justification of what should be in the portfolio”.

There is no question that future funding is a concern for this flagship, just as it is for the entire CGIAR system. CIAT is maintaining communication with three major donors, and is initiating discussions with a one of the major donors of PABRA on this issue. Parallel to any current fund raising efforts is the donor initiative to strengthen support to crop breeding on priority crops of the CGIAR. We are following this initiative closely and are taking steps to be eligible under this evolving situation, by participating in an audit of CIAT breeding programs under the Breeding Program Assessment Tool evaluation. Novel fund raising strategies are being pursued by HarvestPlus that would bring more stability in the long term.

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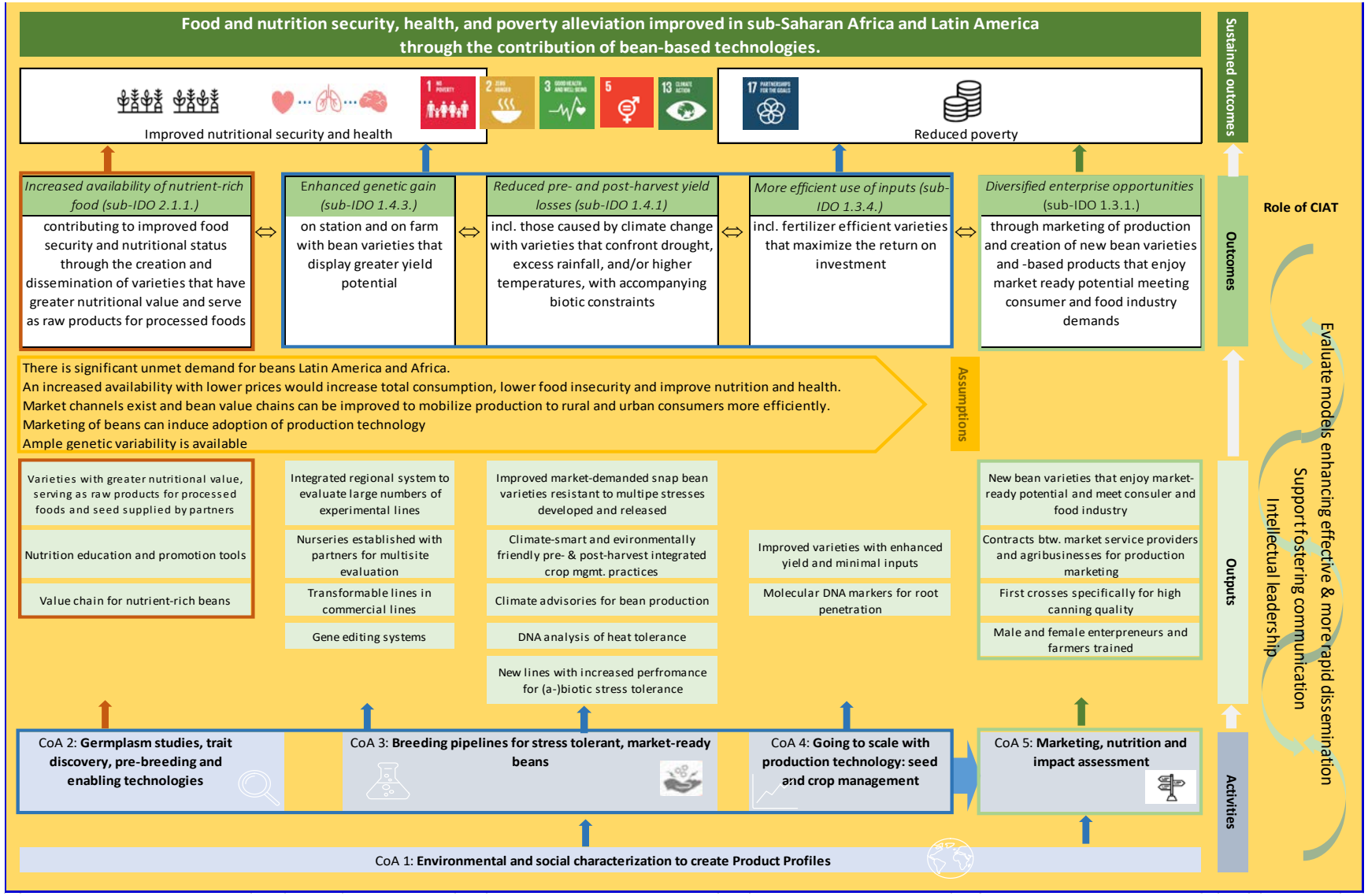
## Impact pathway, assumptions and CIAT's role



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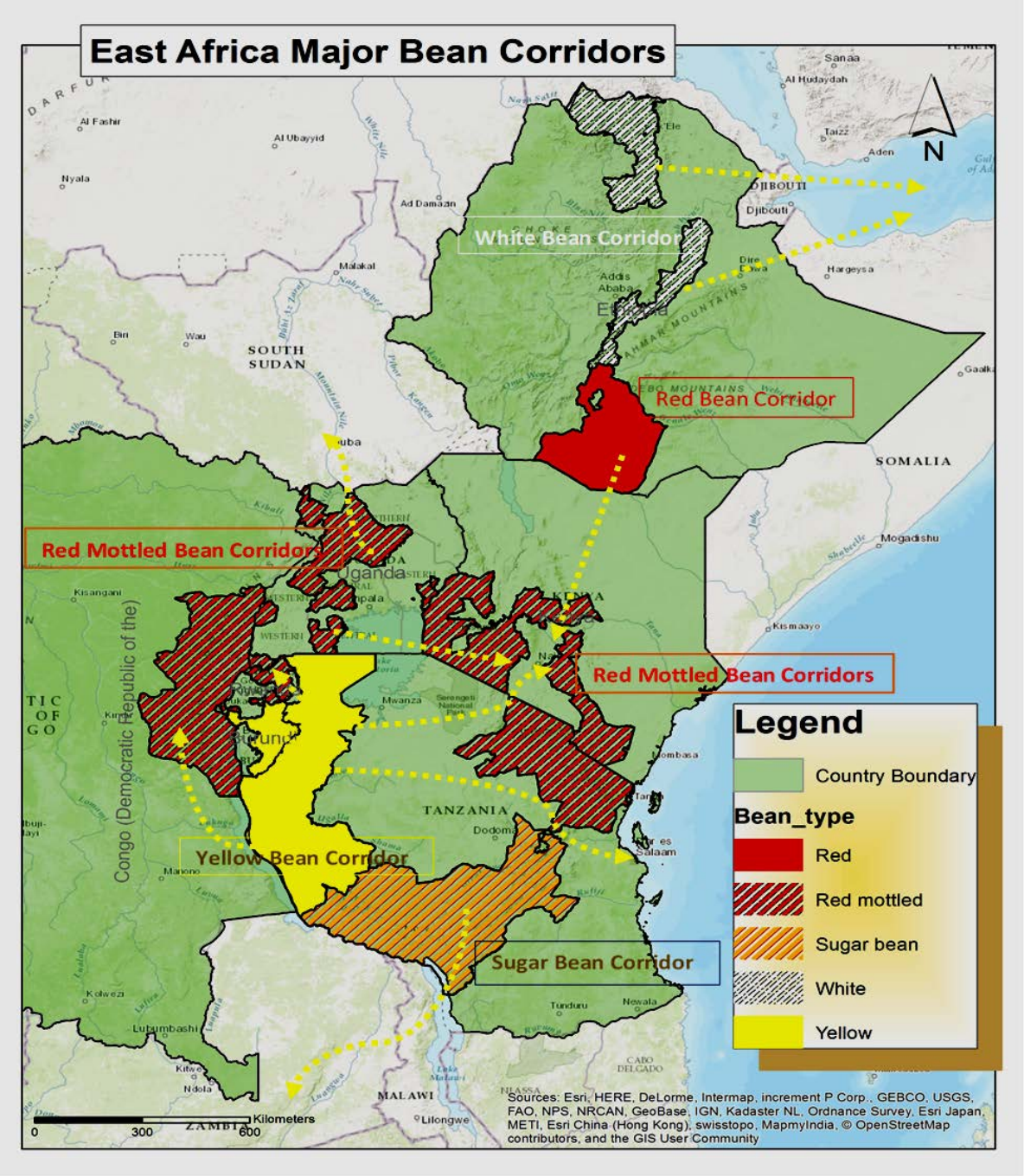
## The Bean Corridor approach




A schematic representation of production-to-consumption bean corridors in Eastern and Southern Africa. Each arrow represents a corridor and is documented with regard to volume of grain, grain types and varieties, and important actors in the respective value chains (traders, credit suppliers, seed producers, etc.).

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