CRP-GLDC
Annual Report 2019

RESEARCH PROGRAM ON
Grain Legumes and Dryland Cereals

CGIAR

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

IITA
Research to Nourish Africa

ICARDA
Science for resilient livelihoods in dry areas

World Agroforestry

Alliance

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

Bioversity International

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

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CGIAR Research Program on Grain Legumes and Dryland Cereals

The CGIAR Research Program on Grain Legumes and Dryland Cereals (CRP-GLDC) is an international consortium led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and CGIAR implementing partners, including the International Institute of Tropical Agriculture (IITA), International Center for Agricultural Research in the Dry Areas (ICARDA), World Agroforestry (ICRAF), International Livestock Research Institute (ILRI) and the Alliance of Bioversity International and CIAT (ABC). In addition to the CGIAR, the CRP-GLDC is implemented by L' Institut de Recherche pour le Développement (IRD) and Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) from France and Commonwealth Scientific and Industrial Research Organisation (CSIRO) from Australia, and various Non-Governmental Organizations (NGOs), national agricultural research system (NARS) and private sector partners. This consortium strives to support beneficiaries in 13 priority countries in South Asia (SA) and Sub-Saharan Africa (SSA) with a mission of improving rural livelihoods and nutrition by prioritizing demand-driven innovation to increase production and market opportunities along value chains.

http://gldc.cgiar.org

Lead Center: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Flagship Program 1: Priority Setting & Impact Acceleration
CGIAR Center: International Institute of Tropical Agriculture (IITA)

Flagship Program 2: Transforming Agri-food Systems*

Flagship Program 3: Integrated Farm and Household Management
CGIAR Center: World Agroforestry (ICRAF)

Flagship Program 4: Variety and Hybrid Development
CGIAR Center: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Flagship Program 5: Pre-breeding and Trait Discovery
CGIAR Center: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Flagship Program 6: Common Bean for Markets and Nutrition
CGIAR Center: International Center for Tropical Agriculture (CIAT)

Other participating institutions: CSIRO, IRD, CIRAD, ICARDA, Bioversity International and ILRI.

**FP2 remained unfunded although some of its deliverables are captured in the cross-cutting theme: Markets and Partnerships in Agri-business (MPAB).*

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Abbreviations and Acronyms

ABC	Alliance of Bioversity International and CIAT
AgMIP	Agricultural Model Intercomparison and Improvement Project
AMF	Arbuscular mycorrhizal bio fertilizer
ANSA	Adolescent Nutrition Sensitive Agriculture Project
APAARI	The Asia-Pacific Association of Agricultural Research Institutions
APIs	Application Programming Interfaces
ArES	Agricultural Research e-Seeker
ARIs	Advance Research Institutes
ATASP	Agricultural Transformation Agenda Support Program
AVCD	Accelerated Value Chain Development
AVISA	Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa
AYT	Advance Yield Trial
BMG	Botrytis grey mold
BMGF	Bill & Melinda Gates Foundation
BMS	Breeding Management System
BPAD	Breeding Program Assessment Tool
BPP	Breeding Product Profile
CAAS	Chinese Academy of Agricultural Sciences
CCAFS	Climate Change, Agriculture and Food Security
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CERAAS	Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse
CtEH	Crops to End Hunger
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CKT	Cooking time
CLARISA	CGIAR Level Agricultural Results Interoperable System Architecture
CNGs	Crop Network Groups
CRISPR/Cas9	Clustered Regularly Interspaced Short Palindromic Repeats - CRISPR-associated protein
CRP-FTA	CGIAR Research Program on Forests, Trees and Agroforestry
CRP-GLDC	CGIAR Research Program on Grain Legumes and Dryland Cereals
CRP-PIM	CGIAR Research Program on Policies, Institutions, and Markets
CRP-RTB	CGIAR Research Program on Roots, Tubers and Bananas
CRP-WLE	CGIAR Research Program on Water, Land and Ecosystems
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWR	Crop wild relatives
DH	Doubled haploid
DLB	Demand Led Breeding
EiB	Excellence in Breeding Platform
EPIA	Ex-post Impact Assessment
Fe	Iron
FtF	Feed the Future
GxEXM	Genotype x environment x management
GS	Genomic selection
GWAS	Genome-wide association study
Ha	Hectare
HI	Haploid inducing pollinator
HOPE	Harnessing Opportunities for Productivity Enhancement of Sorghum and Millets
HPRC	Hybrid Parents Research Consortium
IAVAO	Innovation et amelioration variétale en Afrique de l'Ouest

ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	World Agroforestry
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IER	Institut d'Economie Rurale
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILs	Introgression lines
ILRI	International Livestock Research Institute
IMPACT	International Model for the Policy Analysis of Agricultural Commodities and Trade
INERA	Institut de l'Environnement et des Recherches Agricoles
INRAN	Institut National de la Recherche Agronomique du Niger
IRD	Institut de Recherche pour le Développement
ISRA	Institut Sénégalais de Recherches Agricoles
IVT	Intermediary Variety Trial
IWMI	International Water Management Institute
KAP	Knowledge, attitude, practice
KoLFACI	Korea-Latin America Food & Agriculture Cooperation Initiative
LMS	Learning Management Systems
MABC	Marker-assisted backcrossing
MARLO	Managing Agricultural Research for Learning and Outcomes
MEASURE	Monitoring and Evaluation of Agri-Science Uptake in Research and Extension
MEL	Monitoring, Evaluation and Learning (MEL Platform)
MELIA	Monitoring, Evaluation, Impact Assessment and Learning
MHM	Millet head miner
MIS	Management Information System
MISST	Malawi Improved Seed Systems and Technologies
MNCFC	Mahalanobis National Crop Forecast Centre
MoClo	Modular cloning
MPAB	Markets and Partnerships in Agri-business
MSU	Michigan State University
MT	metric tons
MTAs	Marker trait associations
MWDC	Mulukanoor Women Dairy Cooperative
NARES	National Agricultural Research and Extension System
NARS	National agricultural research system
NGOs	Non-Governmental Organizations
NIAB	National Institute of Animal Biotechnology
NIRS	Near Infrared Reflectance Spectroscopy
NPT	National Performance Trial
OCS	One Corporate System
PABRA	Pan-Africa Bean Research Alliance
PGP	Plant growth promoters
PMS	Performance Management Standard
PMU	Program Management Unit
PPB	Plant Participatory Breeding
PYT	Preliminary Yield Trial
QA	Quality assurance
QC	Quality control
QTLs	Quantitative Trait Loci
RGT	Rapid generation turnover

RuForum	Regional Universities Forum for Capacity Building in Agriculture
SA	South Asia
SDC	Swiss Agency for Development and Cooperation
SI	Sustainable intensification
SLU	Swedish University of Agricultural Sciences
SMO	CGIAR System Management Office
SNP	Single nucleotide polymorphism
SSA	Sub-Saharan Africa
TAAT	Technologies for African Agricultural Transformation
TL III	Tropical Legumes III
TPEs	Target Population of Environments
WUE	Water use efficiency
WUR	Wageningen University of Science
XRF	X-Ray Fluorescence
ZAAS	Zhejiang Academy of Agricultural Sciences
Zn	Zinc

Executive Summary

The CRP-GLDC envisions to increase productivity, profitability, resilience and marketability of critical and nutritious crops grown in the semi-arid and sub-humid dryland agroecologies of Sub-Saharan Africa (SSA) and South Asia (SA) where poverty, malnutrition, climate change and soil degradation are most acute. Improved innovation capacities within agri-food systems of these crops are expected to enable coherent and integrated research and development, production, and market and policy reforms to contribute towards resilience, inclusion, poverty reduction, nutritional security, environmental sustainability and economic growth.

Ex-ante economic, poverty and nutritional impact assessments identified the most promising research and technology options for GLDC crops. A gender-sensitive prioritization of varietal attributes and product profiles defined the most important end-user preferred traits. An impact evidencing strategy showed that over 40% of the cowpea growers in Nigeria adopted improved varieties on over 1 million ha leading to significant increases in yield and income. Demonstration plots served to train over 2,500 farmers and extension agents (46% women), with 110,000 people benefitting from the doubled-up legume systems. Modelling based on decision support tools and nutrient flows generated a 'map' to guide effective nutrient cycles. While a suite of modelling tools/framework comprising 5 domains and 115 indicators was developed for researchers to co-design resilient farming systems, a holistic nutrition education package laid the foundation for studying nutritional knowledge and attitudes. Multi-stakeholder Crop Network Groups in Africa would help product design, development, testing, advancement and delivery of GLDC crops. Improvements in production and market traits resulted in combining high oleic with foliar fungal disease resistance in groundnut and heat tolerance with bold seeds in chickpea varieties. Through inter-specific crosses, accessions of Tepary bean that withstand 28 ^{0}C night temperatures were incorporated into common bean that resulted in the release of 28 heat-tolerant varieties in Africa and Latin America.

Partnerships with the private sector, food and seed industries and service providers are expected to enhance the use of genotyping tools and drone-based imaging technologies. Early generation selection using high-throughput SNP platform and seed-chip in groundnut and chickpea could help reduce cost and enhance operational breeding efficiency for enhanced genetic gains. Products of molecular breeding in groundnut and chickpea, deployment of markers in groundnut and sorghum breeding, development of quality control (QC) panels in groundnut and pearl millet, and the development of next generation tools and technologies are being established in partnership with the public and private sectors. Our efforts through the gender internship program for young scientists, engaging youth in dryland agriculture and their gainful entry points in the GLDC value chains, and gender-responsive product profiling can enhance gender equality and opportunities. Scoping studies on ways of leveraging market opportunities for smallholders and impact pathways of current and future traits using systems dynamics scenarios would provide better targeting and market linkages for GLDC crops, thereby improving rural livelihoods and nutrition through increased production and market opportunities along value chains of these crops. Bean-based flour with high iron (Fe) and zinc (Zn) bean is being promoted in national nutritional strategies.

Part A. Narrative section

1. Key Results

1.1 Progress Towards SDGs and SLOs

1. Improved cowpea varieties contribute to poverty reduction in Nigeria

Cowpea is an important food and fodder legume and essential component of cropping systems in the dry savannas of West Africa. However, cowpea yields are low in much of West Africa. In Nigeria, multi-partner efforts led by IITA resulted in the release over 20 improved varieties. Efforts have also been made to improve cowpea seed systems. An impact study showed over 40% adoption of improved varieties on over 1 million ha which led to a 26% increase in yields and 61% increase in net returns per hectare (Manda et al., 2019a). Adoption also led to a 17 percentage point increase in household income and a 5 percentage point reduction in the incidence of poverty, which is equivalent to 929,450 people being lifted out of poverty following adoption of improved varieties (Manda et al. 2019b).

2. Improved Myanmar Chickpea Production through Early Maturing Cultivars

Following the release of ten cultivars of chickpea in Myanmar from 1976 to 2018, a study was carried out to quantify benefits in the Central Dryland Zone that grows 96% of chickpea. With an adoption lag from initial release to the peak level at 15 years, the cropped area under improved chickpea increased from 67% in 2001-02 to 97.7% by 2017-18. The coverage was much higher in Sagaing (>98%) followed by Mandalay (>96%) and Magway (>94%) regions, where productivity gains were about 51%, with corresponding unit cost reduction at US$ 129 per ton resulting in estimated benefits of US$ 152.8 million.

3. Climbing bean technologies helped 0.8 M farming households increase productivity and food security, resulting to about 5,000 households climbing out of poverty in land-constrained Rwanda

In Rwanda, many farmers have less than a hectare to grow all their crops and thus require technologies that increase land productivity. Impact studies showed that targeted breeding based on agro-ecological adaptation enabled expansion of higher yielding climbing beans from its traditional high altitude to middle and low altitude areas. This provided benefits to over 0.8 million families that were a *priori* disadvantaged due to declining land sizes and quality. Each additional kilogram of climbing bean seed planted raised per capita consumption expenditure by 0.9% and bean consumption by 2.8%. This translates into additional 117,480 tons of bean consumed by 4.4 million people annually, thereby increasing household food security by 0.6% while decreasing the likelihood of being poor by 0.6%, equivalent to 4,714 households lifted out of poverty annually.

1.2 CRP Progress towards Outputs and Outcomes (spheres of control and influence)

1.2.1 Overall CRP progress

FP1: Priority Setting and Impact Acceleration

An ex-ante nutritional impact assessment of research and technology options, conducted as part of the multi-criteria evaluation to identify breeding and other research priorities, led to the identification of early-maturing sorghum with tolerance to drought and resistance to insect pests and drought-tolerant cowpea varieties in WCA; intercropping-compatible pigeonpea varieties, early-maturing sorghum varieties and hybrids with tolerance to drought in ESA; and Fusarium wilt-, root rots-, and Botrytis grey mold (BMG)-resistant chickpea varieties in SA. End-user preferred traits were identified to update product profiles for rainy and postrainy season sorghum in India. Drivers of technology adoption and change within smallholder farmer and specific consumer segments delivered several outputs. Research was conducted on gender and youth, youth realities, aspirations, transitions and opportunity structures in Uganda, Ethiopia and Tanzania, and youth engagement in seed systems in Mali and northern Nigeria. A scaling framework was developed that encapsulates key elements for promoting large-scale adoption and impact assessment of GLDC technologies. An adoption study on improved cowpea varieties in Nigeria showed that over 40% of the growers adopted improved varieties on over 1 million ha and this led to increased yields (26%) and net returns per hectare (61%).

FP3: Integrated Farm and Household Management

Spatial and temporal distribution of emerging diseases of chickpea and pigeonpea in India were assessed. Varieties of soybean, cowpea, groundnut, pigeonpea and sorghum were evaluated for intercropping in agroecologies of Mozambique, Malawi, Burkina Faso and India. A total of 236 soybean (36% women) and 185 cowpea (39% women) farmer demonstration plots were established on farmers' fields. Over 110,000 people are benefitting from 'Optimal' doubled-up legume systems established to train 98 master trainers (28 women) in Malawi. Decision support tools were developed for farm-household livelihood typologies, innovation adoption and to assess the impacts of legume-based technological interventions on production and livelihoods in Burkina Faso and Ethiopia, besides developing a suite of systems modelling tools/framework for co-designing resilient farming systems. A framework for farming systems sustainability was developed with 5 domains and 115 indicators. For targeting gender and nutrition under GLDC farming systems, gender-oriented adoption studies conducted in Burkina Faso for cowpea and in Ethiopia for lentil and chickpea varieties revealed that women were disadvantaged in accessing information, inputs and credit, thereby lowering technology adoption and nutrition access.

FP4: Variety and Hybrid Development

Simultaneous improvement of production and market traits through NARS partnerships over the past years led to the commercialization of 26 GLDC cultivars. High oleic groundnut, cream seed coated pigeonpea and large-seeded chickpea were developed to meet industry needs, while machine harvestable chickpea and lentil provided employment opportunities for youth. Enhanced grain nutritional traits of lentil and groundnut and biofortified pearl millet cultivars will contribute to nutrition security. Improved red-podded pigeonpea in Kenya offers tolerance to pod borers. Fusarium wilt-resistant chickpea in India and Ethiopia, downy mildew-resistant pearl millet in India and foliar fungal disease-resistant and aphid-tolerant groundnut in Tanzania and Mozambique were found to reduce input costs while providing environmental sustainability. Fodder quality being a key trait for some product profiles, a multi-cut fodder sorghum hybrid was released in India. To enhance the rate of genetic gain, speed breeding was deployed to reduce breeding cycle time from 0.5 years to 0.16 in chickpea and lentil and from 0.5 years to 0.33 in groundnut. Besides, high-throughput SNP platform was used for early generation selection in cowpea, groundnut, soybean, chickpea, pigeonpea, sorghum and pearl millet, and the seed-chip technique in groundnut and chickpea for SNP genotyping to reduce cost and enhance operational efficiency.

FP5: Pre-breeding and Trait Discovery

Testing of 274 cowpea wild relatives and 6 cultivated lines for seedling stage drought tolerance led to the identification of 44 drought-tolerant wild lines that were crossed with elite varieties and incorporated into pre-breeding. While over 700K data points combined in all GLDC crops were generated for developing markers, the QC panels that are under development and validation can have significant impact in breeding programs. Advances made in the development of genomic selection in chickpea, groundnut, pearl millet and sorghum, identification of Quantitative Trait Loci/ Marker trait associations (QTLs/MTAs) for priority traits, transcriptomics data and epigenetic (methylation) data related to biotic and abiotic stresses in chickpea, and introgression and pyramiding of identified QTLs in breeding elite lines were done in collaboration with FP4. This included the release of two high oleic groundnut lines in India and three chickpea lines (2 in India, 1 in Ethiopia). Candidate genes and markers for early and late flowering and associated with adaptation to high temperature and dry environment in pearl millet were identified using genome-wide association study (GWAS) analysis in a panel from all of West Africa. The focus for enabling technologies was on establishing protocols for genome editing, second-generation transformation in pearl millet, systematic mutant population, genomic selection models, phenotypic screening, rapid generation turnover platform for pearl millet and sorghum, early stage finger millet leaf blast screening and high quality draft genome assemblies for chickpea and pigeonpea.

FP6: Common Bean for Markets and Nutrition

Two drought-tolerant, high-yielding (>3000 kg/ha), early-maturing (68-72 days) varieties with high Fe and Zn (>70 ppm and >35 ppm, respectively), good marketability, palatability and tolerance to major diseases were released in Uganda. Improved varieties were released in Zimbabwe and South Africa. Improved beans were

promoted through capacity building in partnership with development organizations and seed access through small packs in agrodealer shops in Tanzania, Uganda, Burundi, Kenya, Rwanda and Zimbabwe. To reduce drudgery for women and create business opportunities for youth, threshing technology was introduced for multi-crops, including beans, through local artisans in Burundi, Ethiopia, Uganda and Tanzania. To improve the quality of grains and bean-based products, Solar bubble drier technology was introduced. A market survey was conducted to identify and characterize yellow and other bean corridors. Grain producers (Uganda: 17,000 and Tanzania: 3,500) registered with a Master Farmer Network (MFN) are receiving payment for their grain through a digital platform established through a partnership between Mastcard Lab for Financial Inclusion, United States Africa Development Foundation (USADF) and CIAT. For wider utilization of bean and dry bean products, government and private sector partners were engaged in Tanzania, Malawi, Zimbabwe, Burundi and Uganda to develop national nutritional working groups for nutrition and biofortification policies in school feeding programs, increasing nutrient intake among adolescents, pregnant and lactating women and knowledge-sharing with communities.

1.2.2 Progress by flagships (optional)

For detailed progress by Flagship, please follow the links:

FP1: http://gldc.cgiar.org/progress-in-fp1-priority-setting-and-impact-acceleration-2019/

FP3: http://gldc.cgiar.org/progress-in-fp3-integrated-farm-and-household-management-2019/

FP4: http://gldc.cgiar.org/progress-in-fp4-variety-and-hybrid-development-2019/

FP5: http://gldc.cgiar.org/progress-in-fp5-pre-breeding-and-trait-discovery-2019/

FP6: http://gldc.cgiar.org/progress-in-fp6-common-bean-for-markets-and-nutrition-2019/

1.2.3 Variance from Planned Program for this year

(a) Have any promising research areas been significantly expanded? If so, for each example, please explain clearly where the demand came from (promising research results, demand from partners etc.). Where has the money for expansion come from? (max. 150 words)

Two areas in CoA3.3 leverage bilateral project funding: ESA - Michigan State University and Africa Rising; WCA - ATASP and TAAT; SA - ICAR, SDC and MNCFC in India, and CoP (AgMIP, Big Data for Agriculture Innovation) in the application of integrative data analysis. The ICRISAT/ILRI synergy led to the integration of whole farm modelling and fodder production potential of CRP-PIM for cattle value chain competitive assessment in West Africa.
For breeding modernization, FP4 made an additional investment to improve breeding and testing processes and operational efficiency in SSA. Based on a requirement from FP4 to develop QC panel in GLDC crops, with additional funds FP5 undertook an analysis of existing sequence data in pearl millet, chickpea and groundnut to identify small sets of unique polymorphic SNPs to be used as QC panels.

(b) Have any research lines been dropped or significantly cut back? (Please note that cutting research lines which do not seem to be delivering is seen by Funders and System Organization as a sign of good management, not of failure.) If so, please give specific examples and brief reasons. If funding was reallocated to other work, where did the money go? (max. 150 words)

No major research areas were dropped or significantly cut back in any of the Flagship Programs. However, for the cross-cutting theme on Youth, it was realized that the planned studies were more expensive to conduct than what was originally allocated. Designing the studies, capacity development of the implementing partners and field level data collection would have meant implementing studies in only one country, which would be too meagre to inform the design of the strategy. This was addressed by allocating additional resources instead of dropping or cutting back on these important activities.

(c) Have any Flagships or specific research areas changed direction? If so, please describe how, and the reason. (max. 150 words)

There has been no change in any specific areas of research. Since beans are considered significant in preventing nutritional diseases like obesity and diabetes, the Alliance of Bioversity and CIAT is exploring the potential of diets to address these lifestyle diseases. Hence the Pan-Africa Bean Research Alliance (PABRA) interaction with the food processing sector is a key forward-looking approach that seeks to address the needs of an increasing number of urban consumers who demand more convenience in food preparation. This will be an important component of a strategy to ensure that beans continue to play an important role in the diets of consumers.

1.2.4 Altmetric and Publication highlights

Within the collaboration between CRPs on GLDC and LIVESTOCK, in 2018, ILRI and ICARDA developed a low-cost user-friendly tool to review the altmetric score: ArES (Agricultural Research e-Seeker) based on the free Altmetrics version. The code has been released as Open Access as an International Public Good. In 2019, a user-friendly interface was developed to support data mining across various levels (flagships, countries, crops, research groups and individuals). The interface also addresses the data export required by SMO for CRP reporting, besides saving an annual subscription of US$ 10,000 by CRPs (GLDC, FISH). The SMO included the MEL team in the joint MEL-MARLO collaboration in order to provide lessons learnt and technical expertise in the development of the CGIAR Dashboard.

In 2019, CRP-GLDC produced 80 peer-reviewed publications, of which 90% were ISI and 76% Open Access. Of the over 340 knowledge products, 22% have an Altmetric score and 83% are journal articles, while others are reports, briefs and working papers. For each information product (Table 6), the scores reflect calculation for the Altmetric valuing. High “Mentions” are generally paired with a similar high Altmetric score while the ‘Readers’ value is almost independent. While there is a strong relationship between Twitter, Facebook and Mendeley, the blogs and news are less evident and require more communication effort.

Among the key publications with scores between 100 and 300, three were published in Nature Genetics (Bertioli at al. 2019, Varshney et al. 2019 and Pandey et al. 201 9) and one in Outlook on Agriculture (Gassner et al. 2019). While the first three feature chickpea and peanut, focusing on establishing a foundation for large-scale characterization of germplasm and population genomics and an important resource for trait dissection, accelerating genetic gains in future, the last one is a joint collaboration among CRPs on FTA, PIM and GLDC which advocates more differentiated policies for agricultural development in Africa, and suggests that policymakers should be much more aware of the heterogeneity of farms and target interventions accordingly. Understanding where and for whom agriculture will serve the main purpose of ensuring food and nutritional security and where and for whom there is the potential for significant increases in incomes and a contribution to wider economic growth is a key aspect across several interlinked actions in CRP research.

1.3 Cross-cutting dimensions (at CRP level)

1.3.1 Gender

CRP-GLDC continues to be committed to an ‘inclusive and equitable innovation system for accelerating impacts for women and young people’ in the drylands. GLDC’s gender research agenda was designed to be unique for each FP and aligned to key issues on the impact pathway. Activities on gender and youth integration were implemented in four thematic areas: Gender and breeding; Gender dynamics in seed value chains; Strategies for youth integration; and Gendered impacts on asset ownership.

A framework on gender-responsive Plant Participatory Breeding (PPB) programs in West and Central Africa was developed through a postdoctoral fellowship that is now being tested in a case study for gender analysis of traits and preferences for gender-responsive variety development in the sorghum and millet breeding program in WCA. This study defined targets and identified segments of sorghum and millet value chains as end users and/or customer groups. The research involved crop, production zone or ecology, sex and value chain node. Sorghum and millet trait attributes were defined and aligned with the improved varieties. The analysis identified the most important traits for each value chain segment as the ‘must have’ traits for each customer group through the history of breeding and traits prioritization over time. A team of social scientists and breeders from

Mali attended a joint training on 'Gender Responsive Breeding' and analyzed the social structures in cowpea and groundnut varietal demands. This synergy will contribute to product profile development for GLDC priority crops in WCA.

With regard to achievements in generating primary data, analysis and documentation on various gender dynamics aspects in seed systems, the IITA team gained insights on the opportunities available to women farmers in soybean seed systems in Mozambique. ICARDA generated primary data and insights relating to lentil farming, innovations and women empowerment in rural landscapes, documenting issues of division of labor for men and women in the lentil production cycle; access to extension services, gendered issues in land ownership for lentil production; migration, especially of men from the rural areas and how this impacts production and the resulting challenges faced by women-headed households. Key insights were generated on gendered seed knowledge, seed access and seed use in northern and eastern Uganda. Innovations around behavior change communication on quality seeds of improved groundnut varieties were designed with non-traditional partners, where men and women in the community were involved in co-designing the brand for seeds.

Primary datasets were generated on youth realities, aspirations, transitions and opportunity structures in Uganda, Ethiopia and Tanzania (through qualitative interviews) and on youth engagement in seed systems in Mali and northern Nigeria (through quantitative data collection among 600 women and 600 men). Gendered transition pathways that are unique to boys and girls have implications on access to productive resources and influence who can or cannot engage in farming in the drylands. While there is a blanket narrative that 'youth are not interested in agriculture', evidence generated so far shows that there is a category of youth who remain in agriculture; some because they chose to and others because it is the only option. Models of engagement with youth in value chains will be tested in 2020 with projects aligned to CRP-GLDC. One PhD student has been hosted to deliver the work on youth.

The GLDC-Gender Internship Program was continued where emerging scientists (1 male and 1 female) were mentored on skills in designing and planning gender research, field level collection of qualitative and quantitative data and analysis/interpretation of results. One intern presented a paper at the 'Seeds of change conference' at the University of Canberra, Australia. The WCA team hosted an MSc level intern in the gender and breeding work. These 18-24-month internships are ideal and can result in win-win outcomes both for the student and the CRP.

CRP-GLDC participated in meetings on developing and submitting a proposal for the new GENDER Platform in a consortium led by ILRI, CIP and IRRI. The platform's main research agenda is around transforming food systems for gender equality in the face of climate change. The platform will also provide CRP-GLDC the opportunity to re-orient its work on gender and climate change going forward. Mainstreaming gender awareness and contribution along the bean value chain starting from the research activities was continued in the beans program in FP6. These included innovation on threshers (CoA markets, nutrition); processing of beans into other bean food products to provide business opportunities for women in particular (CoA markets, nutrition); gender-sensitive participatory variety selection (CoA breeding) and policy reported for Tanzania (CoA scaling).

1.3.2 Youth and other aspects of Social inclusion / "Leaving No-one Behind"

Since it was identified that youth as a social group was missing from our gender programming, a youth strategy is being developed with the following inputs.

A literature review identified main concepts to design a youth study in Tanzania, Uganda and Ethiopia. The focus was on "Transitions of young women and men to adulthood in the drylands in relation to their aspirations, realities and opportunity structures". This research is anchored within the "opportunity structures" framework which stipulates that there are socially constructed means through which social groups achieve their interests. Opportunity structures are primarily shaped by inter-relationships between family, education, social networks, technology and employment opportunities, among others. These structures are also confounded by factors such as place, age, gender, wealth and ethnicity. Results from this work will help in designing a youth strategy for the CRP GLDC in 2020. Based on these principles, a methodology was designed for data collection and a training workshop organized for country research teams from Ethiopia, Uganda and Tanzania in February 2019.

Partnerships were established with sociology and anthropology departments of universities in Eastern Africa (Sokoine University of Agriculture in Tanzania, Makerere University in Uganda, and Haramaya University in Ethiopia) to lead the youth studies in each country. The study sites were selected to prioritize semi-arid regions where other CRP-GLDC programs are implemented. Data collection has been initiated in eleven dryland regions within Ethiopia, Uganda and Tanzania.

Youthhood is described as the transition period between childhood and adulthood. The point of transition to adulthood is determined by factors such as age, pathway to employment and rites of passage such as marriage and childbearing. However, this transition is often complex and non-linear. Transition pathways to youthhood vary by gender, where for example, the transition to adulthood for girls is often shorter. Sometimes, a girl can become a wife or a mother before becoming a teenager. The cultural perception of 'youth' for women can have a great influence on their access and control of productive resources such as land (Webinar). Similarly, when young women become mothers, they are excluded from 'youth benefits' such as government youth funds or development programs. Youth transition is closely aligned with access to productive resources, especially land. Traditional inheritance favors male children (in patrilineal societies), which determines the way kinship wealth is redistributed. These societies assume that female children will eventually access the wealth of their husbands. Therefore, if a woman does not get married (which can be common), it is difficult to access land without negotiating with a man, such as a landlord or a relative, thereby creating an environment for potential sex-based exploitation (Webinar). Other consequences of these early transitions for women include early marriages that result in divorce (and further exclusion from society) and high teen pregnancies, which can contribute to generational poverty and poor nutrition.

While there is a narrative that young people don't want to participate in dryland agriculture, it does not seem to apply to all youth. Although there are those who choose to remain in agriculture because of access to resources and productive income, others remain in agriculture due to lack of other opportunities. In addition, the education pathway strongly influences youth transition to agriculture. Those attaining high levels of education often transition out of farming into careers that are coveted by those that remain in the rural areas. An analysis and synthesis of field data results is being carried out for designing a youth strategy for the drylands. For FP6 youth economic empowerment, see examples of innovation thresher service provision and general agricultural mechanization service provision in Tanzania.

ABC-PABRA has partnered with IMARA TECH to develop appropriate labor saving technologies and ensure their access to smallholders through mechanization service providers, including youth.

1.3.3 Capacity Development

Capacity development activities involved over 3,000 beneficiaries through workshops or training courses. Over 2,500 farmers and extension agents (46% women) received training on improved agricultural practices in Mozambique and Malawi. Over 200 NARS from India, China, Ethiopia, Mexico, Nigeria, Philippines, Uganda, Philippines, Kenya, Malaysia, Taiwan, Vietnam, Thailand, Rwanda and Senegal were trained on aspects of genomics and trait discovery. While 613 farmers took part in field days, over 30 PhD students were supported. About 300,000 people (30% women) were trained in short-term capacity development activities under FP6. Trainings were also offered to different stakeholders on preparing a seed catalogue and digital road map, to NARS on gender responsiveness in demand-led breeding, and also a GREAT training on Breeding for gender was held. The Crop Network Groups (CNGs) that are multi-stakeholder platforms comprising NARS, CGIAR, NGOs, private seed and food industries, ARIs, etc. were promoted. These engage all actors along crop commodity value chains in the design of crop product profiles in Africa for soybean, sorghum and millets, groundnut, and cowpea, besides promoting development, testing, advancement and delivery and capacity building needs.

The Capacity Development Task Force continued to raise awareness on the diversity in capacity development approaches that are expected to further improve the reporting on organizational and institutional capacity development efforts. Besides, the Task Force set up an E-Learning portal using a commonly known Learning Management System (LMS) to facilitate a flexible and user-friendly environment for both learners and facilitators. This portal (https://gldc.codeobia.com/) currently has three free online courses to enroll following a registration process. The Task Force also facilitated the Innovation Fund investment through the Regional

Universities Forum for Capacity Building in Agriculture (RuForum) that includes 34 BSc and MSc students. Six Master's theses (2 females, 4 males) and 12 Bachelor's theses (5 females, 7 males) are in progress.

1.3.4 Climate Change

The activities of FP3 contributing to climate change issues revolved around assessing the spatial and temporal distribution of emerging diseases of chickpea and pigeonpea and mapping the risk areas for future interventions. In addition, drought-tolerant varieties of GLDC crops have been screened for intercropping under various agroecologies (as a buffer to climate variability) to evaluate both their production and water use efficiency (WUE) in the face of variable climate. A comprehensive framework for farming systems sustainability with 5 domains and 115 indicators was developed. A multi-dimensional analysis was undertaken to explore the near-future effects of different scenarios on food security dimensions of sustainable intensification (SI). It was found that family planning interventions reducing household size, increased productivity through mineral fertilizer subsidy and promoting cereal inventory credits will contribute to SI of farming systems. Whole farm models were run successfully to support Krishi Vigyan Kendras (KVKs) - Farm Science Centers in Telangana, Maharashtra and Andhra Pradesh states of India for upscaling climate resilient agriculture. Cropping system models were run to help the breeding programs optimize G × E × M interactions. The focus of FP6 in addressing climate change in the Bean Program continues to lay strong emphasis on drought tolerance (as reflected in the number of drought tolerant varieties released in 2019), and is increasingly incorporating tolerance to high temperatures into the agenda. A trait discovery project funded by the Norwegian government through Crop Trust highlights the use of wild relatives (wild *Phaseolus acutifolius*) to combat climate change.

1.3.5 Markets and Partnerships in Agri-Business

MPAB explored emerging market opportunities through a portfolio of scoping studies with stakeholder engagement as a pathway to develop and pitch new funding proposals. Underpinning this work is a conceptual framework being developed in collaboration with FP1 based on a working review paper exploring the narratives and evidences around value chain interventions forming the basis for a science agenda around markets and partnerships as well as a way of framing design interventions in this domain. Progress on the scoping studies include:

1. Implications of Kenya's sorghum and millet composite flour policy: A review of secondary literature and interviews with policy stakeholders are complete. Interviews with county-level stakeholders, including farmers, are underway.
2. Future studies on GLDC crops as functional foods: A market research company was contracted to gauge consumer trends and preferences. Results are expected in March 2020.
3. Neighborhood / food movement effects as a potential mechanism to change food habits: The focus was on aflatoxin-free groundnuts in Nairobi's low-income urban areas. A literature review and interviews were undertaken. Key informants included mentors of community-based actions in Mombasa and Kisumu informal settlements. A behavior change communication product was produced as a result of this work.
4. Pilot study on sorghum fodder enterprises: Members of Mulukanoor Women Dairy Cooperative (MWDC) in Karimnagar district of Telangana state in India were surveyed to capture feed and fodder transaction patterns. This study revealed that landless and small farmers whose livelihoods depend on dairy production need to purchase feed and fodder to increase dairy productivity. Pilot testing of silage making by farmers with large land holdings suggests that this could be a variable, village-level source of fodder to replace expensive feed concentrates.

2. Effectiveness and Efficiency

2.1 Management and governance

During 2019, two meetings of the Independent Advisory Committee (IAC) of the CRP-GLDC were held. The first meeting was held virtually on 12 March 2019 followed by an in-person meeting on 25 November in Nairobi, Kenya. Currently, the IAC has a vacancy due to the resignation of a member, which will be filled in 2020.

IAC currently includes seven non-CGIAR members and five ex-officio CGIAR members. One of the ex-officio members is the Director General of ICRISAT as the lead center.

The Director of CRP-GLDC, who is also the Deputy Director General for Research at ICRISAT, reports to the Director General of ICRISAT and chairs the Research Management Committee (RMC), is responsible for the implementation of the CRP-GLDC. The RMC has 14 members, including four Flagship Program Leaders, the Senior Gender Scientist, three cross-cutting theme leaders, three Center Focal Points and the CRP-GLDC Director. The RMC is primarily responsible for the establishment, execution and monitoring of the research portfolio, strategy, work plans and annual budgets. In 2019, five meetings of the RMC were held, including an in-person joint meeting of the RMC, IAC and partners in November 2019. Overall, FP management is the responsibility of the FP Leader who is supported by CoA leaders of the respective Flagship. FP leaders devote at least 40% of their time on the Program's operational activities, funded by W1 and W2, and supported by W3 and bilateral projects. The CRP leadership positions combine management responsibilities with active research leadership.

2.2 Partnerships

2.2.1 Highlights of External Partnerships

FP1 partnered with the University of Cologne and University of Bonn Future Rural Africa Research Group for a special publication on aspirations. The gender and youth team partnered with universities in ESA on 'youth transitions' and 'opportunity structures' for research activities on 'commodity corridors' for groundnuts and sorghum in Tanzania. Adoption and impacts of improved cowpea varieties and agronomic practices in Nigeria was done with IAR, Nigeria. FP3 worked with European universities and NARES in SSA and SA on pest and disease control, sustainable intensification and sustainability assessment framework, joint systems modelling and capacity building, research contextualization and farmer engagement (Table 8). Bilateral funding and CoP (AgMIP, Big Data for Agriculture Intensification) were leveraged through adaptive crop-soil-climate models. There was enhanced engagement with 35 private seed companies through ICRISAT-HPRC and food industries in Asia and ESA (Table 8). Private partners, Intertek for SNP genotyping and HIPHEN for drone-based imaging indices, provided services. Corteva AgriScience helped access to cutting edge technologies like gene editing and training in sorghum and pearl millet. Methods for RGT in sorghum and pearl millet were developed with private and public sector partners for accelerated varietal delivery in AVISA. Pearl millet heat screening trials with Pioneer Hi-bred Pvt. Ltd., Bayer BioScience Pvt. Ltd. and Rallis India Limited; drought screening trials with CCSHAU-India, and integrated pearl millet improvement strengthened existing partnerships. Gender partnerships with non-traditional institutions like the Centre for Behaviour Change and Communication is contributing to insights on working with communities to generate a brand identity for quality seeds of improved varieties. Partnerships with local universities are supporting in generating insights on youth transitions. Eighty-four new partners/donors representing various actors across the production, distribution and consumption hubs joined the PABRA network and through Korea-Latin America Food & Agriculture Cooperation Initiative (KoLFACI).

2.2.2 Cross-CGIAR Partnerships

FP1 worked with CRP-PIM to update the IFPRI IMPACT Platform for foresight modelling and ex-ante analysis and priority setting and with CGIAR Platform for Gender Research. Understanding household situations and outlook, and the implications for adoption and dietary and entrepreneurship entry points was enhanced with CRP-PIM, and synergistic activities around urban food system with CIAT for better access to farmers. Gender perspectives on breeding were improved with the Gender and Breeding Initiative and EiB. The whole farm modelling work in West Africa on scenarios of access to quality feed/ fodder from crop residues and cultivated fodder to project livestock performance, market value and potential income for the farmer was enhanced. Resource persons from seven CGIAR centers/platforms (Table 9) supported the second training course on enhancing operational efficiencies and genetic gain held in Tanzania for breeders (12 women and 14 men) from Asia and Africa. Fodder quality parameters were analyzed with ILRI to streamline fodder traits in GLDC product profiles. With EiB, tools were developed for using drone-generated images in breeding, besides developing product profiles, stages &

gateways, genotyping/sequencing-related services, phenotyping and data management. We contributed to re-designing the CGIAR GENDER platform to operationalize a 'go-to-place' for evidence, tools/frameworks and capacity in gender research. How gender equality impacts food systems and vice versa are common overarching questions across the centers; CRP-GLDC's niche area will be understanding the impacts of gender equality in the drylands. PABRA's work on nutrition in Africa served to promote both high Fe beans and orange fleshed sweet potatoes with CIP (see Table 9).

2. 3 Intellectual Assets

CPR-GLDC did not manage any intellectual assets directly but through partner institutions as evidenced by submitted Innovations and Outcome Impact Case Reports.

2.4 Monitoring, Evaluation, Impact Assessment and Learning (MELIA)

Two key ex-post impact assessment studies have been completed on cowpea and soybean in Nigeria and Malawi, respectively. The work conducted within FP1 is evidenced by a paper on the yield and income effects of improved cowpea published in the Journal of Agricultural Economics and on the poverty impacts of improved cowpea in World Development.

The collaboration with SMO and MARLO increased during 2019 in order to improve the pilot result-dashboard launched with 2017-2018 data. The work will continue in 2020 and will lay the foundation for a one-CGIAR Result-Based Management approach. The overall architecture is based on Application Programming Interfaces (APIs) that exchange data among the tools (MEL, MARLO, OCS, CGSPACE, etc) within the One-System and presents an overview of planned and achieved results.

CRP-GLDC opened a position for an M&E Research Fellow that started in 2019 and will continue in 2020. The Research Fellow has the opportunity to interact with CRP scientists across the portfolio and contribute to the improvement of M&E processes along the CRP Theory of Change from indicators baseline to target. The collaboration with scientists allows the Research Fellow to contribute to the identification of innovations, policies and outcome-impact case reports.

2.5 Efficiency

As a follow-up of the CGIAR Performance Management Standard (PMS) Assessment, CRP-GLDC implemented a more robust mechanism to collect W3 and Bilateral project information along PMS criteria. The process allows more efficient sharing of project information across and within flagships. ICRISAT's Monitoring and Evaluation of Agri-Science Uptake in Research and Extension (MEASURE) is a mobile-web-based platform exclusively designed to collect real-time, geo-tagged data about farmers, farmland, livestock, on-field interventions, and other key indicators of agriculture research and extension. The tool was configured to interact with the CRP Management Information System (MIS) and share data to avoid duplication. The 2019 data exchanged is mainly related to innovations. In 2020, the team will explore the further use of APIs in line with the overall CGIAR effort towards a One-System.

2.6 Management of Risks to CRP

The CRP-GLDC Director's 20% role undertaken by the Deputy Director General-Research (DDG-R) of ICRISAT is supported by a full-time Program Manager. The CRP-GLDC management was reviewed by the IAC in 2019, where the IAC recognized the need of continuity in leadership until the end of the Program and recommends an increase in the Director's engagement with focal points and partners.

While the CRP continued to operate with the unfunded FP2 in 2019, projects worth US$ 2.71 M supported through bilateral funds were mapped to FP2. This was partly mitigated by creating a cross-cutting theme on Market and Partnerships in Agri-business (MPAB). Although a new Flagship (FP6) on Common Bean for

Markets and Nutrition led by CIAT has been integrated with CRP-GLDC in 2019, concerns with the governance challenges and management information system Managing Agricultural Research for Learning and Outcomes (MARLO) remain unresolved and could present potential risk for the remaining period of CRP-GLDC. This is an important issue since the alignment and adjustment of processes may create difficulties in reporting. On the specific integration between the MEL system of CRP-GLDC and MARLO used by CIAT, the main challenges relate to the changing elements in terms of SMO POWB and AR formats, standards (e.g. lists of options in tables) and the recently introduced Web-based Quality Assurance Tool that has not been test-launched yet with any CRP. However, frequent communications and joint tasks between the MEL and MARLO teams recently under the guidance of the SMO team should help minimize the risks.

2.7 Use of W1-2 Funding

FP1 conducted a strategic ex-ante nutrition impact evaluation, developed future climate scenarios for GLDC mega environments in Asia and SSA, researched on aspirations to target and scale agricultural innovations, assessed the potential impact of GLDC crops on urban food and nutrition security, characterized youth in drylands of Tanzania, Uganda and Ethiopia and developed an integrated and multi-faceted impact assessment and learning strategy for GLDC. FP3 develop biocontrol methods, surveillance tools for diseases and pests, soil management options, screened crop varieties for intercropping, gender responsive farming systems, large-scale cereal-legume system demonstrations and capacity building of NARES. With SLU, WLE, CCAFS and RTB, a framework for sustainability of farming systems was developed. FP4 commercialized crop cultivars to meet market/industry needs, shared knowledge through CNGs, deployed SNP-genotyping for early generation selection, phenotyping and mainstreaming biofortification in pearl millet and sorghum. FP5 leveraged W3/bilateral projects for pre-breeding, marker development and deployment, genomic selection, molecular breeding/markers-based introgression of QTLs/genomic regions in elite lines, development of QC panels and supporting new partnerships for RGT and capacity building. These funds supported gender research on youth under bilateral projects for proof-of-concept to integrate youth in GLDC value chains. FP6 advanced the Bean Program, including Fe and Zn biofortification and crop resilience (heat and drought tolerance, disease resistance) through recovery of traits from *P. acutifolius* and *P. parvifolius* for potential towards major objectives. Spatial adjustment of field data is being implemented to expand this capacity to partners, besides releasing varieties developed with W2 funds in the past.

3. Financial Summary

The CRP-GLDC budget of US$ 8.20 million was expressed in PoWB 2019. In view of the shortened duration of CRPs by one year (ending 2021), which will have an adverse impact on achieving all the milestones set for 2022, CRP-GLDC has reviewed its planned budget for 2019. An additional amount of US$ 776,820 from the PMU activity budget was supplemented to the already allocated budgets of FP1, FP3, FP4 and FP5. This decision was taken in order to align and support high impact activities that can help hasten the process of achieving the planned milestones within 2020 and 2021.

In 2019, new Flagship FP6: Common Bean for Markets and Nutrition, led by CIAT was integrated into CRP-GLDC. A total budget of US$ 1,715,000 through W2 funds was allocated for the implementation of its activities. It was agreed with CIAT that ICRISAT would charge a 5% pass through cost for the management of FP6. A payment of US$ 1,633,333 was made to CIAT after deducting the 5% pass through cost with the signing of a Program Participating Agreement (PPA).

The total budget for W3/bilateral was planned at US$ 75.35 M and spent at 76% in 2019.

Part B. Tables

Table 1: Evidence on Progress towards SRF targets (Sphere of interest)		
SLO Target (2022)	**Brief summary of new evidence of CGIAR contribution**	**Expected additional contribution before end of 2022** *(if not already fully covered).* **Optional narrative. Evidence not required.**
1.1. 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	1. The duplicated extent of coverage of improved cultivars with > 98% in Sagaing region followed by Mandalay (>96%) and Magway (> 94%) regions in Myanmar. https://hdl.handle.net/20.500.11766/9784; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/e21ed7 2. A study conducted in Nigeria using a nationally representative sample survey of over 1,500 cowpea producing households showed that over 40% of the cowpea producers (equivalent approximately to 900,000 households) adopted improved varieties on over 1 million hectares of land. https://doi.org/10.1111/1477-9552.12331; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/c7534c 3. A study conducted in Malawi using a nationally representative sample of over 1,200 soybean growing households showed that over 33% of the households adopted improved varieties following the recommended agronomic practices. Over 220,000 households adopted improved soybean varieties and agronomic practices. (https://doi.org/10.1016/j.worlddev.2019.104631) 4. An important screening work of legume crop varieties has been undertaken in CoA3.2 for intercropping. This was complemented by demonstration plots that served to train master trainers, of which 29% were females. All these actions have led to 110,000 benefitting from the doubled-up legume systems. CRP-GLDC FP3.2 2019 Report: https://bit.ly/2D7X0if 5. In Southern Highlands of Tanzania, increased access to seed has driven the adoption of new improved varieties from 32% in 2013 (67,907 adopting households) to 42% of growing households in 2016 (148,408 adopting households), which is equivalent to 3.3% annual growth in adoption rate. In terms of area share, adoption of new varieties increased from 21% in 2013 (40,744.4 Ha area planted) to 25% in 2016 (89,045 Ha area planted). Technical Report 6. There has been a remarkable diffusion of climbing bean in Rwanda over the last two decades, both in terms of percentage of bean growers and area planted to climbing bean. About 50% of bean-producing households have adopted climbing bean (0.8 million climbing bean growing households), and for most adopting households, climbing bean is the only bean type grown; only 9 % of bean growers are partial adopters. https://doi.org/10.1007/s12571-017-0753-4; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/7d03d8	An ongoing variety adoption study will be completed and documented in 2020.

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Table 1: Evidence on Progress towards SRF targets (Sphere of interest)		
SLO Target (2022)	**Brief summary of new evidence of CGIAR contribution**	**Expected additional contribution before end of 2022** *(if not already fully covered).* **Optional narrative. Evidence not required.**
1.2. 30 million people, of which 50% are women, assisted to exit poverty	1. The estimated welfare benefits accrued in the Myanmar due to adoption of chickpea improved cultivars was estimated at $152.8 million. https://hdl.handle.net/20.500.11766/9784. Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/e21ed7 2. A study conducted in Nigeria showed that adoption of improved cowpea varieties led to a 17% increase in household income, a 24% increase in asset ownership, and a 5% reduction in the incidence of poverty, which is equivalent to 929,450 people lifted out of poverty due to adoption of improved varieties. https://doi.org/10.1016/j.worlddev.2019.05.027; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/c7534c	None

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Table 1: Evidence on Progress towards SRF targets (Sphere of interest)		
SLO Target (2022)	**Brief summary of new evidence of CGIAR contribution**	**Expected additional contribution before end of 2022** *(if not already fully covered).* **Optional narrative. Evidence not required.**
2.1. Improve the rate of yield increase for major food staples from the current <1% to 1.2-1.5% per year	1. A study conducted in Nigeria using a nationally representative sample survey of over 1,500 cowpea producing households showed that adoption of improved varieties was associated on average with a 26% increase in yields and 61% increase in net returns per hectare. https://doi.org/10.1111/1477-9552.12331; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/c7534c 2. A study conducted in Malawi using a nationally representative sample of over 1,200 soybean growing households showed that 34% of the total soybean area was planted to improved varieties following the recommended agronomic practices and adoption of improved soybean varieties and agronomic practices led to an average of 61% yield gain and 53% net income gain for adopters. https://doi.org/10.1016/j.worlddev.2019.104631 3. The productivity gain due to adoption of chickpea improved cultivars in the study regions in Myanmar was estimated at 51%, benefitting approximately 0.2 million chickpea growers. (https://hdl.handle.net/20.500.11766/9784); Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/e21ed7 4. Tanzania: Adopters of new improved varieties produced 32% more beans for the same unit of land, compared to if they had planted landraces. As result of increased yield, adopters marketed surplus increased by 38%, which is remarkable and confirms that bean improvement has contributed to smallholder integration into the market. Extrapolated numbers are: 223kg/ha effect on yield, 19,857.04 tons additional yield, 8,459.28 tons effect on marketed per agricultural season as a result of adopting IV by adopting improved varieties. https://doi.org/10.1177/0030727018813698 5. Rwanda: The climbing bean adoption study revealed an average yield gain of 22% among adopters. One additional kilogram of climbing bean seed planted raises per capita consumption expenditure by 0.9% and that of bean consumption by 2.8% and increases the probability that a household is food secure by 0.6% while decreasing the likelihood of being poor by 0.6%. 0.8 million households adopted climbing bean, for a cultivated area of 201,558 ha, resulting to additional harvest of 108,841.09 tons per year. For poverty effects: 5000 people lifted out poverty /year, and a bean consumption of 2,400 tons annually. https://doi.org/10.1007/s12571-017-0753-4; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/7d03d8	None

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Table 1: Evidence on Progress towards SRF targets (Sphere of interest)		
SLO Target (2022)	**Brief summary of new evidence of CGIAR contribution**	**Expected additional contribution before end of 2022** *(if not already fully covered).* **Optional narrative. Evidence not required.**
2.2. 30 million more people, of which 50% are women, meeting minimum dietary energy requirements	No contribution to SLO Target 2.2 in 2019	
2.3. 150 million more people, of which 50% are women, without deficiencies in one or more essential micronutrients	1. Biofortified pearl millet and lentil varieties with elevated Fe and Zn content are commercialized in India. High oleic groundnut varieties offer consumer health benefits as they contribute to reduced cardiovascular diseases. Pearl millet evidences: https://hdl.handle.net/20.500.11766/10690; https://doi.org/10.1002/cche.10227, https://academic.oup.com/jn/article-abstract/145/7/1576/4644387; Lentil evidences: https://www.icarda.org/media/drywire/lentil-biofortification-research-fight-hidden-hunger, https://doi.org/10.1016/j.foodpol.2018.11.004; Groundnut evidences: https://www.icrisat.org/mainstreaming-biofortification-of-pearl-millet-to-tackle-malnutrition/, http://measure.icrisat.org/enumerator/pi2019_survey372_surveydata/68/372; Link to relevant impact story: https://hdl.handle.net/20.500.11766.1/9a68e5	
3.1. 5% increase in water and nutrient efficiency in agroecosystems	No contribution to SLO Target 3.1 in 2019	
3.2. Reduction in 'agriculturally'-related greenhouse gas emissions by 5%	No contribution to SLO Target 3.2 in 2019	
3.3. 55 M ha degraded land area restored	No contribution to SLO Target 3.3 in 2019	
3.4. 2.5 M ha forest saved from deforestation	No contribution to SLO Target 3.4 in 2019	

Table 2: Condensed list of policy contributions in this reporting year (Sphere of Influence)								
Title of policy, legal instrument, investment or curriculum to which CGIAR contributed (max 30 words) *Spell out acronyms in every row*	**Description of policy, legal instrument, investment or curriculum to which CGIAR contributed (30 words). See guidance for what to cover.**	**Level of Maturity**	**Link to sub-IDOs (max. 2)**	**CGIAR cross-cutting marker score**				**Link to OICR (obligatory if Level of Maturity is 2 or 3) or link to evidence (e.g. PDF generated from MIS)**
				Gender	**Youth**	**CapDev**	**Climate Change**	
Revision of the Burundi memorandum/ strategy to enhance the consumption of beans to include promotion of high iron beans	Burundi: Country strategy that enhance the consumption of beans and dry bean products facilitated with CIAT's support their memorandum was reviewed towards continually promoting high iron beans	1	2.1.1,2.1.2	1	1	1	1	https://hdl.handle.net/20.500.11766.1/8d9501
Crop biofortification technical guidance in Uganda	Country strategy championed by NARO-Bean Programme which is a member of PABRA facilitated by Alliance of Biodiversity and CIAT facilitates the increase in the consumption of beans and bean products.	1	2.1.1,2.1.2	1	1	1	1	https://hdl.handle.net/20.500.11766.1/a5c562
2nd Uganda Nutrition Action Plan (2020-2025)	This plan contributed to the development of the Country strategy that includes intensifying production of bio-fortified crops to address micro-nutrient gaps among women and children.	1	2.1.1,2.1.2	1	1	1	1	https://hdl.handle.net/20.500.11766.1/fdc0bb
Zimbabwe: 1) National Food Fortification Policy (2019)	CGIAR especially CIAT-PABRA through the national the government Department of Research and Special Services (DR&SS) influenced the policy makers to develop and enact food fortification policies.	1	2.1.1,2.1.2	1	1	1	1	https://hdl.handle.net/20.500.11766.1/ed7f78

Zimbabwe: 2) National school feeding programme (2019)	CG especially CIAT-PABRA through the national the government Department of Research and Special Services (DR&SS) influenced the policy makers and mainstreamed the use of nutritious food in school feed programme.	1	2.1.1,2.1.2	1	1	1	1	https://hdl.handle.net/20.500.11766.1/e3acae
Zimbabwe: 3) Command Agriculture (2019)	The CGIAR especially Alliance of Biodiversity and CIAT-PABRA Project, through the Zimbabwe national government Department of Research and Special Services (DR&SS) influenced the policy makers to increase agricultural productivity.	1	1.4.2	0	0	1	0	https://hdl.handle.net/20.500.11766.1/e04100

Table 3: List of Outcome/ Impact Case Reports from this reporting year (Sphere of Influence)

Title of Outcome/ Impact Case Report (OICR)	Link to full OICR.	Maturity level	Indicate if this is: new outcome updated Case- same level of maturity updated Case- new level of maturity
Improved cowpea varieties contribute to poverty reduction in Nigeria	https://hdl.handle.net/20.500.11766.1/c7534c	Level 3	New impact case
Improved Myanmar Chickpea Production through Early Maturing Cultivars	https://hdl.handle.net/20.500.11766.1/e21ed7	Level 3	New impact case
Climbing bean technologies helped 0.8 M farming households increase productivity and food security, resulting to about 5,000 households climbing out of poverty in land-constrained Rwanda	https://hdl.handle.net/20.500.11766.1/7d03d8	Level 3	New impact case
TPE and beyond: laying the base for modern geography-specific crop improvement methodologies across CGIAR and partnering institutions	https://hdl.handle.net/20.500.11766.1/d5b1a5	Level 1	New outcome case
High oleic groundnut varieties commercialized in India meet the enhanced shelf-life needs of food industry and consumer health benefits.	https://hdl.handle.net/20.500.11766.1/9a68e5	Level 1	New outcome case
Rapid generation advancement (RGA): enabling speed breeding in chickpea, and lentil	https://hdl.handle.net/20.500.11766.1/419c75	Level 1	New outcome case
Efficient Legume Seed Systems for Better Smallholder Farmers' Livelihoods in the Semi-Arid Tropics	https://hdl.handle.net/20.500.11766.1/baeb8c	Level 2	Updated outcome case

Table 4: Condensed list of innovations by stage for this reporting year			
Title of innovation with link *(e.g. to CLARISA dashboard, MARLO)*	**Innovation Type**	**Stage of innovation**	**Geographic scope** *(with location)*
Methods for assessing poverty reduction due to adoption of improved varieties https://mel.cgiar.org/innovation/getinnovationview/id/335	Social science	Stage 3: Available/ready for uptake	National (Nigeria)
Bio-control agents of pests and diseases in Benin and Burkina Faso https://mel.cgiar.org/innovation/getinnovationview/id/339	Production systems and Management practices	Stage 2: Successful piloting (PIL-end of piloting phase)	Regional (West Africa)
Plant growth promoting microorganisms (PGP) for sweet sorghum https://mel.cgiar.org/innovation/getinnovationview/id/340	Production systems and Management practices	Stage 2: Successful piloting (PIL-end of piloting phase)	National (India)
Five soybean (high yield & large size) and six cowpea genotypes (multi-traits) selected for further integration into cropping systems in Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/343	Production systems and Management Practices	Stage 2: Successful piloting (PIL-end of piloting phase)	National (Mozambique)
Identification of varieties of groundnut and pigeon pea for intercrops to optimize yields https://mel.cgiar.org/innovation/getinnovationview/id/344	Production systems and Management Practices	Stage 3: Available/ready for uptake	Regional (Southern Asia, Eastern Africa, Western Africa)
Farming system sustainability assessment through mix-methods approach for arid and semi-arid regions https://mel.cgiar.org/innovation/getinnovationview/id/336	Other: Framework	Stage 3: Available/ready for uptake	Global
A multi-dimensional scenario analysis https://mel.cgiar.org/innovation/getinnovationview/id/337	Research and Communication Methodologies and Tools	Stage 3: Available/ready for uptake	Global
Model to assess sustainable intensification in the 'old cotton basin' in southern Mali https://mel.cgiar.org/innovation/getinnovationview/id/338	Research and Communication Methodologies and Tools	Stage 3: Available/ready for uptake	Global
High yielding Pearl millet hybrid: BHB 1602 for drought prone environments of north-west India https://mel.cgiar.org/innovation/getinnovationview/id/316	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India)
Iron and zinc-biofortified Pearl millet cultivar: ICMH 1301 (Phule Mahashakti) for India https://mel.cgiar.org/innovation/getinnovationview/id/317	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India), Subnational (Maharashtra)

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Table 4: Condensed list of innovations by stage for this reporting year			
Title of innovation with link *(e.g. to CLARISA dashboard, MARLO)*	**Innovation Type**	**Stage of innovation**	**Geographic scope** *(with location)*
Iron and zinc-biofortified Pearl millet cultivar: ICMH 1505 (GHB 1225) for India https://mel.cgiar.org/innovation/getinnovationview/id/318	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India), Subnational (Gujarat)
New forage sorghum hybrid - Punjab Sudax Chari 4 developed using ICRISAT-bred female parent ICSA 94012 was released by Punjab Agricultural University, Ludhiana, India https://mel.cgiar.org/innovation/getinnovationview/id/319	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India)
Chickpea cultivar: ICCV 08112 (BG 3062) https://mel.cgiar.org/innovation/getinnovationview/id/320	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India)
Chickpea cultivar: ICCIL 01029 (Geletu) https://mel.cgiar.org/innovation/getinnovationview/id/321	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Ethiopia)
Chickpea cultivar: ICCV 07108 https://mel.cgiar.org/innovation/getinnovationview/id/322	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Ethiopia)
Chickpea cultivar: ICCV 04305 (Koka) https://mel.cgiar.org/innovation/getinnovationview/id/323	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Ethiopia)
Early maturing, groundnut rosette disease resistant groundnut cultivar: ICGV-SM 01514 (MGV9) for Zambia, Tanzania and Malawi https://mel.cgiar.org/innovation/getinnovationview/id/324	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Malawi, Spillover: Tanzania)
Drought tolerant, and high yielding groundnut cultivar: ICGV-SM 03520 (AMM – 018) for Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/325	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Mozambique)
Drought tolerant, and high yielding groundnut cultivar: ICGV-SM 03530 (Mapupulo 2018) for Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/326	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Mozambique)
Drought tolerant, and aphid resistant groundnut cultivar: ICGV-SM 08528 (AMENA 2018) for Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/327	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Mozambique)
High oleic groundnut cultivar, Girnar 4 (ICGV 15083) available in India https://mel.cgiar.org/innovation/getinnovationview/id/328	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India)

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Table 4: Condensed list of innovations by stage for this reporting year			
Title of innovation with link *(e.g. to CLARISA dashboard, MARLO)*	**Innovation Type**	**Stage of innovation**	**Geographic scope** *(with location)*
High oleic groundnut cultivar, Girnar 5 (ICGV 15090) available in India https://mel.cgiar.org/innovation/getinnovationview/id/329	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (India)
Large seeded groundnut variety: CG7 (EUGN-1) for Kenya https://mel.cgiar.org/innovation/getinnovationview/id/330	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Malawi, Spillover: India, Kenya)
High yielding groundnut cultivar ICGV 08307 (EUGN-2) for Kenya https://mel.cgiar.org/innovation/getinnovationview/id/331	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Zambia, Spillover: Kenya)
ICEAP 00557-1 (Egerton Mbaazi 3): a new pigeon pea medium maturing cultivar with drought tolerance and fusarium wilt resistance, for mid and high altitude areas of Kenya https://mel.cgiar.org/innovation/getinnovationview/id/332	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Kenya, Spillover: Zambia)
ICEAP 00554-1 (Egerton Mbaazi 4): a new pigeon pea medium maturing cultivar with drought tolerance and fusarium wilt resistance, for Kenya and Zambia https://mel.cgiar.org/innovation/getinnovationview/id/333	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Kenya, Spillover: Zambia)
UFM 19-1 (KNE 689): a new finger millet high yielding variety for Mid Altitude Medium rainfall in Kenya and Tanzania https://mel.cgiar.org/innovation/getinnovationview/id/334	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Tanzania, Spillover: Kenya)
Markers deployment in breeding programs in groundnut, sorghum and soybean https://mel.cgiar.org/innovation/getinnovationview/id/345	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	Global
Quality control panel developed and initially validated in groundnut and pearl millet https://mel.cgiar.org/innovation/getinnovationview/id/347	Genetic (varieties and breeds)	Stage 2: Successful piloting (PIL-end of piloting phase)	Regional (South Asia)
Molecular breeding products released in chickpea and groundnut https://mel.cgiar.org/innovation/getinnovationview/id/341	Other: Molecular breeding tools	Stage 3: Available/ready for uptake	Global
Genome editing platform for sorghum https://mel.cgiar.org/innovation/getinnovationview/id/346	Research and Communication Methodologies and Tools	Stage 1: Discovery/proof of concept	Global
RapidGen (RGT) platform https://mel.cgiar.org/innovation/getinnovationview/id/342	Production systems and Management practices	Stage 3: Available/ready for uptake	Global

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Table 4: Condensed list of innovations by stage for this reporting year			
Title of innovation with link *(e.g. to CLARISA dashboard, MARLO)*	**Innovation Type**	**Stage of innovation**	**Geographic scope** *(with location)*
Varietal performance assessment using crowd-sourcing citizen science approach to test sorghum and finger millet varieties in Kenya, Uganda and Tanzania https://mel.cgiar.org/innovation/getinnovationview/id/349	Research and Communication Methodologies and Tools	Stage 3: Available/ready for uptake	National
Multi-model systems analysis to identify Low Emissions Development Pathways – exploring synergies and trade-offs in Mahbubnagar District, Telangana, India https://mel.cgiar.org/innovation/getinnovationview/id/315	Research and Communication Methodologies and Tools	Stage 1: Discovery/proof of concept	Global
Bean cultivar: NAROBEAN 7 https://mel.cgiar.org/innovation/getinnovationview/id/419	Genetic (varieties and breeds)	Stage 3: Available/ready for uptake	National (Uganda)

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.01. Improved targeting and responsiveness of research to market and household demands in the face of climate change for greater technology adoption, food and nutrition security, resilience, and poverty reduction	Increased resilience of agro-ecosystems and communities, especially those including smallholders	With the priority GLDC crops, countries and lines of research identified based largely on the initial foresight and ex-ante impact evaluation work, the subsequent multi-criteria ex-ante impact evaluations are providing a sound decision support to enhance the targeting, responsiveness and impacts of GLDC research.	Ex-ante evaluation of GLDC research and technology options completed and working papers published on the potential poverty and nutrition security impacts to guide priority setting.	Complete	Reports on ex-ante (1) poverty, and (2) nutrition security impacts of Research and Technology Options for Grain Legumes and Dryland Cereals in Sub-Saharan Africa and South Asia.	https://hdl.handle.net/20.500.11766/9469 https://hdl.handle.net/20.500.11766/10874

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.02. Market and household demand identified, and trade-offs assessed for more inclusive value chains that improve income and nutrition status in target regions	Increased livelihood opportunities	The different needs and wants of households based on various circumstances like aspirations and farm size among others, has been outlined in various studies and shared widely through scientific publications, blogs and magazine contributions.	Diversity of farm household preferences vis-a-vis market demand by context outlined in view of research in GLDC.	Complete	Insights shared on farming household diversity and entry points for technology development and dissemination outlined and shared in GLDC meetings.	https://hdl.handle.net/20.500.11766/10592 https://hdl.handle.net/20.500.11766/10058 https://doi.org/10.1177%2F0030727019888513 https://hdl.handle.net/20.500.11766/10680 https://hdl.handle.net/20.500.11766/9408 https://doi.org/10.1080/09614524.2018.1446909
1	FP1.02. Market and household demand identified, and trade-offs assessed for more inclusive value chains that improve income and nutrition status in target regions	Increased livelihood opportunities	The work on household aspirations is helping to better identify end-user demands and profiles and build on what has been documented in several market and value chain studies in terms of market and household demands and preferences.	Shared learning across GLDC stakeholders and FPs on implications of diverse target aspirations and future scenarios leading to strategic adjustments.	Complete	Report on diversity of target group preferences and match and mismatch of GLDC research targets based on meetings and workshops across GLDC.	https://hdl.handle.net/20.500.11766/10592 https://hdl.handle.net/20.500.11766/10058 https://doi.org/10.1177%2F0030727019888513 https://hdl.handle.net/20.500.11766/10680 https://hdl.handle.net/20.500.11766/9408 https://doi.org/10.1080/09614524.2018.1446909

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.03. Inclusive and equitable technologies and innovation systems and broadened impact across the agri-food system	Improved capacity of women and young people to established for accelerated participate in decision-making	N/A	Inclusive and equitable innovation system tested and adjusted to different biophysical and socioeconomic contexts including policy interactions.	Cancelled	Reasons for cancelling: 7. Others- This milestone is duplicating the milestone "Inclusive and equitable innovation system for accelerating impacts for women and young people designed and piloted including policy interactions". The retained duplicate was edited to make it more inclusive of the gender and youth work.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.03. Inclusive and equitable technologies and innovation systems established for accelerated and broadened impact across the agri-food system	Improved capacity of women and young people to participate in decision-making	The ongoing strategic youth research work involving cross-country surveys in Tanzania, Ethiopia and Uganda is enhancing our understanding of the potential nodes for participation of youth in GLDC value chains. Ongoing work on women participation in cowpea and chickpea seed value chains in Ethiopia, Zambia and Mozambique gives insights on inclusive and equitable technologies, innovation systems and policy recommendations.	Inclusive and equitable innovation system for accelerating impacts for women and young people designed and piloted including policy interactions.	Changed	Reasons for extending: 7. Others- There was a delay in the youth study partnerships` establishment in 2019, but data collection was initiated in 2019 and will proceed for analysis and stakeholder meetings in 2020.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact	Conducive agricultural policy environment	The review of scaling approaches has generated useful lessons for increased technology adoption and impact through the identification of successful approaches to technology scaling and the underlying institutional and policy contexts.	Evaluation designed and implementation underway to evaluate current GLDC scaling approaches & associated impact evidence.	Complete	The review of scaling approaches was designed and already implemented by the team.	https://hdl.handle.net/20.500.11766/11029

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact	Conducive agricultural policy environment	The review of impact studies of GLDC innovations has identified major gaps in terms of crops, countries and types of impact and offered recommendations for future impact assessments of GLDC technologies to expand crop and country coverage; to assess environmental, nutritional or social impacts in addition to economic impacts; and to improve on methodological approaches.	Joint systematic review of impact studies with CoA 1.2.	Complete	A working paper has been published on the review of impact studies of GLDC technologies.	http://dx.doi.org/10.5716/WP19006.PDF

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact	Conducive agricultural policy environment	The ongoing review of scaling approaches is generating useful lessons for increased technology adoption and impact through identification of successful approaches to technology scaling and the underlying institutional and policy contexts.	Scaling toolkit for Design, Execution, Monitoring, and Evaluation (DEME) content agreed to support improved horizontal and vertical scaling of GLDC commodities and management practices.	Extended	Reason for extending: 4. Internal resources - key staff, infrastructure or equipment was not available at the time needed.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact	Conducive agricultural policy environment	The ongoing review of scaling approaches is generating useful lessons for increased technology adoption and impact through identification of successful approaches to technology scaling and the underlying institutional and policy contexts.	Evaluation documenting the strengths, shortcomings and key lessons learned on GLDC scaling approaches and impacts.	Extended	Reason for extending: 7. Other, please state: A scaling framework was developed that encapsulates key elements considered important in promoting the large-scale adoption and impacts of GLDC technologies. Following an internal review, it was decided to expand the framework to make it more comprehensive for supporting and enhancing GLDC's scaling approaches and impact.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact	Conducive agricultural policy environment	The impact evidencing strategy that has been developed is expected to facilitate monitoring and evaluation and impact assessment systems for greater accountability and enhanced adoption and impacts of GLDC innovations.	Working strategy for evidencing the outcomes and impacts of GLDC.	Complete	Strategy note.	https://hdl.handle.net/20.500.11766/10867
3	FP3.O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	N/A	Participatory field trials under smallholder conditions in different cropping systems and environments evaluated.	Cancelled	Reason for cancelling: 7. Others. This milestone was merged with the milestone: 3,000 farmers are trained in the use of crop mixes and sequences in which they have jointly identified with researcher for better water and soil management.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Research and training of farmers, extension agents and students on legume systems and crop mixes for better water and soil management for increased productivity.	3,000 farmers are trained in the use of crop mixes and sequences in which they have jointly identified with researcher for better water and soil management.	Complete	Research and evaluation reports, training manuals.	https://hdl.handle.net/20.500.11766/10358 https://hdl.handle.net/20.500.11766/9406 https://hdl.handle.net/20.500.11766/10880 https://hdl.handle.net/20.500.11766/11036 https://hdl.handle.net/20.500.11766/11037 https://hdl.handle.net/20.500.11766/11038 https://doi.org/10.1080/14735903.2019.1609166 https://doi.org/10.1017/S0014479719000280
3	FP3.O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Surveys have been completed for impacts of legume-based technological interventions on smallholder production and livelihood performance in Burkina Faso and Ethiopia.	Ex-post impacts of innovation practices on crop production efficiency and household livelihoods measured.	Complete	Reports and publications on ex-post impact assessment with an efficiency focus. Surveys have been completed for impacts of legume-based technological interventions on smallholder production and livelihood performance in Burkina Faso and Ethiopia.	https://hdl.handle.net/20.500.11766/8815 https://hdl.handle.net/20.500.11766/8901 https://hdl.handle.net/20.500.11766/9551 https://dx.doi.org/20.500.11766/9512

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Surveys have been completed for farm-household livelihood typologies in Burkina Faso and Ethiopia.	Farm-household typologies characterized and participatory field trials under smallholder conditions in different cropping systems evaluated for common and type-specific determinants of adoption of innovations, intensification and diversification options.	Complete	Research reports, training manuals and other IEC materials: Surveys have been completed for farm-household livelihood typologies in Burkina Faso and Ethiopia.	https://hdl.handle.net/20.500.11766/9556 https://hdl.handle.net/20.500.11766/9542 https://hdl.handle.net/20.500.11766/9512 https://hdl.handle.net/20.500.11766/9551

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	This milestone was merged with the milestone: 3,000 farmers are trained in the use of crop mixes and sequences in which they have jointly identified with researcher for better water and soil management.	Map out areas suitable for crop diversification using GIS. Participatory field trials under smallholder conditions to evaluate the different cropping systems under different environments in different countries for farmers with landholdings less than 1 ha.	Cancelled	1. Research/science - inherent risk in unknown cutting-edge research or science; 2. Financial - funding delayed and/or cut; 6. External environment (political, economic, legal, market) - e.g. conflict, economic/ market changes: This Milestone was changed into "Participatory field trials under smallholder conditions in different cropping systems under different environments".	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	At least two intercropping systems tested in India, Mozambique, Malawi, Uganda, Burkina Faso and Senegal.	At least two options per site per country to promote diversified, profitable and sustainable crop-livestock systems discussed and agreed upon with local communities and researchers.	Complete	Research reports detailing intercropping systems tested in India, Kenya, Mozambique, Malawi, Uganda, Burkina Faso, Senegal, and economic evaluation reports.	https://pub.epsilon.slu.se/16308/7/muoni_t_190903.pdf https://pub.epsilon.slu.se/16153/7/mukangango_m_190517.pdf https://doi.org/10.1007/s10457-019-00455-8 https://hdl.handle.net/20.500.11766/10358 https://hdl.handle.net/20.500.11766/9406 https://hdl.handle.net/20.500.11766/10880 https://hdl.handle.net/20.500.11766/11036 https://hdl.handle.net/20.500.11766/11037 https://hdl.handle.net/20.500.11766/11038 https://hdl.handle.net/20.500.11766/11027 https://bit.ly/2Y0oONY https://hdl.handle.net/20.500.11766/11039 https://hdl.handle.net/20.500.11766/11040 https://hdl.handle.net/20.500.11766/11041

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O2. Pest and diseases controlled safely and with reduced agro-chemical inputs	Reduced production risk	Five strains each of *Streptomyces* and *Bacillus* were evaluated as biocontrol agents against *Fusarium* wilt and PGP agents in chickpea under both greenhouse and field conditions and they reduced disease incidence. Sweet sorghum bagasse was found to decompose fast and its compost prepared with microbes successfully promoted plant growth and significantly enhanced yields. Five indigenous *Bradyrhizobium* strains were evaluated on soybean and showed promising results with decreasing *Striga* population and increasing biomass and grain yields in Mozambique.	1) Pest and diseases management components for the target pests and 2) resource and soil management options in different regions fine-tuned.	Extended	Reason for extending: 3. Partnership - partners were not able to deliver a key piece on time.	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O2. Pest and diseases controlled safely and with reduced agro-chemical inputs	Reduced production risk	The spatial and temporal distribution of emerging diseases of chickpea and pigeonpea in India were assessed and risk areas mapped. In a large-scale application of biocontrol agents in Benin and Burkina Faso, adults of *Therophilus javanus* were recovered from parasitized *Maruca vitrata* caterpillars. Cowpea pods were collected 3 years after the release and the borer populations remains reduced by 86.3%. Plant growth promotion products like AMF inoculation proved to be effective on *Striga* infection and yield of sole-cropped maize and maize-bean intercrops in Uganda.	Efficacy of 1) selected pest and diseases management options and 2) resource and soil management options confirmed at pilot scale.	Extended	1. Research/science - inherent risk in unknown cutting-edge research or science; 2. Financial - funding delayed and/or cut; 6. External environment (political, economic, legal, market) - e.g. conflict, economic/ market changes (activities under this milestone will be informed by the results previous milestone (of course with overlaps), so we expect this one to be completed by the end of 2021.).	N/A

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
3	FP3.O3. Tested, adapted and validated options applied for sustainable intensification and livelihood diversification by farmers	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Comprehensive framework for farming systems sustainability with 5 domains and 115 indicators in India. A multi-dimensional analysis was undertaken to explore the near-future effects of different scenarios on food security dimensions of SI in southern Mali. A remote sensing-based model has been calibrated for millet yield estimates allowing to account for parkland effects (R^2=0.70) in Senegal.	Suite of systems modelling tools/ framework for co-designing resilient farming systems in GLDC regions.	Complete	We have been working relevant stakeholders including research and extension in SSA and SA and have parametrized and run whole farm systems models as decisions support at farming systems level (see evidence links for publications)	https://doi.org/10.1016/j.landusepol.2019.104149 https://bscmsc.pps.wur.nl/assessment-potential-future-sustain-ability-smallholder-farming-old-cotton-basin-mali http://oar.icrisat.org/11038/ https://bit.ly/38yMGvn https://bit.ly/2DkljtH https://cgspace.cgiar.org/handle/10568/105731 https://bit.ly/2O1CiD0
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply	Enhanced genetic gains	TPE characterization in Asia and WCA is completed for groundnut, sorghum and chickpea and this activity is prioritized under CoA 4.1 and has received co-investment from AVISA and other bilateral projects. See link in evidence.	Initial analysis of stress patterns in target populations of environments (TPE) on few crops are available to better decide on breeding target.	Extended	1. Research/science - inherent risk in unknown cutting-edge research or science; The TPE analysis has been initiated under CoA 4.1, completed for some crops and on-going for others. For all the GLDC crops and all regions, TPEs characterization will not be completed in next two years as it needs pooling of datasets and modeling. Human resources are limiting.	https://hdl.handle.net/20.500.11766/11035

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
4	FP4.O2. Robust and responsive global to national breeding systems produce and deliver novel varieties and allied innovations at appropriate scale and scope	Increased capacity for innovation in partner research organizations	The GLDC crop product profiles have been developed and uploaded on the EiB platform. NARS were also trained on development of PPs at the second training course organized by FP4.	Develop product profiles for crops X regions with NARS.	Complete	The EiB (Excellence in Breeding) platform has a portal to upload the Product Profiles and this exercise was done. In addition the information on the portal is shared to Jake in a excel sheet that can be provided as evidence.	https://bit.ly/2W9nUMt https://hdl.handle.net/20.500.11766/11028
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply	Closed yield gaps through improved agronomic and animal husbandry practices	The simultaneous improvement of both production and market traits through partnership with NARS under FP4 resulted in the commercialization of 26 GLDC crop cultivars: chickpea (6), lentil (5), groundnut (8), pigeonpea (2), sorghum (1), pearl millet (3), and finger millet (1) in Africa and Asia.	New suite of resilient varieties released by NARS partners. (Phase 1 investments start being released).	Complete	Towards the end of the Extension Phase of CRP-GL and DC, the varieties at various stages of testing in national trails and/ or MLTs are released for commercial cultivation in CRP-GLDC. The variety profile meets the Product Lines of CRP-GL and DC.	https://hdl.handle.net/20.500.11766/10987

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply	Increased availability of diverse nutrient-rich foods	The first high oleic groundnut varieties that confer consumer health benefits are commercialized in India. Bio-fortified lentil and pearl millet cultivars commercialized are important to reduce the burden of micro-nutrient malnutrition.	New varieties with enhanced nutrient levels (Fe, Zn, oil, protein, high oleic) developed.	Complete	Varietal profile. Evidence is available for biofortified pearl millet, and lentil and links are reported in AR, and in the evidence links section in this masterlist.	https://mel.cgiar.org/innovation/addinnovation/id/329 https://mel.cgiar.org/innovation/addinnovation/id/328
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply	Enhanced genetic gains	Rapid generation advancement (RGA) that enhances rate of genetic gain is used to develop and commercialize high oleic varieties, and protocols were standardized and deployed in lentil and chickpea. New genetic material of GLDC crops was shared with NARS partners in Africa and Asia and multi-location testing is established jointly with NARS to identify new cultivars for the target-agroecologies. Report	Phase I genetic materials deployed in GLDC crop improvement by CGIAR centers - annually 8 crops X 3 trait clusters X 2 regions tested by NARS.	Extended	7. Others. Deployment of innovations including RGA requires logistic adjustment. Initial logistics plan for genetic materials deployment will be completed with all stakeholders, and optimized RGA technology just recently completed optimization for other several crops	https://hdl.handle.net/20.500.11766.1/9a68e5 https://hdl.handle.net/20.500.11766.1/419c75

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

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5	FP5.O1. Pre-breeding products through use of genebanks and other sources and modern tools to increase genetic diversity in breeding programs globally	Increased conservation and use of genetic resources	Advanced the work related to Botrytis grey mold in chickpea, blast/heat tolerance in pearl millet and drought tolerance in cowpea by using wild germplasm.	Development/ refinement of technologies for overcoming barriers to wide crosses for 1 crop.	Complete	Publications, reports, technical bulletins. The papers cited talks about successful wide crosses.	https://doi.org/10.1111/pbi.13311 https://doi.org/10.18805/LR-3817 https://doi.org/10.3389/fgene.2019.01177 https://doi.org/10.1017/S1479262119000030 https://doi.org/10.3389/fpls.2019.01269 https://doi.org/10.2135/cropsci2018.07.0438 https://doi.org/10.3390/agriculture9060121

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
5	FP5.O2. Trait discovery and development based on genomics and phenomics to generate new markers to support trait integration through use of modern enabling technologies and forward breeding	Enhanced genetic gains	Molecular breeding products (2 in groundnut, 3 in chickpea) released in India and Ethiopia. Markers deployed in breeding program in groundnut, sorghum and cowpea resulting in more than 700K marker data points generated in 2019. QC panels developed and initially validated in groundnut and pearl millet. Germplasm reference sets, other germplasm sets, mapping populations assembled, and traits prioritized for discovery research in 4 legumes (groundnut, chickpea, pigeonpea, cowpea) and 3 cereals (sorghum, pearl millet, finger millet).	Precision phenotyping for key traits for these collections and genotyping to identify novel alleles for 2 traits in 2 crops that have limited variability in breeding populations.	Complete	The papers cited describe the traits characterized at genotypic and phenotypic levels to develop markers.	https://doi.org/10.1111/pbi.13311 https://doi.org/10.18805/LR-3817 https://doi.org/10.3389/fgene.2019.01177 https://doi.org/10.1017/S1479262119000030 https://doi.org/10.3389/fpls.2019.01269 https://doi.org/10.2135/cropsci2018.07.0438 https://doi.org/10.3390/agriculture9060121

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
5	FP5.O3. National researchers able to apply the acquired skills in other pre-breeding programs. Development of enabling technologies platforms to be used for rapid trait discovery, trait validation, trait development and trait introgression **This milestone was planned under FP5.2 in the POWB 2019, but was corrected, and now reported under FP5.3 in this Annual Report 2019.*	Enhanced genetic gains	Public-private partnerships to accelerate the development and deployment of modern enabling tools and technologies. Data management in at least 3 of the GLDC crops digitalized. RapidGen (RGT) platform established in pearl millet and chickpea. Quickcrop nextgen transformation established in sorghum and pearl millet. Genome editing ,platform established in sorghum.	Network of precision phenotyping sites is established across GLDC crops to provide unique and relevant testing locations for key traits (FP4.1). Gain-of-function or loss-of-function platform in 1 cereal and 2 legumes established.	Complete	The papers cited describe the traits characterized at genotypic and phenotypic levels to develop markers.	https://doi.org/10.1016/j.heliyon.2019.e01914 https://doi.org/10.3389/fnut.2019.00068 https://doi.org/10.1002/9781119468677.ch33 https://bit.ly/3eIVEc7

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6	General	Sub-IDO 1.4.3: Adoption of CGIAR materials with enhanced genetic gains	Six product profiles have been defined with current traits and traits to add: red mottled, cream mottled, yellow, small white, small red and small black. This process was initiated under the Tropical Legumes III project, and also benefits from on-going consultations in business platforms within bean corridors where commercial interests and gender considerations are taken into account. A foresight exercise will contribute to an evolving set of profiles over time.	Researchers created and shared draft product profiles with partners.	Complete	EiB site. The profiles are registered with the Excellence in Breeding platform, but they have apparently chosen not to make them public.	https://excellenceinbreeding.org/

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6	Outcome 1: Livelihoods	Sub-IDO 1.3.2: Increased livelihood opportunities	The impact model as developed jointly by IFPRI and collaborating CGIAR centers was applied to beans on a country by country basis. As expected, the model predicts significant growth in bean productivity, although it underestimates realized gain in Ethiopia where government support attained the predicted gains in 10 years instead of 30 years. Unfortunately, the model does not permit experimenting with theoretical changes, for example, in annual genetic gain under different breeding innovations, or improved markets that incentivize use of inputs. Such innovations must be explored independently.	Researchers wrote a report on foresight analysis that predicts demand for bean based on CIAT research.	Extended	Reason for extending: 1. Research/ Science. Delays in contracting a post-doc required extension. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 3: Less yield losses	Sub-IDO 1.3.2: Increased livelihood opportunities	The large seeded Mesoamerican bean lines' drought-tolerance was tested against drought checks for two years. They also present excellent combining ability. The parentage of these lines does not reveal the source of their traits, with the exception of one parental line with superior low fertility tolerance. These lines illustrate the importance of maintaining a large number of crosses in a breeding program, to identify serendipitous combinations.	Researchers collected agronomic data on large- seeded Mesoamerican beans to indicate their potential as a breeding class.	Complete	Data for experimental bean lines selected for tolerance to drought.	https://doi.org/10.7910/DVN/EZBQBF

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6	Outcome 4: Enhanced genetic gain	Sub-IDO 1.3.2: Increased livelihood opportunities	A series of greenhouse experiments was performed to establish a rapid generation advance (RGA) protocol. We tested soil types, light regimes, pod sizes, watering regimes, fertilizer applications and hormone applications, as well as harvest and post-harvest factors such as early harvesting and seed drying regimes. More experiments are ongoing. A field RGA protocol was developed, inspired by work at IRRI to advance single plants one generation for about USD 0.0 9 per plant, with additional savings in seed handling. A recent population was advanced 3 generations by RGA and is entering yield trials now. The protocol will be applied more broadly in several more populations.	Researchers advanced and established RGA-rapid generation for climbing beans.	Extended	While partially met for bush beans, climbing beans represent a greater challenge as they are inherently late to flower and mature. Progress evidence: 2019 Report to government of Canada. The system has been tested as part of an undergraduate thesis. While functional, it is quite expensive and may not be practical.	https://hdl.handle.net/10568/107917

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6	Outcome 1: Livelihoods	Sub-IDO 1.3.2: Increased livelihood opportunities	A breeding population for early cooking time was developed using sources described in a recent publication with ABC breeding material. A bush breeding diversity panel was evaluated for cooking time (CKT) and well performing lines were used in the described crosses. This population is now to be sown in F3. A climbing bean panel has also been evaluated for CKT, in order to use the data in upcoming crosses. A publication on evaluations of CKT in 4 populations is being developed. ACIAR-Australia is funding a genomic selection project on cooking time.	Researchers developed and shared first crosses specifically for fast cooking time.	Extended	1. Research/ Science. Interpreted literally, the first crosses were indeed created, but have not yet been shared with partners. This is continuous process depending on demand of complementary traits e.g. disease / drought tolerance and consumers preference. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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6	Outcome 1: Livelihoods	Sub-IDO 1.3.2: Increased livelihood opportunities	Platforms focus on product profiles that have established consumer/ buyer demand. Business platforms have been established in the red mottled bean corridor in Uganda (with 2 lead firms), Tanzania, Rwanda (3 lead firms) and Burundi (1 lead firm). One platform was established in the yellow bean corridor in Tanzania in the Kagera region (1 lead firm). In Southern Tanzania, in the sugar bean corridor, another platform has been set up (1 lead firm). The Ethiopian platforms are established for the white pea bean corridor with a series of cooperatives and private sector off-takers.	Researchers developed four multi-stakeholder bean business platforms with partners using the corridor model to support trade.	Complete	2019 Report to government of Canada. We may not have included enough evidence in the report. However FP6 through PARBA adopted bean corridor approach see the additional evidence links.	https://hdl.handle.net/10568/107917 https://bit.ly/3iMqyCC https://bit.ly/3iDPfB6 https://bit.ly/2O39PNa

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 1: Livelihoods	Sub-IDO 1.3.2: Increased livelihood opportunities	One of the key areas supported by ABC is scaling up value added bean products via micro and small-scale entrepreneurs in a number of countries. Producer groups have also been trained within the framework of business platforms, where some of the training areas include collective production and marketing, management of finances, quality control and gender empowerment among others. In total, 1500 entrepreneurs were trained, about 30% women.	Capacity training completed with partners with 750 male and female entrepreneurs and farmers.	Complete	Evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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6	Outcome 1: Livelihoods	Sub-IDO 1.3.2: Increased livelihood opportunities	ABC supported small-scale entrepreneurs to develop six bean composite flour products in Burundi, Uganda, Rwanda, Tanzania, Kenya, Madagascar, Zambia, Malawi and Zimbabwe. The products are principally nutrient-dense porridges targeting children and women. CIAT supported studies in i) establishing willingness to consume and pay; ii) linking farmers to processors via bean platforms, iii) trainings with grain processors and bean off-takers on how to get certification from governments, iv) nutrient analysis of bean-based flours and v) supporting women entrepreneurs in value addition of bean products. These efforts will be scaled in several countries including Ghana, Cameroon, Lesotho and Eswatini.	Two bean-based products developed with partners through private sector engagement.	Complete	Evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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6	Outcome 3: Less yield losses	Sub-IDO 1.3.4: More efficient use of inputs	Some 123 Mesoamerican lines were developed in the drought tolerance breeding program with disease resistance and promising levels of Fe in red, black and yellow grain color classes. In the Andean program, 200 lines from a population developed for drought and BCMV resistance were evaluated in a drought and irrigated trial. Thirty-eight lines from a population developed for heat tolerance were evaluated in drought and irrigated conditions. Data needs to be analyzed to code new lines (~70) for multi-location testing.	Researchers developed 100 new lines with increased performance for abiotic and biotic stress tolerance.	Complete	Data for bean experimental lines selected for tolerance to drought, high temperatures, low P in the soil, high aluminum in the soil and high content of Fe / Zn in grain.	https://doi.org/10.7910/DVN/CDBHQW

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6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	An initial evaluation of wild *P. acutifolius* under a GCDT project revealed 2 accessions (G40287 and G40056) that could withstand night temperatures of 28°C and still produce seed. Families developed from these accessions were evaluated in the greenhouse under 25°C nights, with some 30 families presenting good pod formation. Further evaluation will support the search for QTL for heat tolerance. These lines complement other interspecific lines developed in previous years, of which the line SEF 16 emerged as the best in field trials on the north coast of Colombia.	Researchers confirmed ten heat-tolerant lines selected from interspecific populations.	Extended	1. Research/ Science. Delays in contracting a post doc required extension. This has been completed in a greensouse trial but COVID shut down has inhibited discussions with the student. Materials are in the field in two sites pending results. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 3: Less yield losses	IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	Greenhouse screening using breeding lines for ALS using aggressive strains identified MAB349 and MAB359 as promising resistant genotypes. Other genotypes such as NUA184, SMN184 and NXB080 showed acceptable levels of resistance.	Researchers confirmed resistance to root (Pythium) and foliar (ALS, web blight) pathogens derived from *P. coccineus* / *P. dumosus*.	Changed	4. Internal Resources. Personnel of the pathology section were over-stretched on other objectives. Data are now available to meet the goal for Pythium resistance., and a publication is in preparation. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	Resistance to BLCrV was identified in Mesoamerican lines; so a population was developed to backcross this trait into Andean germplasm. The population was advanced under disease pressure, evaluated in two seasons, and is now entering yield trials.	Researchers introgressed Mesoamerican genes to Andeans for disease and heat resistance.	Extended	1. Research/Science; 3. Partnership. Field phenotyping for virus resistance and for heat tolerance has been delayed, the latter by administrative steps in establishing a partnership. Crosses were made with a heat tolerants Mesoamerican line. The breeding process was developed under moderate conditions of heat. The total of 25 advanced lines were then tested under moderately severe heat conditions and at the moment we have seven lines of Andean type that can produce seed in the Caribbean coast where the nighttime temperatures exceed 22 degrees Celsius. In a second season a subsequent group with different commercial types (red mottled, red and pink) will be evaluated. For diseases, the Phg-2 gene for angular leaf spot resistance is being employed in the Andean gene pool. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	More than 70 families have been developed for heat tolerance. Several were evaluated under heat in the Caribia Research Station of AgroSavia, the Colombian national program. Other populations presented modest resistance to leafhoppers. Entomological studies demonstrate resistance or tolerance to leaf miners and white flies. Initial data on Fe concentration in some lines exhibit as much as 20 ppm above the baseline. These early results highlight the great value of tapping the tertiary gene pool.	Researchers developed new populations with *P. acutifolius* using bridging genotype.	Complete	CRP-GLDC FP6 Report 2019; 2019 Report to government of Canada. Populations were advanced and moved into phenotyping for tolerance to Empoasca kramerii leafhoppers and for heat tolerance.	https://hdl.handle.net/10568/107796 https://hdl.handle.net/10568/107917

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6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	This was adopted as a PhD research topic, and thus was not pursued within the program.	Researchers analyzed sequence of bridging genotype between tepary and common bean.	Changed	3. Partnership. A PhD student has included this in his dissertation research, leading us to leave this objective to him. Although we have supplied germplasm, we are not formally associated with the PhD project. Thus completion may be some years off. The student is about midway in his studies.	
6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	No new markers for BGMV have been tried this year. The MAGIC population needs to be evaluated for this trait in LAC, or the BASE needs to be re-evaluated in replicated trials.	Improved markers for BGYMV resistance availed, in collaboration with USDA.	Extended	1. Research/ Science. Data analysis is progressing but is complex. This is a true example of the challenges of BIG DATA. While progress was registered, this topic continues under investigation. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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6	Outcome 3: Less yield losses	IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	An R programme facilitates data processing from MSPQ tool for heat-related photosynthate transport, performing basic statistics, reflecting behavior under heat and identifying the best 10% genotypes. MPSQ seeks multidimensional evaluation of data to understand tolerance. Artificial intelligence to evaluate seed filling in scanning bleached bean pods is in final evaluation. We also verified that tolerant genotypes under heat elongate pods rapidly and consistently during pod elongation and later in seed-filling stage. An approach to evaluate abortion with and without heat shock is being developed in growth chambers.	Researchers characterized limits on photosynthate transport under heat.	Extended	Reason for extending: 1. Research/ Science. Data analysis is progressing but is complex. This is a true example of the challenges of BIG DATA. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	ABC research teams in Tanzania have shown that the use of micronutrients based fertilizers increase agricultural productivity by at least 25% across crops and geographies. Beyond phosphorus, research is needed on bean response to molybdenum, zinc, boron, manganese and copper.	One climate-smart and environmentally friendly pre-and post-harvest integrated crop management (ICM) practice developed and recommended to partners.	Extended	Reason for extending: 1. Research/ Science. ABC is pursuing collaboration with private companies such as OCP (Morocco), Toyota Kyushu (Kenya) to advance research on use of micronutrient fertilizer blends. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917
6	Outcome 3: Less yield losses	Sub-IDO 1.4.1: Reduce pre- and post-harvest losses, including those caused by climate change	11,885 tons produced in 7 countries. Increased utilization of quality seed of improved varieties. Reduced time between the release and use. Increased number of seed producers engaged and increased seed business volume. Increased linkages between seed and grain production.	9,000 tons of seed of climate-resilient bean varieties produced and disseminated by partners.	Complete	Evidence: 2019 Report to Government of Canada	https://hdl.handle.net/10568/107917

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FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 5: Nutrient-rich food	Sub-IDO 2.1.1: Increased availability of diverse nutrient-rich foods	Biofortified crops formed part of four strategies of Malawi's nutrition policy (see reported policies table 2). Outcomes: Increased number of seed companies producing biofortified seeds including high Fe and Zn beans. Biofortified crops form part of most of Malawi government's agriculture projects such as AFIKEPO, KULIMA and Adolescent Nutrition Sensitive Agriculture Project (ANSA).	Partners jointly developed two policy tools based on ABC research and made them widely available.	Complete	Development of the 2nd Uganda Nutrition Action Plan (2020-2025) - See table 2 policies.	https://hdl.handle.net/10568/107947

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6	Outcome 4: Enhanced genetic gain	Sub-IDO 1.4.3: Adoption of CGIAR materials with enhanced genetic gains	Marker assisted selection (MAS) is increasingly used in the breeding program. The Mesoamerican program in Cali evaluated 12,000 samples, principally for virus resistance genes (bc-3, bgm-1, I gene), and a small number for angular leaf spot resistance (gene Phg-2) and common blight resistance (SU91 SNP marker). The Andean program used ~6200 samples in 2019, markers for ALS, BCMV, lpa and bruchids, next to QC applications. In total about 200,000 data points generated.	Researchers and partners evaluated ~ 20,000 DNA samples at Intertek.	Complete	SNP genotyping results from Intertek Sweden outsourcing service. Genetic markers are associated with important genes for resistance. More than 20,000 leaf samples were sent a laboratory in Sweden to detect presence of absence of 5 resistance genes.	https://doi.org/10.7910/DVN/HMB1ZO

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6	Outcome 4: Enhanced genetic gain	Sub-IDO 1.4.3: Adoption of CGIAR materials with enhanced genetic gains	The nursery was shipped to Nicaragua, Honduras (2 sites), Guatemala and El Salvador with checks for Fe level and local adaptation.	Nurseries of 200 lines established with at least five partners for multi-site evaluation.	Extended	3. Partnership. In Honduras 46 were selected; and 50 in Nicaragua. Evaluations continue in Guatemala and El Salvador. Delays in planting and delays in data recovery from partners have not permitted compiling a complete report. COVID quaratine of the assistant who coordinates communication has further slowed the process in recent days in 2020. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 4: Enhanced genetic gain	Sub-IDO 1.4.3: Adoption of CGIAR materials with enhanced genetic gains	While the first evidence of successful gene editing was reported two years ago, this was a random event, and the methodology was far from consistent. Two years were dedicated to creating a system from which a significant number of gene editing candidates could be obtained. Plantlets can now be recovered routinely from callus culture with both roots and shoots. In particular, the rooting medium has been improved dramatically.	Researchers and partners established a gene editing system.	Extended	1. Research/ Science. Regeneration done. This is truly uncertain. It may simply not be achieved. The assistant who has worked on this has plans to leave for post-graduate study in September, and no work has been done in three months due to COVID. The importance of this topic makes it difficult to erase it from our workplans, but until we can plan more systematically, it is suspended. Progress evidence: 2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 5: Nutrient-rich food	Sub-IDO 2.1.1: Increased availability of diverse nutrient-rich foods	6,284 tons of seed produced in 8 countries. Increased investments from other partners as result of information. Good interest by private sector, especially small processors. Increased demand of grain translated into seed demand.	1000 tons of seed of new micro-nutrient bean varieties produced and disseminated by partners.	Complete	2019 Report to Government of Canada.	https://hdl.handle.net/10568/107917

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Table 5: Summary of status of Planned Outcomes and Milestones (Sphere of Influence-Control)							
FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	2019 Milestone	2019 Milestone status	Provide evidence for completed milestones *Max 50 words/ milestone*	Links to evidence
6	Outcome 5: Nutrient-rich food	Sub-IDO 2.1.1: Increased availability of diverse nutrient-rich foods	A number of varieties were released: 1 biofortified variety with moderate drought tolerance (line SMR 156) in Nicaragua; 10 varieties, 4 with >20 ppm Fe above the check in the Dominican Republic; 2 varieties - SCR26 = NAROBEAN6 and SCN11 = NAROBEAN7 with drought tolerance, early maturity (68-72 days), relatively high Fe (>70 ppm) and Zn (> 35 ppm) and tolerance to diseases in Uganda; 4 varieties – S CN11 (small black), NUA517 (large red mottled biofortified), SCR15 (small red) and RAZ42 (small white) with drought tolerance in Ethiopia; 3 varieties - AFR703 (red kidney) and 2 small white Canpsula (for baked beans industry); and SMC16 (biofortified) in Zimbabwe; 7 bean varieties - CIM-ALS-FeZn08-16-6 (Lusemfwa), CIM-CBB-FeZn08-30-2 (Luswishi), ZMPB-12-61-4 (Lui), SER 124 (Lusitu); Zorro (Lufubu), CIM-SUG05-01-02 (Machili) and MBC 33 (Maninga) in Zambia and NUA45 (Ferrina) in Mauritius.	Seven consumer-preferred bean varieties including biofortified, that are climate resilient and environmentally friendly developed and released by partners.	Complete	2019 Report to government of Canada. A number of varieties are about to be released in several countries but their multiplication is being fast tracked by partners. Two have been released in Uganda. See Page 9 of GAC report.	https://hdl.handle.net/10568/107917

Table 6: Numbers of peer-reviewed publications from current reporting period (Sphere of control)		
Type of peer-reviewed publications	**Number**	**Percent**
Open Access (non-ISI)	6	8%
Open Access (ISI)	54	68%
Non-Open Access (non-ISI)	2	2%
Non-Open Access (ISI)	18	22%
Total peer-reviewed publications	80	100%

Full list of publications available at: https://mel.cgiar.org/reporting/download/report_file_id/19002

Table 7: Participants in CapDev activities		
Number of trainees	**Total female**	**Total male**
In short-term programs facilitated by CRP	90,045	216,384
In long-term programs facilitated by CRP (All academic degrees including PhDs)	26	45
Only PhDs in long-term programs facilitated by CRP	16	32

Full list of capacity development activities available at: https://mel.cgiar.org/reporting/download/report_file_id/19085

Table 8: Key external partnerships			
Lead FP	**Brief description of partnership**	**List of key partners in partnership.**	**Main area of partnership** **dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify _____**
1	Collaborative planning and work on publication of special issue on farmer's aspirations	University of Cologne Future Rural Africa Research Group, University of Bonn	Other: Publication
1	Collaborative planning, project design and data collection work on youth transitions and opportunity structures with sociology departments of these universities, aligned to ongoing initiatives by partners in participating countries, together with 1 planned PhD student participation	Makerere University, Uganda Haramaya University, Ethiopia Sokoine University of Agriculture in Tanzania	Research, Capacity Development
1	Adoption and impacts of improved cowpea varieties in Nigeria which benefited from technical inputs from breeders and agronomists who were involved in the development and dissemination of improved varieties and agronomic practices	Institute of Agricultural Research (IAR), Nigeria	Research, Delivery
3	Develop research approaches on the control of pest and diseases	NARS in West African countries: Institut de l'Environnement et des Recherches Agricoles (INERA), Burkina Faso Institut Sénégalais de Recherches Agricoles (ISRA), Senegal	Research
3	Collaborative work on the framework for sustainable intensification and sustainability assessment	Wageningen University of Science (WUR) Swedish University of Agricultural Sciences (SLU)	Research, Policy
3	Systems modelling and capacity building through workshops	Commonwealth Scientific and Industrial Research Organization	Capacity Development

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Table 8: Key external partnerships			
Lead FP	**Brief description of partnership**	**List of key partners in partnership.**	**Main area of partnership** **dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify _____**
3	Joint work to contextualize research, capacitate stakeholders and partner with farmer communities	Institut de l'Environnement et des Recherches Agricoles (INERA), Burkina Faso Institut d'Economie Rurale (IER), Mali Institut National de la Recherche Agronomique du Niger (INRAN), Niger Indian Council of Agricultural Research (ICAR), India	Research, Capacity Development
3	CRP-GLDC resources and network leveraged W3/ Bilateral projects	Mahalanobis National Crop Forecast Centre, India	Research, Delivery
4	The Hybrid Parents Research Consortia meeting for sorghum, pearl millet and pigeonpea, with SA meeting successfully attended by 35 private sector organizations, and replicated in ESA for enhanced engagement with private seed companies and food industry	Advanta Seed Company Nielsen Seeds Around 30+ other private sector organizations	Delivery, Capacity Development
4	Partnership with private service providers e.g., for SNP genotyping and developing drone-based imaging indices for GLDC crops	Intertek HIPHEN (a start-up from INRA-Avignon)	Research
5	Access to cutting edge technologies, knowledge from industry for translating to crop improvement efforts e.g., developing rapid generation turnover methodologies in sorghum and pearl millet; training of students and researchers on different activities including quick crop transformation techniques and collaborative work on formulating and starting overall improvement of pearl millet	Corteva AgriScience	Research, Capacity Development

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Table 8: Key external partnerships			
Lead FP	**Brief description of partnership**	**List of key partners in partnership.**	**Main area of partnership** **dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify _____**
5	Heat screening trials conducted in collaboration with the private sector	Pioneer Hi-bred Pvt. Ltd. Bayer Crop Science Pvt. Ltd. Rallis India Limited	Research
5	Drought screening trials conducted in collaboration with public sector partner	Chaudhary Charan Singh Haryana Agricultural University	Research
5	Further strengthening of existing collaborative work with advanced research institutes (ARIs)	Rothamsted Research Cambridge University The National Institute of Animal Biotechnology (NIAB), India The Sainsbury Laboratory, UK	Research
6	Negotiations with KoLFACI, the agency of international cooperation of the Korean government for Latin America have taken place; they came on board as an important donor for 2020.	Korea-Latin America Food and Agriculture Cooperative Initiative (KoLFACI)	Other: Funding partnership
G&Y	The partnership contributes to the CRP-GLDC's insights on how to work with communities to generate a brand identity for quality seeds of improved varieties.	Centre for Behaviour Change and Communication	Research

Table 9: Internal Cross-CGIAR Collaborations		
Brief description of the collaboration	**Name(s) of collaborating CRP(s), Platform(s) or Center(s)**	**Optional: Value added, in a few words e.g. scientific or efficiency benefits**
Strong collaborative work with CRP-GLDC FP1 core implementing partner CGIAR Centers	International Crops Research Institute for the Semi-Arid Tropics; International Institute of Tropical Agriculture; International Center for Agricultural Research in the Dry Areas; World Agroforestry	Narrowing collaborative gaps and further strengthening them while exploring new areas to collaborate among CRP-GLDC FP1 implementing centers
Database updating of CRP-GLDC Flagship 1 research on IFPRI's International Model for the Policy Analysis of Agricultural Commodities and Trade (IMPACT) for foresight modelling and ex-ante analysis for priority setting; collaboration to enhance understanding of household situation and outlook and the implications for adoption as well as dietary and entrepreneurship entry points	CGIAR Research Program on Policy, Institutions and Markets	Well-rounded capacity development and integration of CRP-GLDC FP1 in the wider policy research community
Close collaboration while conducting CRP-GLDC FP1 initiatives	CGIAR Collaborative Platform for Gender Research	Improved integration and positioning of CRP-GLDC within the wider gender research community of the CGIAR
Involvement of gender scientists and breeders from CGIAR centers that have commodity breeding programs	The CGIAR Gender and Breeding Initiative	Improved integration of gender research perspectives in implementing crop breeding efforts with CRP-GLDC
Collaborative whole farm modelling work in West Africa using scenarios of access to quality of feed/ fodder to project livestock performance, market value and potential income for the farmer	CGIAR Research Program on Policy, Institutions and Markets	Utilization of CRP-GLDC materials/outputs e.g., quality feed as crop residues or cultivated fodder
Collaborative work on the framework for sustainable intensification and sustainability assessment (together with external partners)	International Crops Research Institute for the Semi-Arid Tropics; International Center for Agricultural Research in the Dry Areas	Strengthening the discussion and resulting framework and assessment materials with more participating CGIAR centers, apart from external partners
Collaborated capacity building through systems modelling workshop	International Crops Research Institute for the Semi-Arid Tropics	Capitalizing on the systems modelling expertise within ICRISAT
The Hybrid Parents Research Consortium (HPRC) pioneered by ICRISAT is a successful model to deliver hybrid GLDC crops, wherein parent material is accessed from the CGIAR by the private sector to develop hybrids.	International Crops Research Institute for the Semi-Arid Tropics	Further widen the reach of GLDC crops and relevant research products with this consortium led by ICRISAT

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Table 9: Internal Cross-CGIAR Collaborations

Brief description of the collaboration	Name(s) of collaborating CRP(s), Platform(s) or Center(s)	Optional: Value added, in a few words e.g. scientific or efficiency benefits
Training course conducted by CRP-GLDC FP4 to share new technologies and best practices in crop breeding to meet the knowledge gaps of 'Practicing Plant Breeders' and crafted to enhance operational efficiencies and rate of genetic gain per unit cost, with participants from 14 countries in Asia and Africa.	CGIAR Excellence in Breeding Platform; International Maize and Wheat Improvement Center (CIMMYT); International Center for Agricultural Research in the Dry Areas; International Center for Tropical Agriculture; World Agroforestry; International Institute of Tropical Agriculture; International Crops Research Institute for the Semi-Arid Tropics	High quality capacity development by drawing resource persons from these CGIAR Centers and a Platform
Collaborative work to improve the fodder value of crop residue, the single most important feed resource in most of the CRP-GLDC target countries, resulting in selection decisions based on fodder quality.	International Livestock Research Institute	Improved decision support for selection by capitalizing on ILRI's expertise
Collaborative development of tools to use drone-generated images to assist breeding.	CGIAR Excellence in Breeding Platform	Accelerate enhancement and precision of breeding through technologies and expertise hosted by EiB
Scientists involved in CRP-GLDC FP5 activities attended modular trainings to leverage their expertise in the development of product profiles, stages and gateways, genotyping/sequencing-related services, phenotyping and data management.	CGIAR Excellence in Breeding Platform	Enhanced capacities of CRP-GLDC FP5 affiliated scientists
Formulation and start of a new partnership along with external partners for the overall improvement of pearl millet.	International Crops Research Institute for the Semi-Arid Tropics	Capitalized on ICRISAT's technologies and expertise to expedite integrated improvement of pearl millet
CRP-GLDC gender researchers contributed to the re-designing of the GENDER platform, particularly on how gender equality impacts the agri-food systems in the drylands.	CGIAR GENDER Platform	Contributing CRP-GLDC relevant aspects to the theme on how gender equality impacts food systems as well as how food systems impact gender equality

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Table 9: Internal Cross-CGIAR Collaborations		
Brief description of the collaboration	**Name(s) of collaborating CRP(s), Platform(s) or Center(s)**	**Optional: Value added, in a few words e.g. scientific or efficiency benefits**
Building nutritious food baskets - sweet potato (CIP, beans (CIAT/PABRA), maize (IITA/CIMMYT) (ended in 2019)	CIP/CIMMYT/IITA/CIAT	Mulongo G, Maru J, Munyua H, Kasuga R, Olapeju P, Wende M, Rubyogo JC, and Gethi J. 2018. The Building Nutritious Food Baskets Project 'Insights from the Field'. International Potato Center (CIP), Lima, Peru. 48 pp. https://cgspace.cgiar.org/handle/10568/98539 Rubyogo JC, Lung'aho M, Ochieng J, Binagwa P, Mdachi M, Zakayo E, Shida N, Msaky J, Kadege E, Birachi B, Mutua M, Nyakundi F and Kalemera S. 2019. Consumer acceptance of and willingness to pay for high-iron beans in northern Tanzania. Nairobi (Kenya): International Center for Tropical Agriculture (CIAT); Tanzania Agricultural Research Institute (TARI). Arusha, Tanzania. 60 pp. https://hdl.handle.net/10568/105881
Tropical legumes III Project (funded by BMGF)	ICRISAT/ IITA/CIAT	Jean-Claude Rubyogo, Essegbemon Akpo, Lucky Omoigui, Gaur Pooran, Sushil Kumar Chaturvedi, Asnake Fikre, Desmae Haile, Ajeigbe Hakeem, Emmanuel Monyo, Stanley Nkalubo. 2019. Market-led options to scale up legume seeds in developing countries: Experiences from the Tropical Legumes Project. https://doi.org/10.1111/pbr.12732
Joint project AVISA project (funded by BMGF) https://www.avisaproject.org/	ICRISAT/ IITA/CIAT	Only in the first year it offered a good opportunity for integration for the three Centers and building on the publications mentioned for Tropical legume III Project. It is good to get PABRA seed systems commercialization and wider impact principles across to other legumes and small dryland cereals and CGIAR Centers working on these projects.
Project in DRC Congo (funded by WB but channeled through IITA) http://www.pabra-africa.org/	IITA/ HarvestPlus/CIAT	It is a good opportunity to bring the PABRA experience on commercialization of nutritious food together with the sustainability of bean seed systems which was a major challenge in HarvestPlus and combined with the great DRC Congo country expertise of HarvestPlus.

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Table 9: Internal Cross-CGIAR Collaborations		
Brief description of the collaboration	**Name(s) of collaborating CRP(s), Platform(s) or Center(s)**	**Optional: Value added, in a few words e.g. scientific or efficiency benefits**
Promotion of orange fleshed sweet potatoes originating from Peru	CIP	Valuable source of technologies for scaling work in Africa.
Collaboration on improving efficiency in M&E systems with improved workflows and processes. Improved Technical capacity	CRPs on Roots, Tubers and Bananas and FISH; CIP, IITA, WorldFish, ICRAF, ICRISAT, ICARDA	Operational efficiency, harmonization of information management.
Team building across data/knowledge managers and tool developers in partnership with CGIAR Operation Supporting Unit (OSU): https://hdl.handle.net/20.500.11766.1/09a519	CRPs on Livestock, Roots, Tubers and Bananas and FISH; ILRI, CIP, IITA, WorldFish, ICRAF, ICRISAT, ICARDA, OSU	Increased capacity to cope with unplanned requests/ volatile environment.
The relationship was formalised with ILRI entering into a 'Program Participant Agreement' with ICRISAT. In 2019, US$ 80,000 was received from CRP-GLDC towards the development of dual-purpose crops.	GLDC, ILRI	Scientific benefits, advancing the development of new dual-purpose crop varieties.

Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Adoption and impacts of improved cowpea varieties in Nigeria (IITA)	Complete	EPIA: Ex-post Impact Assessment	This study assessed the ex-post impacts of improved cowpea varieties on yields, incomes and poverty in Nigeria. A paper on the yield and income effects of improved cowpea has been published in the Journal of Agricultural Economics and another paper on the poverty impacts of improved cowpea has been published in World Development.	https://doi.org/10.1111/1477-9552.12331; https://doi.org/10.1016/j.worlddev.2019.05.027
Adoption and impacts of improved soybean varieties and agronomic practices in Malawi (IITA)	Complete	EPIA: Ex-post Impact Assessment	This study assessed the ex-post impacts of improved soybean varieties on yields and incomes in Malawi and the results have been published in World Development. Further data analysis will be carried out and a paper will be prepared and published in 2020 on the poverty impacts of improved soybean varieties and agronomic practices in Malawi.	https://doi.org/10.1016/j.worlddev.2019.104631
Impact Assessment of N2Africa project	Cancelled	EPIA: Ex-post Impact Assessment (at scale)	The N2Africa project ended in 2018 and the staff are no longer pursuing the impact study.	N/A
Analysis of advantages and disadvantages of rice fallow vs rice legumes (ICARDA)	Extended	Effectiveness study (development project- level adoption and impact studies)	The study aims to provide credible estimates of livelihood and agro-ecological impacts of the adoption of improved lentil varieties of ICARDA origin, developed to fit in the short fallow season between two rice crops in South Asia. Using DNA fingerprinting, a SPIA-funded study (Yigezu et al. 2019) estimated the adoption of these varieties at 99% in Bangladesh.	N/A (Progress: https://doi.org/10.1016/j.foodpol.2018.11.004)

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Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Adoption and impacts of groundnuts in Tanzania and Nigeria (ICRISAT)	Extended	EPIA: Ex-post Impact Assessment (at scale)	The research carried out under ICRISAT'S Tropical Legumes III project (TL III) with NARS in Tanzania and Uganda, computed the impact of adoption, while accounting for possible errors from access to technology transfer and improved seed.	https://doi.org/10.4236/as.2020.112009
Adoption and impacts of chickpea in Ethiopia (ICRISAT)	Extended	Other MELIA activity: Ex-post Impact Assessment – at national level	The research carried out under ICRISAT'S Tropical Legumes III project (TL III), with the Ethiopian Institute of Agricultural Research, computed the impact of adoption, while accounting for possible errors from access to technology transfer and improved seed.	N/A (Progress: http://dx.doi.org/10.1016/j.foodpol.2016.11.007)
DryDev five-country impact assessment (ICRAF)	Extended	EPIA: Ex-post Impact Assessment (at scale)	This study is quasi-experimental looking at difference-in-differences design of a large-scale rural development program that scaled some GLDC crop varieties, as well as other management practices. This is an impact assessment of the Drylands Development Programme, which was partially mapped to GLDC, as it promoted some GLDC crops and management practices. The impact assessment was huge effort and is currently being finalized.	N/A
What do we really know about the impacts of improved grain legumes and dryland cereals: A critical review of 18 impact studies (ICRAF)	Extended	Synthesis: Reviews, systematic reviews, evidence gap maps	Improved grain legume and dryland cereal (GLDC) varieties hold potential to intensify smallholder agriculture and improve livelihoods in semi-arid regions of sub-Saharan Africa and South Asia. To assess the empirical evidence base for these potential benefits, we review 18 GLDC impact studies and identify gaps in current knowledge on GLDC impacts.	N/A (Progress: http://dx.doi.org/10.5716/WP19006.PDF)

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Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Review of scaling approaches applied in GLDC scaling projects: Tropical Legumes III, Harnessing Opportunities for Productivity Enhancement 2, Feed the Future initiatives and DryDev (ICRAF)	Extended	Synthesis: Reviews, systematic reviews, evidence gap maps	Key GLDC scaling projects are reviewed against an idealized scaling framework implied in GLDC's proposal. Recommendations to enhance GLDC's contribution to transforming agri-food systems are presented.	N/A (Progress: https://hdl.handle.net/20.500.11766/11029)
Assess the potential nutrition security impacts of GLDC technologies in the drylands of SSA and South Asia	Completed	Ex-ante, baseline and/or foresight study	This study aims to quantify the ex-ante impact of GLDC technologies on nutrition security in the drylands of South Asia and sub-Saharan Africa. A research report has been developed for 2019. The plan is to have one to two peer-reviewed journal articles in 2020 which would tackle the multi-dimensional (social welfare, poverty and nutrition security) impact of GLDC technologies.	https://hdl.handle.net/20.500.11766/10874
Integrated and multi-faceted impact assessment and learning strategy for GLDC	Extended	EPIA: Ex-post Impact Assessment	Strategy to broadly estimate the impacts of GLDC vis-à-vis the CGIAR's Strategic Results Framework (SRF) targets. Three key components for 2020: mapping extent of adoption of GLDC technologies; estimating likely resulting impacts on nutrition via systematic review and estimating likely natural resource management impacts via systematic review.	N/A (Progress: https://hdl.handle.net/20.500.11766/10867)

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Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Sustainability assessment of smallholder´s farming system: Assessment of the impacts of sustainable intensification options	Extended	EPIA: Ex-post Impact Assessment	Comprehensive framework for sustainability assessment. A comprehensive framework for farming systems sustainability assessment with 5 domains and 115 indicators in SA and SSA was developed and the same was implemented and validated in one location in India (Nalgonda) for different functional farm types. Good progress was made in developing an online open access tool for farming system sustainability assessment, which will be a global public good.	N/A (Progress: https://doi.org/10.1016/j.landusepol.2019.104149) https://bscmsc.pps.wur.nl/assessment-potential-future-sustain-ability-smallholder-farming-old-cotton-basin-mali) https://hdl.handle.net/20.500.11766/11153 https://hdl.handle.net/20.500.11766/11154 The framework has been shared with the stakeholders and NARS. However, the major output is yet to be published.
Identify a common set of performance indicators that all projects can report on at the CRP level beyond the CGIAR ones	Extended	CRP-level performance indicator standardization	The activity has been extended to 2020 to complete the formulation of indicators reference sheets and validate the applicability at portfolio level including all source of funding.	N/A
Capacity development and Joint learning exercises	Completed	Collaborated capacity enhancement	In 2019, CRPs on FISH, LIVESTOCK, GLDC and RTB organized the 1st technical retreat for MEL developers. The main objective was to strengthen team building and have an overview of a fit-for-purpose data architecture across the CGIAR. In this light, the collaboration with the OCS (OSU) team supported the effort to link corporate and research data.	https://hdl.handle.net/20.500.11766.1/09a519

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Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Ensure real-time data visualization based on conceptualized indicator framework: CGIAR Level Agricultural Results Interoperable System Architecture (CLARISA)	Extended	Indicator-based information visualization	The initial phase, carried out in 2019, has achieved the development and implementation of a mutual visualization dashboard, CLARISA. However, the need for a further integration around CGIAR AR Indicators, for a better disaggregation of data, and new requirements, led the MEL-MARLO team to continue in 2020 the activities for an increased synergy of systems under the guidance of SMO team and in partnership with GLDC, FISH and RTB CRPs.	N/A (Progress: https://www.cgiar.org/impact/results-dashboard/)
Tropical Legumes III Project	Completed	Ex-post adoption study	**Tanzania** - Assessing the impact of the Tropical Legumes II & III projects on common bean productivity, profitability and marketed surplus in Southern Highlands of Tanzania.	https://cgspace.cgiar.org/handle/10568/105989

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Table 10: Monitoring, Evaluation, Learning and Impact Assessment (MELIA)				
Studies/learning exercises planned for this year *(from POWB)*	**Status**	**Type of study or activity**	**Description of activity/study**	**Please include any links to MELIA publications here.**
Pan-Africa Bean Research Alliance	Completed	EPIA: Ex-post Impact assessment	Climbing bean is evidenced in Rwanda as a solution to increase productivity in land-constrained environments. The effect of climbing bean adoption on the welfare of smallholder common bean growers in food security in Rwanda has been established.	DOI: 10.1177/0030727018813698. https://doi.org/10.1007/s12571-017-0753-4

Table 11: Update on Actions Taken in Response to Relevant Evaluations							
Name of the evaluation (this may be for example IEA, CCEEs and Others - both CRP-specific and cross-cutting)	**Recommendation number (from evaluation) (accepted recommendations only)**	**Text of recommendation (can be shortened)**	**Status of response to this recommendation Dropdown: Completed/ Ongoing**	**Concrete actions taken for this recommendation. (one row per action)**	**By whom (per action)**	**When (per action)**	**Link to evidence**
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 12: Examples of W1/2 use in this reporting period (2019)	
Please give specific examples, one per row (including through set aside strategic research funds or partner funds)	**Select broad area of use of W1/2 from the categories below - (drop down) Select only one category.**
Strategic ex-ante nutrition impact evaluation was undertaken to identify the GLDC research options with the greatest potential for enhancing nutrition security	Research
Developing future climate scenarios data for GLDC mega environments for Asia and SSA	Research
Making aspirations work for targeting and scaling agricultural innovations	Research
Assessment of the potential impact of GLDC crops on urban food and nutrition security	Research
Characterization of the youth in the drylands of Tanzania, Uganda and Ethiopia	Research
Integrated and multi-faceted impact assessment and learning strategy for GLDC	Research
Crop Network Groups were established for sorghum and millets, soybean, groundnut and cowpea in Africa, represented by NARS, CGIAR, Advance Research Institutes, Feed the Future Innovation Labs, NGOs, private seed sector, processing industries, etc. It is a platform for product design, development, testing, advancement and delivery. The platform enhances engagement with small and medium private seed companies and enables end-use driven seed systems like the sorghum brewing industry in Kenya and high oleic groundnut varieties in India. The annual engagement meets continuous capacity building needs.	Partnerships
Speed breeding: To enhance the rate of genetic gain by increasing the number of crop breeding cycles per year, speed breeding technologies were deployed in lentil, chickpea and groundnut. In groundnut, under low-cost semi-controlled conditions, 3.5 cycles per year are routinely taken, while controlled conditions in chickpea and lentil resulted in 6 cycles per year.	Research
Host resistance or tolerance to diseases and pests: Improved genetics for resistance or tolerance to diseases and pests reduces input cost and contributes to environmental sustainability as fungicide/pesticide molecules are released into the production system. Commercialized GLDC crop cultivars possess host resistance and tolerance. For example, pigeonpea cultivars with red pods confer tolerance to pod borers in Kenya and groundnut cultivars in India and chickpea cultivars in India and Ethiopia confer Fusarium resistance.	Research
GLDC cultivars to meet industry needs and drive new employment opportunities: The high oleic groundnut varieties commercialized in 2019 in India with enhanced shelf life and consumer health benefits are preferred by the industry, and the machine-harvestable chickpea varieties create new employment opportunities to the youth and also result in area expansion that is constrained by the non-availability of human labor for harvesting.	Research
Drone-based imaging tools for phenotyping: In partnership with HIPHEN, a start-up from INRA-Avignon that mostly assists breeding companies in the generation of indices for breeding plots and EiB, FP4 is developing indices for GLDC crops to use drone-based imaging technologies for crop phenotyping to guide breeding decisions. The tools are expected to optimize resources for phenotyping.	Other: Modernizing crop breeding operations
Value-added traits of grain and fodder: While yield remains the basic trait of interest, other value-added traits include nutrition security and support to crop-livestock system, the predominant system in the semi-arid tropics. In this direction, GLDC cultivars with value-added traits have been commercialized: (a) three biofortified pearl millet hybrids released in different zones of India, and (b) multi-cut forage sorghum to support crop-livestock production systems. In partnership with ILRI, fodder quality testing for advancement decision has been streamlined in the breeding pipeline of GLDC crops, and fodder quality parameters of over 10,000 samples of GLDC crops were assessed during 2019 for advancement decisions.	Research

Table 13: CRP Financial Report

Amount in US$

	Planned budget 2019			Actual expenditure 2019*			Difference			Comments
	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	
FP1	1,002,448	12,057,304	13,059,752	979,116	9,082,129	10,061,245	23,332	2,975,175	2,998,507	
FP2	-	2,716,000	2,716,000	-	1,764,898	1,764,898	-	951,102	951,102	
FP3	1,883,300	16,116,565	17,999,865	1,716,510	12,000,919	13,717,429	166,790	4,115,645	4,282,435	
FP4	2,890,047	22,913,240	25,803,286	2,763,409	19,383,431	22,146,840	126,637	3,529,809	3,656,447	
FP5	1,326,917	8,445,528	9,772,445	1,305,321	7,245,171	8,550,492	21,596	1,200,357	1,221,953	
FP6	1,633,333	13,109,514	14,742,847	1,633,333	7,731,796	9,365,129	-	5,377,718	5,377,718	
Pass through cost for management of FP6	81,666	-	81,666	81,666	-	81,666	-	-	-	5% pass through cost charged by ICRISAT for the management of FP6 grant
Strategic Competitive Research Grant	512,000	-	512,000	455,000	-	455,000	57,000	-	57,000	
CRP Management and Support Cost	678,289	-	678,289	459,523	-	459,523	218,766	-	218,766	
Total CRP-GLDC	10,008,000	75,358,151	85,366,150	9,393,878	57,208,344	66,602,222	614,121*	18,149,806	18,763,928	

Note: The difference in W1/W2 of US$ 614,121* will be carried forward to 2020 and the same has already been approved by the Director, CRP-GLDC for the implementation of ongoing activities of 2019 on the request of CRP-GLDC participating centers.

Part C: Additional evidences are accessible through Management Information system and relevant links are provided in the report.

CRP-GLDC MIS System (*mel.cgiar.org*) allowed to report data all year around as soon as information was available across research teams. CRP-GLDC PMU presents here some of the charts that allowed its members to have a sense of the progress made by the program in target countries.

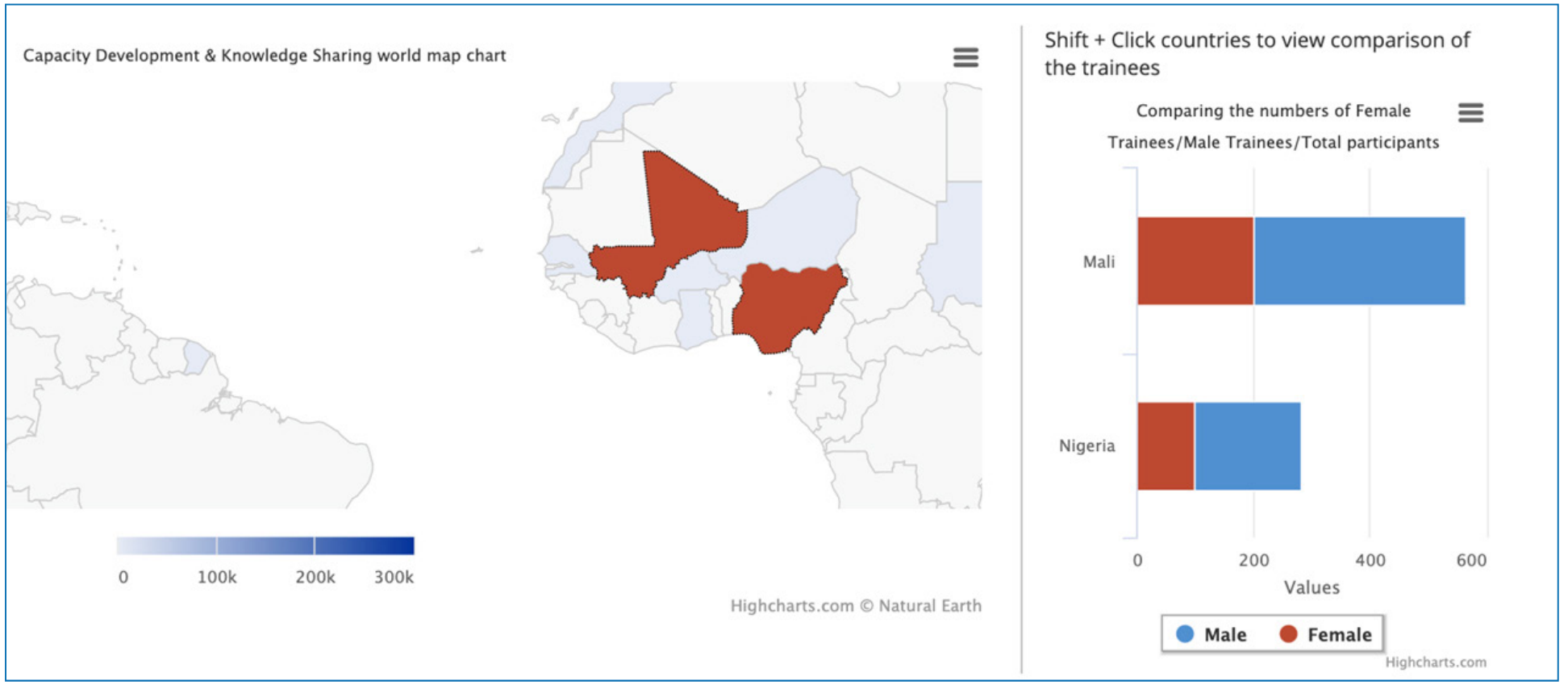

Figure 1: Capacity development initiatives by countries helped to gain a clear understanding of how to support field teams in delivery and communication during the year.

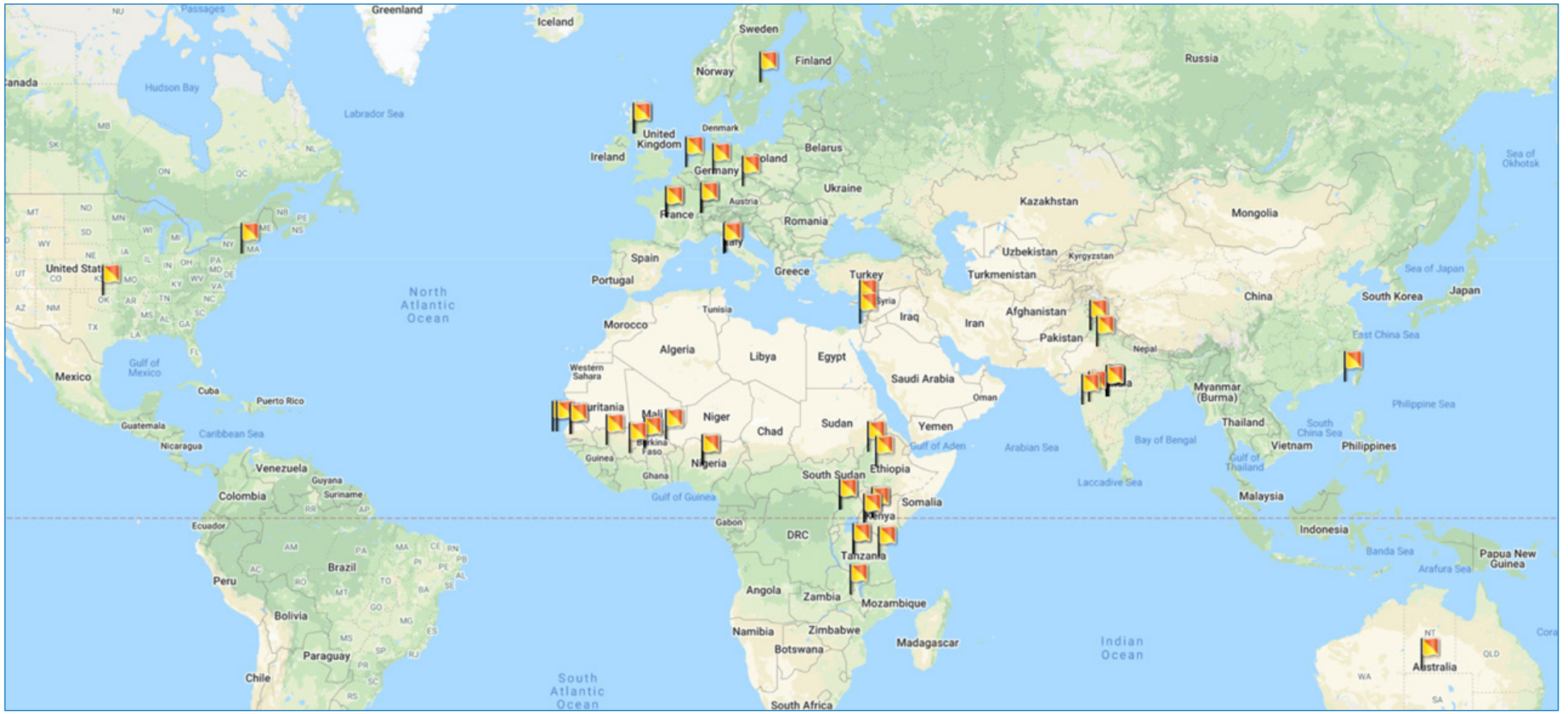

Figure 2: Delivery of results starts from partnerships. The CRP brought together partners from Europe, US and Australia to work together with partners on the ground. The dialogue with partners was an important cross-cutting activity for CRP-GLDC research teams.

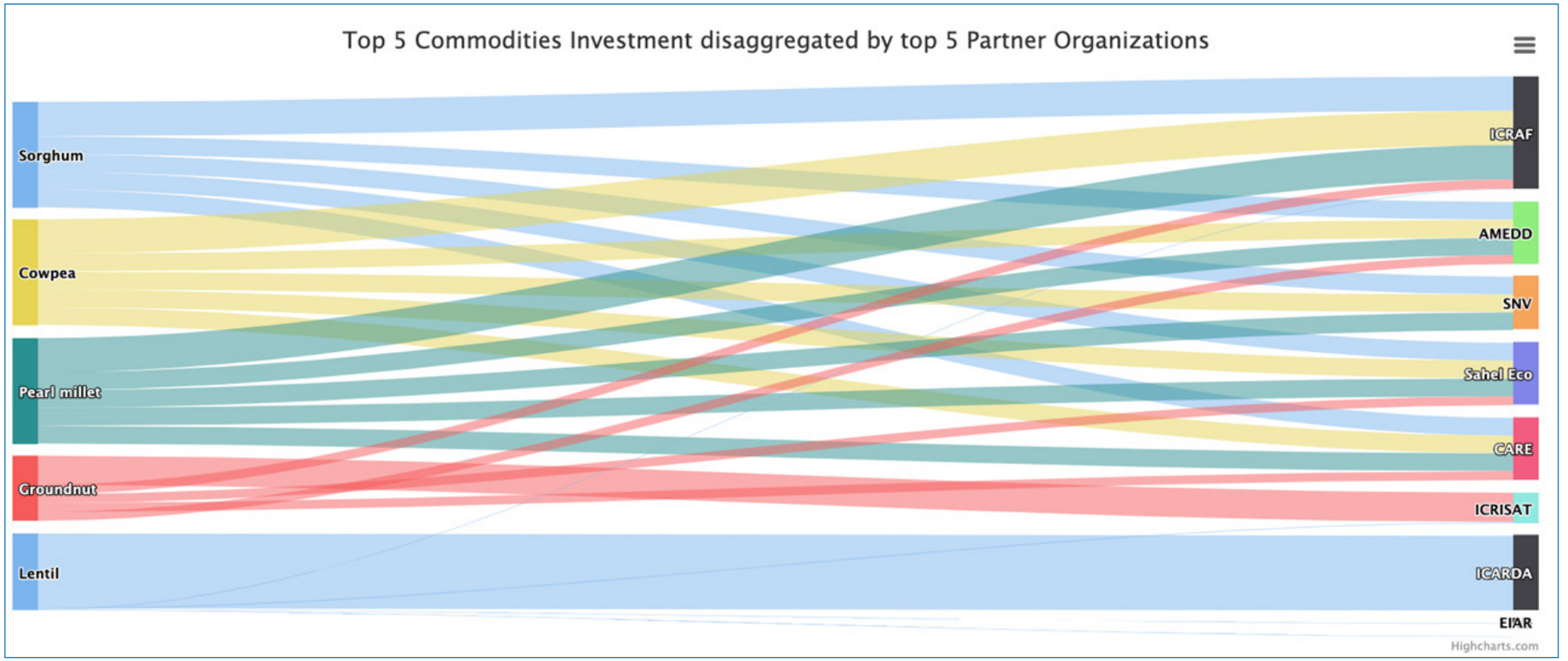

Figure 3: CRP-GLDC's multi-crop approach helped to strengthen partnerships and solve common problems together.

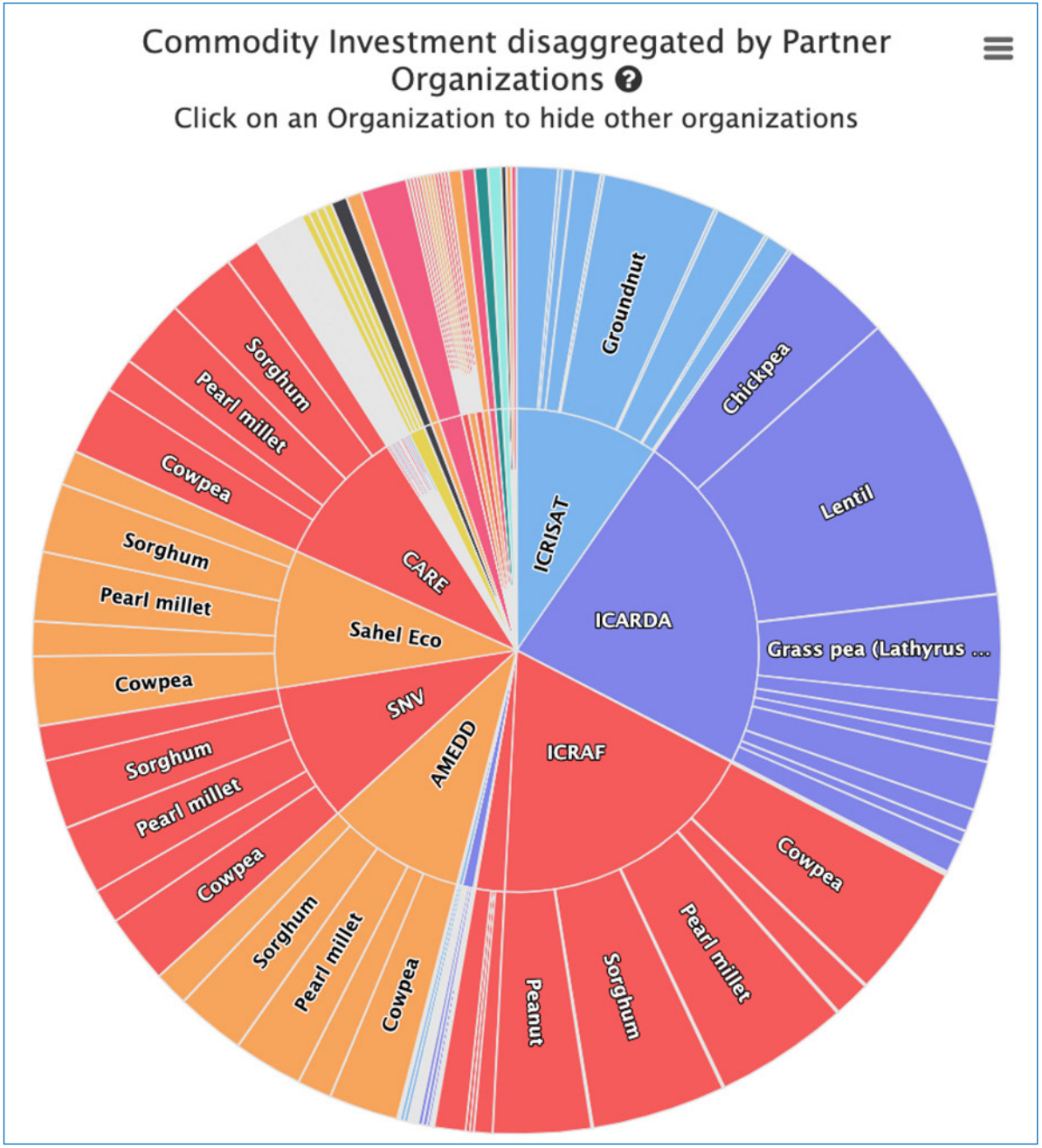

Figure 4: CRP-GLDC partners increase common knowledge on key crops and complete a multi-disciplinary approach.

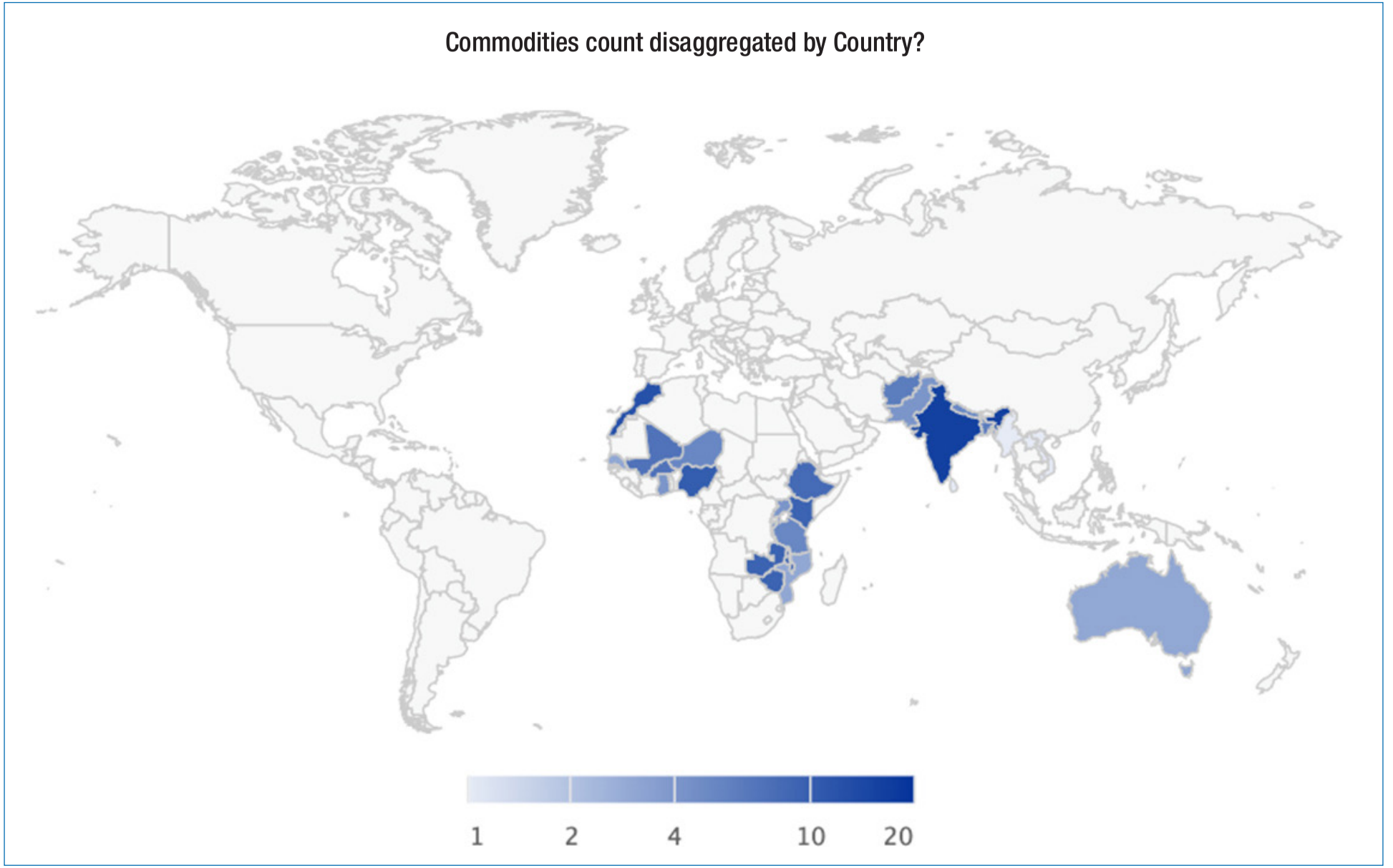

Figure 5: CRP-GLDC delivers international public goods that address the needs of target countries and support others with similar conditions.

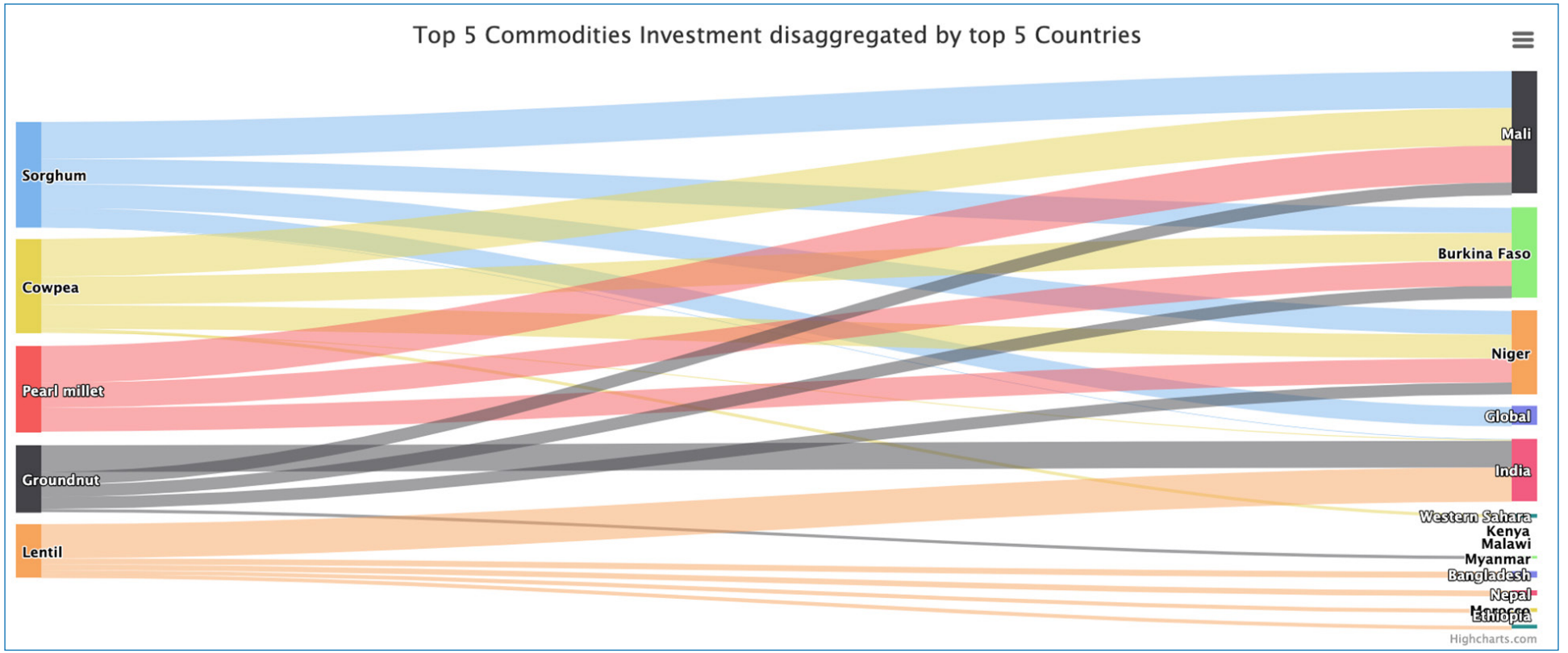

Figure 6: CRP-GLDC focuses on integrated systems and country needs with multiple solutions for our crop portfolio.

RESEARCH PROGRAM ON
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