

CRP-GLDC

Annual Report 2021

How Did We Do

Transform Agri-Food Systems



RESEARCH
PROGRAM ON
Grain Legumes and
Dryland Cereals



Alliance



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 the International Center for Tropical Agriculture (CIAT). 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), France and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, and various Non-Governmental Organizations (NGOs), national agricultural research systems (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 the mission of improving rural livelihoods and nutrition by prioritizing demand-driven innovations 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 have been captured in the cross-cutting theme: Markets and Partnerships in Agri-business (MPAB).*

Contact us:

Kiran K Sharma

Director, CGIAR Research Program on Grain Legumes and Dryland Cereals

Tel (O) +91 84556 83300

Mobile +91 98495 48540

E-mail: k.sharma@cgiar.org

Skype: kksarmai

For more information: <http://gldc.cgiar.org>

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Abbreviations and Acronyms

AB	Agrobacterium
ABI	Accelerated Breeding Initiative
AB-QTL	Advanced Backcross-Quantitative trait loci
AICRP	All India Coordinated Research Project
ANR	Agence Nationale De La Recherche (French National Research Agency)
APSIM	Agricultural Production Systems sIMulator
ARC	Agricultural-Research-Center, Egypt
ATCC	American Type Culture Collection
AVCD	Accelerated Value Chain Development
AVISA	Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa
AVT	Advanced Variety Trial
BBC	British Broadcasting Company
BMS	Breeding Management System
BNI	Biological Nitrification Inhibition
CAMCOCA	Cameroon, Congo, Central Africa Republic (Bean corridor)
CGIAR (or CG)	Consultative Group for International Agricultural Research
CHIBAS	Foundation Centre Haïtien d'Innovation sur les Biotechnologies et l'Agriculture Soutenable, Haiti
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture, Colombia)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (The French Agricultural Research Centre for International Development)
CIT	Cowpea International Trial
CLARISA	CGIAR Level Agricultural Results Interoperable System Architecture
COVID-19	Coronavirus disease-19
CRISP	Centre for Research on Innovation and Science Policy, India
CRP	CGIAR Research Program
CRP-GLDC	CGIAR Research Program on Grain Legumes and Dryland Cereals
CSA	Climate-Smart Agriculture
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CT	Computed Tomography
DArT	Diversity Arrays Technology
DM	Downy Mildew
DNA	Deoxyribonucleic Acid
DR & SS	Department of Research and Special Services, Zimbabwe
DRC	Democratic Republic of the Congo
DSSAT	Decision Support System for Agrotechnology Transfer
EAREM	East Africa Red Mottled (Bean corridor)
ELS	Early Leaf Spot disease
FAW	Fall Army Worm
FG	Farmer Group
FP	Flagship Program

GHG	Greenhouse gas(es)
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GLDC	Grain Legumes and Dryland Cereals
GOBii	Genomics Open-source Breeding informatics initiative
GS	Genomic Selection
GWAS	Genome-Wide Association Studies
HIB	High-Iron Beans
HPRC	Hybrid Parent Research Consortium
IAC	Independent Advisory Committee
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agriculture Research in the Dry Areas
ICRAF	International Council for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communications Technology(ies)
IDR	Institute for Rural Development (University of Nazi Boni)
IET	Initial Evaluation Trial
IFPRI	International Food Policy Research Institute
IIPR	Indian Institute for Pulses Research
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Institut de l'Environnement et de Recherches Agricoles (Environmental Institute for Agricultural Research, Burkina Faso)
INRAN	Institut National de la Recherche Agronomique du Niger
IRD	Institut de Recherche pour le Développement (The Research Institute for Development, France)
ISI	Institute for Scientific Information
ISRA	Institut Sénégalais de Recherches Agricoles (Senegalese Institute of Agricultural Research)
JIRCAS	Japan International Research Center for Agricultural Sciences
KASP	Kompetitive allele specific PCR
LDSF	Land Degradation Surveillance Framework
LLS	Late Leaf Spot disease
LMS	Learning Management Systems
MABC	Marker-Assisted Backcrossing
MARLO	Managing Agricultural Research for Learning and Outcomes (platform)
MCT	MultiCrop Thresher
MEL	Monitoring, Evaluation and Learning Online Platform
MELIA	Monitoring, Evaluation, Learning, and Impact assessment (study/ies)
MET	Multi-Environment Testing
MFN	MasterCard Farmer Network
MIT	Massachusetts Institute of Technology
MPAB	Markets and Partnerships in Agri-business
MSc	Master of Science
MSU	Michigan State University
NARES	National Agricultural Research and Extension System
NARS	National Agricultural Research System

NECS	Nutrition Education and Communication Technology
NIL	Near Isogenic Lines
NIRS	Near Infrared Spectroscopy
NM-AIST	Nelson Mandela African Institution of Science and Technology
NRM	Natural Resource Management
OICR	Outcome and Impact Case Reports
PABRA	Pan-Africa Bean Research Alliance
PGP	Plant Growth Promoters
PhD	Doctor of Philosophy
PIL	Peanut Innovation Lab
PIM	Policies, Institutions, and Markets (CGIAR Research Program)
PVS	Participatory Variety Selection
PVT	Preliminary Variety Trial
QC	Quality Check
QDS	Quality Declared Seed
RAB	Rwanda Agricultural Board
RGA	Rapid Generation Advancement
RGT	Rapid Generation Technology
RIL	Recombinant Inbred Lines
RNA	Ribonucleic Acid
RTB	Roots, Tubers, and Bananas (CGIAR Research Program)
SA	South Asia
SI	Sustainable Intensification
SIL	Soybean Innovation Lab (University of Illinois, USA)
SLO	System-Level Outcome
SMD	Sterility Mosaic Disease
SNP	Single Nucleotide Polymorphism
SNV	SNV Netherlands Development Organisation
SSA	Sub-Saharan Africa
SWC	Soil-Water Conservation
TARI	Tanzania Agricultural Research Institute
TAZAMA	Tanzania, Zambia, Malawi (Bean corridor)
TOGHABU	Togo, Ghana, Burkina Faso (Bean corridor)
TOPSIS	Technique for Order Performance by Similarity to Ideal Solution
TPP	Target Product Profiles
UK	United Kingdom of Great Britain and Northern Ireland (Britain)
UNDP	United Nations Development Programme
US (or USA)	United States of America
USAID	United States Agency for International Development
WCA	West and Central Africa
WECABREN	West and Central Africa Bean Research Network
WUR	Wageningen University & Research, Netherlands
ZEF	Zentrum für Entwicklungsforschung (Center for Development Research, Germany)

EXECUTIVE SUMMARY

FP1: Priority setting identified promising GLDC options based on their potential for economic, poverty reduction, and nutrition impacts for prioritization of important end-user preferred breeding traits. Work on rural aspirations focusing on the drivers of technology adoption led to five publications in a [special issue. Adoption and impact studies](#) provided evidence of progress towards SLO targets. A study in Malawi highlighted the importance of adoption of improved soybean varieties and agronomic practices leading to a 4.16 percentage-point reduction in poverty ([Tufa et al. 2021](#)).

FP3: Biotic and abiotic stresses were addressed through surveillance, greenhouse and field testing for reduced agro-chemicals, bio-agents or their combinations, crop genotypes, and nutrient deficiency. Packages of inputs and diversified crop combinations including intercropping cereals-legume and doubled-up legume system capitalizing on synergies between and among crops and systems were developed. Co-designed frameworks/tools for household typologies, [whole farm system model](#) for decision support, and [farming systems sustainability assessment framework](#) were tested and validated for resilient rural livelihoods in SA and SSA.

FP4: Public and private sector partnerships resulted in delivery of improved seed in target countries. For six GLDC crops in Africa and Asia, 59 market segments were identified for Target Product Profiles. The Hybrid Parent Research Consortia and Crop Network Groups played a pivotal role in stakeholder engagement in Asia and Africa. GLDC crops with traits for nutritional security, climate resilience, ability to drive new value chains, employment opportunities among youth and women, and environmental sustainability were developed. ICRISAT was awarded the 2021 Africa Food Prize for improving food security across 13 countries in SSA during 2007-19, thereby helping over 25 million smallholder farmers become more resilient to climate change.

FP5: Pre-bred genotypes of cowpea, pearl millet, finger millet and pigeonpea were developed and integrated into breeding programs. While quality control markers were developed and validated in sorghum, cowpea, finger millet, pigeonpea and chickpea, trait markers were developed and validated in finger millet, groundnut, chickpea and pigeonpea. A sorghum TILLING population was used to identify and validate candidate genes for Striga resistance. A sensor-based high throughput phenotyping platform was established at ICRISAT for research on climate change and plant protection.

FP6: Over 6,719 entrepreneurs (including 3,141 women) benefitted from trainings in finance and credit management, digital transaction, marketing, seed business, and management of cooperatives. Use of ICT improved from 7% to 62%, comprising of at least 70% youth and women. Twelve nutrition strategies developed by 31 partners resulted in 94 products across seven bean corridors since 2017. High-yielding bean varieties (27) with farmer and market preferred traits including high iron and zinc (8) and multiple disease resistance (19) were released. While 758 change agents (456 women, 68 youth) were engaged in EAREM and TAZAMA corridors, addition of 35 new enterprises resulted in a total of 156 (22% were women-led or -owned). Private companies in eight PABRA member countries produced 10,296 ton of certified and Quality Declared Seed. From the projected target of 123% for seed production, women-managed enterprises (22%) contributed to about 12% of production.

Part A: NARRATIVE SECTION

1. Key Results

1.1. Highlight Global Progress and Achievements

Improved GLDC crops are cultivated on over 15.37 M ha by 17.64 M households in 13 priority countries ([Woldeyohanes et al. 2021](#)). Adoption of improved soybean varieties and agronomic practices in Malawi led to a 4.16 percentage-point reduction in poverty, thereby translating to over 150,000 people lifted out of poverty ([Tufa et al. \(2021\)](#)).

The ability of parasitoid *Liragathis javana* to survive harsh conditions led to its large-scale release in Burkina Faso, Niger, and Nigeria. Cropping systems based on maize, sorghum, or millet with grain legumes in combination with planting densities developed. Agroforestry systems involving *Faidherbia albida* trees, rotation sequences including maize following soybean or cowpea and vice versa and doubled-up legume systems that capitalize on the synergies between and among crops and systems were also considered.

Over 21.9 M farm households adopted improved GLDC varieties, exceeding the target for 2022 by about 13 M. Commercialization of biofortified cultivars of sorghum, pearl millet, lentil, and groundnut during 2018-2020 was driven by a positive response from the public and private sector stakeholders. To enhance rate of genetic gain, RGA in chickpea and lentils, and MAS in breeding pipelines of groundnut, soybean, chickpea, pearl millet and cowpea were deployed.

An interspecific recombinant inbred between *Cicer arietinum* with *C. reticulatum* developed for resistance to *Helicoverpa armigera* and genotyped by high-throughput AxiomCicerSNP array resulted in nine main-effect QTLs showing 42.49% phenotypic variance. QC markers developed in most crops, besides deploying GWAS for discovery of novel QTLs; cowpea (drought and Striga resistance), pearl millet (root traits, blast and micronutrient content), chickpea (nutrition), groundnut (aflatoxin), sorghum (Striga and agronomic traits), and pigeonpea and finger millet (blast and Striga). Flapjack-MABC and Galaxy-GS pipelines were optimized for all crops, while Timescope and HaploTool were deployed for tetraploids.

A policy tool on scaling up of bean processing in Kenya, a policy brief on constraints women participation in national and regional export trade, and a nutrition strategy on enhancing bean and bean-based product consumption [across five bean corridors](#) were developed. The targets of 27 bean-based products and 80 promotional materials were achieved in [six corridors](#). Climate information tools (25) for access to climate-related information in 14 countries, 15 ICM technologies, innovations, management practices, and 35 climate-smart pre-and post-harvest practices were developed and promoted across the bean corridors. Thirty-five new enterprises across the countries (22% women-led or owned), resulted in the 121 total seed enterprises engagement (22% women-led or owned).

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

1.2.1. Overall CRP progress

FP1: The impacts of GLDC research were enhanced by improved gender-sensitive targeting and priority-setting through ex-ante impact evaluations as well as adoption and impact studies. Multicriteria priority setting resulted in the identification of the promising GLDC research and technology options based on their potential economic, poverty reduction, and nutrition impacts. Prioritization of varietal attributes and gender-responsive product profiles are being used to define and target important end-user preferred traits for GLDC crops. Work on rural aspirations as the drivers of technology adoption aimed at targeting GLDC research led to several publications in a special issue in the European Journal of Development Research on *Rural Aspirations: Livelihood Decisions and Rural Development Trajectories* ([Mausch et al.](#); [Nandi & Nedumaran](#); [Mausch et al.](#); [La Rue et al.](#); [Crossland et al.](#); [Dilley et al.](#)). Varietal adoption studies revealed that improved GLDC crops are cultivated on 15.37 M ha by 17.64 M households in 13 priority countries ([Woldeyohanes et al. 2021](#)). Adoption of improved soybean varieties and agronomic practices in Malawi led to a 4.16 percentage-point reduction in poverty, which translates to over 150,000 people lifted out of poverty ([Tufa et al. 2021](#)).

FP3: Reducing agro-chemical inputs to control pests and diseases through tailored management options using biocontrol agents or in combination with agro-chemicals was pursued. Based on its ability to survive harsh conditions, the parasitoid *Liragathis javana* was released at a large scale in Burkina Faso, Niger, and Nigeria. For the abiotic stresses, two of the three cellulose degrading microbes that decompose sorghum bagasse into compost, thereby enhancing plant growth by solubilizing phosphorous was studied under field conditions. Sustainable intensification systems with diversified crop combinations were developed in Burkina Faso, Malawi, Mozambique, Nigeria, and Senegal. Resilient and high-yielding varieties that fit well in these cropping systems together with appropriate inputs, planting time, planting densities and arrangements were promoted to increase resilience and productivity on smallholder farms. [Decision support tools](#) were developed to evaluate the performance of [legume varieties and combinations](#), and farm management [options](#) across agro-ecologies and socio-economic conditions in Burkina Faso, Ethiopia, and Nigeria. Over 750 households (about 4,000 beneficiaries) growing GLDC crops adopted improved seeds, cereal-legume intercropping systems, and specific recommendations on varieties and sowing dates. Improving natural resources and ecosystem services were supported by APSIM modelling in Malawi for sustainable intensification and diversification of integrated cropping systems, crop genotypes with complementary growth habits and plant architecture, soil type, and environmental factors.

FP4: The research initiatives included variety development and/or improvement, product profile development, scaling and impact assessment under the crosscutting aspects of gender, youth, capacity development, and partnerships. To enhance the rate of genetic gain, small- and medium-seed companies and public sector partners enabled collaborative breeding, delivery of improved seed in target countries, and design of product profiles. Consequently, new cultivars were released that offer production, market, and consumer traits contributing to nutritional security, climate resilience, drive new value chains, promote employment opportunities among the youth and women, and environmental sustainability. Key innovations for breeding pipelines include scaling up of speed breeding at ICRISAT and ICARDA for chickpea and lentil, defining target product profiles (TPP) based on market segments, stage gate system (IITA) with multi-disciplinary teams along the breeding and testing pipeline, and institutionalized Multi-Environment Testing (MET). These were

combined with advanced analytical tools for data analysis and decision making, seed-chip genotyping in groundnut (ICRISAT) and chickpea (ICARDA), and CT-imaging tools for grain physical quality. Over 20.5 M ha are currently under improved GLDC crop varieties that have been adopted by over 21.9 M smallholder farmers in target countries.

FP5: Lines of cross-compatible cowpea wild relatives including those exhibiting seedling stage drought tolerance in greenhouse trials were crossed with elite cultivated varieties and incorporated into pre-breeding resources. Cross-compatible drought tolerant cowpea genotypes were hybridized with improved breeding lines and varieties from INERA-Burkina Faso, INRAN-Niger, and IITA-Nigeria. Pigeonpea mutants for seed color and 100 seed weight in the background of ICPL 87119 and ICP 8863 were identified and crossed with the respective parent line to generate F1s and selfed to generate F2 seeds. High resolution mapping and near-isogenic lines were used to fine map fertility restoration genes in pigeonpea that identified highly significant QTLs. For AB resistance in chickpea, transcriptome, small RNA, and degradome sequencing helped to identify 6767 differentially expressed genes and 297 miRNAs related to pathogenesis-related proteins and disease resistance genes. The analysis of both small RNA and transcriptome data identified 12 miRNA-mRNA interaction pairs related to AB infection. While genomic selection has been optimized in chickpea, pigeonpea and groundnut, a high throughput phenotyping platform was developed at ICRISAT. Enabling technologies focused on establishing protocols for proof of concept in genome editing, second-generation transformation, systematic mutant population, phenotypic screening, and rapid generation turnover (RGT).

FP6: Activities focused on bean variety development, dissemination, and technology package offerings with well-integrated into crosscutting themes on gender, youth, and capacity development, highlighting, (1) satisfaction among women and youth on inclusivity within the bean business platform, (2) high adoption of bean business models, (3) Using ICT tools for easier access to services and advisory to farmers, (4) empowering bean value chain actors as change agents, (4) development of bean corridors in African regions, and (5) release of bean varieties and technology packages. Impact studies in Burundi showed that having access to profitable markets allows traders to negotiate for higher prices, compared with those who are yet to join market platforms. In Kenya, a women-only group (Ushirikiano-Nakuru) earned an additional US\$10 per ton by linking with a woman-owned bean processor, Smart Logistics Ltd. which now trades in highly demanded varieties that attracted better prices. Increased transparency across bean value chains and partnerships contributed to higher levels of satisfaction amongst a sample of 302 farmers (165 women) who were linked to buyers by using digital payment solutions through MasterCard Farm Network (MFN) in Uganda. Over 86% of the women and 80% of the men were satisfied with the financial solutions (FinTech), and 89% of the non-user willing to embrace use of digital payment platforms.

1.2.2.a. Progress by Flagships

FP1: <http://gldc.cgiar.org/progress-in-fp1-priority-setting-and-impact-acceleration-2021/>

FP3: <http://gldc.cgiar.org/progress-in-fp3-integrated-farm-and-household-management-2021/>

FP4: <http://gldc.cgiar.org/progress-in-fp4-variety-and-hybrid-development-2021/>

FP5: <http://gldc.cgiar.org/progress-in-fp5-pre-breeding-and-trait-discovery-2021/>

FP6: <http://gldc.cgiar.org/progress-in-fp6-common-bean-for-markets-and-nutrition-2021/>

1.2.2.b. Relevance to Covid-19 by flagship

FP1: The urban food work has generated some interest considering the Covid-19 pandemic. A BBC feature story is under production that focuses on the GLDC-supported response under COVID-19 restrictions to ensure food availability to the urban poor while value chains faced disruptions.

FP3: Since the pandemic protocols restricted travel and in-person meetings, trainings and field days, messages and information was broadcast through radio and digital media involving extension agents and lead farmers. Where possible, online meetings were conducted to discuss issues and disseminate information. Implications on resilience, food and nutrition security and recovery policies by the governments in major farming and food systems of Asia were also assessed.

FP4: The pandemic led to delays in the release of cultivars and reduced the scale of on-farm testing to some extent, besides limiting the field days.

FP5: While most research activities progressed as planned, travel of breeding teams were severely affected due to travel restrictions.

FP6: PABRA members swiftly adjusted implementation of the planned and extension activities through digital platforms including WhatsApp, virtual trainings, radio, and television broadcasts. Besides, extension teams carried out field under country-specific restrictions and health guidelines. The pandemic had a negative impact on crop markets and supplies affecting businesses of traders and processors. Hence, investments were made in digital solutions to ensure support to key players, especially women and rural producers. New partners were onboarded to expand the MasterCard Farmer Network (MFN), besides a guideline and three virtual gender tools to integrate women and youth into the MFN system. Videos highlighting impacts of COVID-19, mitigation measures and strategies in the EAREM corridor were produced and disseminated across PABRA member countries. PABRA also provided prioritized support to vulnerable groups and women, besides providing options to reduce post-harvest losses.

1.2.3. Variance from Planned Program for this year

1.2.3.a. Have any promising research areas been significantly expanded?

FP1: While no research area was significantly expanded, outreach activities on aspirations were expanded.

FP3: New areas included the development of a phenotyping facility for fall armyworm at ICRISAT, household level studies to assessing profitability and risks of technologies upscaled, modelling climate impact on legume crop varieties, crop productivity under trees, and the monitoring of greenhouse gases balance.

FP4: Speed breeding expanded at ICARDA and ICRISAT, besides mainstreaming biofortification in breeding pipelines of pearl millet, sorghum, lentil, and groundnut and expanded MET testing in Africa and Asia. The Pan African Soybean Variety trials also expanded to Bangladesh and Myanmar.

FP5: QC and trait marker development was significantly expanded with the additional support from EiB and USAID-CtEH projects.

FP6: PABRA expanded the use of MasterCard Farmer Network and messages on the nutrition value of beans and financial institutions to build the capacity of SMEs, particularly during the COVID-19.

1.2.3.b. Have any research lines been dropped or significantly cut back (max 150 words)?

FP1: A market survey planned for sorghum and chickpea sorghum varietal trait preference study in India during 2021 could not be completed due to COVID-19 surge and travel restrictions. Hence, this work was limited only to key informant surveys in selected markets to map the value chains for sorghum and chickpea.

FP3: Collection of new isolates of pearl millet downy mildew and blast pathogens from farmers' fields and exchange visits were cancelled due to travel restrictions/lockdown. The field work on assessment of whole farm model decision support could not be undertaken at village/farm level with stakeholders in India and in Sub-Saharan Africa.

FP4: None

FP5: Innovation fund awarded to a partner of ICARDA could not be implemented due to the lack of clearance from ARC-Egypt. This activity had to be cancelled.

FP6: None

1.2.3.c. Has the flagship or specific research areas changed direction (max 150 words)?

FP1: The urban food systems work under CoA1.2 was adjusted to ensure that the interventions take COVID-19 implications into account.

FP3: None

FP4: None

FP5: None

FP6: Instead of in-person training, digital trainings and expanding digital transactions were implemented due to COVID-19.

1.3. Cross-cutting dimensions (at CRP/Platform level)

1.3.1 Gender

A strategy for Women and youth integration in technology development and deployment process was developed to support the process of how research for development activities target and select participants and beneficiaries. The strategy for the gender-responsive technology development and deployment process applied the gender equity and equality model of checklist questioning of:

- (i). Who? – responding to the types of men, women, and youth from each crop value chain segment.
- (ii). What? – responding the issues, needs, preferences, and constraints of men, women, and youth analyzed and considered in outcome goals and intervention design.
- (iii). How and why? - responding to the overall research activities, objectives, and welfare outcomes targeted at, sensitive to, and responding to men, women, and youth-specific needs.

Indicators developed for checklist questions included the number of men, women, and youth designed and targeted in project design include data collection protocol, capacity building field demonstration/trials plans, number/percentage of men, women, and youth reached, included, and participating in (survey and interviews, and attendance in training, trials /demonstrations). This also has intersectional consideration and data, outcomes and interventions designed with women, men and youth-specific needs integrated and implemented. The strategy was implemented with over

80% success rate wherein the percentages of women and men participants of the research for development activities were achieved at 50-50 men to women targets and beneficiaries. Sometimes more women or women only beneficiaries were targeted to close an identified gender gap. One such intervention activity was designed to improve access to improved seeds and engender behavior change. Women groups were targeted and trained to strengthen their role in improved seed production and dissemination.

Three training sessions were organized in Mali targeting only women farmer organizations to strengthen the role of women in improved seed production and dissemination. The main objective of the training was to equip and to build the capacity of women involved in seed production, and to connect them to high-quality seeds suppliers, and raise awareness on the added value of using improved seeds. About 80 women were trained on seed production and essential agronomic techniques for the production and preservation of quality seed.

The first module addressed the production of high-quality seeds; discussions were focused on the importance of growing high-quality seeds which increases yield by 30% to 40%, especially of hybrid sorghum and millet. The focus of the second module was on minimizing the risk of production by checking the seed certification with seed companies and cooperatives before purchasing any seed and testing the seed germination capability before sowing.

The third module was on postharvest handling techniques to strengthen the capacity of women and youth groups to produce and provide high-quality grain to marketers, processors, and consumers. The participants learned the causes of losses in production and early or late harvesting. They were taught to be cognizant of the different moisture content of grains for storage and were equipped with knowledge on the appropriate times for harvesting millet, sorghum, and groundnut. In addition, the participants were taught the importance of packaging and labeling grains to enable effective product tracing and stock management. The bag or packaging must bear certain information such as producer's code, the product's place of origin, weight, the name, or the type of the product. This module also included lessons on marketing and networking techniques, to support women and youth groups to better manage their seeds and grain demands, define a marketing strategy and business plan.

The training sessions identified additional capacity building needs among women and youth groups in seed production, grain marketing, and processing of agricultural products including:

- Structural and organizational capacities of the groups.
- Establishment of efficient information systems with the outside world and between the actors of the value chains.
- Acquisition of appropriate equipment for agricultural production and processing of millet, sorghum, and groundnuts.
- Strengthening of seed storage facilities and capacities.
- Low literacy level among participants (5% for women and 10% for men).

1.3.2. Youth and other aspects of Social inclusion / “Leaving No-one Behind”

To unlock the potential of youth in agriculture, targeted, inclusive interventions that appeal to specific and diverse groups of youth, especially females and differently abled youth. For this, customized training sessions for young women, and hearing-impaired youth from the Wa School for the Deaf were conducted in Ghana with a focus on behavior change communication that incentivizes choice of improved varieties and quality seeds of cereals and legumes.

The trainings focused on developing an organized group of groundnut producers to understand the market potential in groundnut seed production and marketing, as well as developing sustainable market linkages for the commodities produced in Tamale, Northern Ghana. Key areas of the training included groundnut seed production, quality control of seeds, seed business development, the concept of the Village Savings and Loans Association (VSLA), group dynamics for sustainable grassroots organization among seed producers, and processing of groundnut into confectionaries of high nutritional and market value.

A total of 300 youth aged 15 to 35, including 30 from the Wa School of the Deaf in Tamale, Ghana, benefited from this intervention. By targeting and reaching out to every gender and social group, the outcome of the training will engender greater adoption, production, marketing, and utilization of improved groundnut varieties.

The mapping and inventory of artisanal units for processing local products were conducted in Mali 30 women economic interest groups in the processing of agricultural products (millet, sorghum, groundnut, and cowpea) were identified within the framework of a *Memorandum of Understanding* (MoU) between The ICRISAT and the WFP. Each of the 30 groups will receive modern equipment (mills, dryer, storage warehouse, hulling, cooling, sorting, roasting rooms, sales stores, toilets, etc.) for processing products, and will be connected on the one hand with health centers and canteens to ensure a better supply of Smart Foods (i.e. biofortified foods), and on the other hand, with farmer groups that will receive high nutrient content varieties from ICRISAT.

1.3.3. Capacity Development

The CRP-GLDC scientists across the flagships and cross-cutting themes were engaged in substantial capacity development activities. Since the beginning of the CRP, at least 28,492 people including 35% females were reported to have benefited from the program's capacity development efforts. For short-term trainings, the beneficiaries included farmers and farmer groups, scientists, and R&D personnel from CGIAR centers, research programs (CRP) and platforms, partners from advanced research institutions, national agricultural research and extension systems (NARES), academic institutions, government and non-government entities, development organizations and the private sector among others. For long-term training, 35 PhD and 26 MSc students enjoyed more intensive support. The distribution of these participants are presented here [2018](#), [2019](#), [2020](#), and [2021](#).

Due to the COVID-19 pandemic, e-Learning experienced a huge boost across the globe. In response, the Capacity Development Task Force set-up an e-Learning portal using a commonly known Learning Management Systems (LMS) to facilitate a flexible and user-friendly environment for both learners and facilitators. Available learning materials were related to "Breeding Approaches for Enhancing Genetic Gains in Food Legumes", "Sustainable Food and Agriculture", "Creating Impact at Scale" and "Designing of Resilient Farming Systems". After the closure of GLDC, the E-Learning platform will be open accessible through the [ICARDA E-Learning platform](#) which currently has over 70 courses and 1100 users in different languages and is continuously growing.

The Capacity Development Task Force further revamped and upgraded the [AGskilled platform](#). The platform is now published in Android PlayStore for use by farmers. The content platform has been transformed into an aggregation platform for mobile based e-learning courses targeted for farmers and frontline extension staff.

1.3.4. Climate Change

In both pest and disease as well as resource and soil management options, efforts of FP3 have been to reduce the use of pesticides and mineral fertilizers, and consequently the GHG emissions. In addition, sustainable intensification systems with diversified crop combinations including intercropping cereals-legume and doubled-up legume systems were developed and promoted in Burkina Faso, Malawi, Mozambique, Nigeria, and Senegal. Resilient and high-yielding varieties that fit well in these cropping systems together with appropriate input bundles and production practices were promoted to increase resilience and productivity on smallholder farms. A training for trainers on Climate Information Services (CIS) for Beans (CIS4B) was carried out for 126 bean value chain actors (including 48 women and 36 youth) from [the EAREM corridor in Rwanda and Burundi and SEMAGUI Corridor in Senegal and Mali](#). Finally, a suite of tools, analytics and frameworks helped co-design resilient farming systems in India, Malawi, Niger, Burkina Faso, Mali, Nigeria, and Mozambique. Our sustainability assessment tool was tested and validated followed by strengthening the capacity of extension systems and NARS partners for enhancing resilience of rural livelihoods SA and SSA. To strengthen the capacity in climate change and plant protection activities, collaboration with advance research institutions such as University of Strathclyde, Scotland and Wageningen University Research, Netherlands was established. The main purpose was to develop high throughput phenotyping platforms using sensor-based technology for rapid detection of pathogens and to develop modelling tools to predict the distribution of pests and diseases under future climate scenarios.

1.3.5. Markets and Partnerships in Agri-Business

The MPAB crosscutting theme developed a set of case studies, reviews, and foresight reports that explore pathways to scaling market facing interventions for GLDC crops. This has been accompanied by the development of new analytical perspectives to explore these issues through an agri-food system lens. These empirical and theoretical building blocks have been used propose a modified theory of change for the way market engagement by commodity research can drive the transformation of agri-food systems for the benefits of poor producers and consumers of GLDC crops. This research has been published as [working papers, journal articles, and blogs](#), with further manuscripts nearing completion. The pathway to impact of this research is through influence on strategic choices in project and program design within the CGIAR and beyond. Earlier indicators of influence of research output from MPAB is reflected in strong altimetric scores, with one journal article in the top 5% and others in the top 25% of papers published. Another dimension of MPAB work has focused on collaboration between ICRISAT (FP3) and CSIRO on modelling sorghum futures in India. This has successfully recalibrated the Crop Livestock Enterprise Model (CLEM) farming systems model for Indian farming systems conditions. Draft manuscripts on methodological and empirical and methodological aspects of this work have been prepared. A further strand of MPAB work has been led by ILRI and has explored technological upgrading processes associated the development of women's dairy enterprises.

MPAB developed a close collaboration between CSIRO, ICRAF, IITA, and ICRISAT and across flagships, specifically FP1 (understanding adoption), FP3 (farming systems modeling), FP4 (understanding adoption), FP5 (scoping the potential of GLDC crops as functional foods) and FP6 for understanding market led breeding and scaling approaches. Strong external partnerships have also been developed and leveraged with advanced research institutes and think tanks outside of the CGIAR.

2. Effectiveness and Efficiency

2.1. Management and governance

The Independent Advisory Committee (IAC) that includes seven non-CGIAR members and five ex-officio CGIAR members, including the Director General of the lead center provided scientific guidance through its biannual meetings. Two meetings of the IAC were held virtually due to the COVID-19 pandemic, on April 12 and October 21-22, 2021. The second meeting also included an interactive review session with the FP leaders and cross-cutting theme leaders.

The Director of CRP-GLDC reports to the Director General of ICRISAT and chairs the Research Management Committee (RMC), where the responsibility of implementing the CRP-GLDC rests. The RMC has 14 members, including four FP Leaders, a 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 CRP research portfolio, strategy, work plans and annual budgets. In 2021, four meetings of the RMC were held virtually due to the pandemic. Overall, FP management is the responsibility of the FP leaders who are supported by the CoA leaders of the respective Flagships. The FP leaders devote at least 40% of their time on the CRP-GLDC's operational activities, funded from W1 and W2, and supported by W3 and bilateral projects.

2.2. Partnerships

2.2.1. Highlights of External Partnerships

Enhanced partnerships with German university networks, Institute of Development Studies (University of Sussex), and MercyCorps through activities on rural aspirations. While collaborated with JIRCAS on the ex-ante impact assessment of BNI sorghum technology, the Swedish Agricultural University is leading the systematic review on the effects of GLDC crops on soil health. Working with Soybean Innovation Lab (SIL), University of Illinois, Feed the Future Innovation Lab for Legume System Research at the Michigan State University, Lilongwe University (Malawi), University of Nazi BONI (Burkina Faso), Center for Development Research (ZEF), University of Bonn, Zurich University of Applied Science, SCIO Systems, Centre for Dryland Agriculture, Bayero University, Kano; Massachusetts Institute of Technology (MIT), WUR, CSIRO, the Indian Council of Agricultural Research, GIZ, and Tanzanian Agricultural Research Institute.

Exclusive time bound commercial rights being awarded to Good Nature Agro and Afriseed in Zambia. ICRISAT partnered with Egerton University to initiate contract farming model to produce a new standard seed class of pigeonpea on 41 ha. ICRISAT funded by ICAR for field trials and release of molecular breeding lines in chickpea. While collaborated with ISRA (Senegal) on root traits in pearl millet, other collaborators included Osmania University, India, AICRP-PM, India, University of Strathclyde, Wageningen University Research, Corteva Agriscience, University of Amsterdam, University of Nairobi, and Peanut Innovation Lab.

Gender based PVS on promising bean lines was conducted with Institut des Sciences Agronomiques du Burundi ([ISABU](#)). With [Imara Tech](#), [catalyzed the private sector to test, adapt and promote post-harvest grain handling prototypes](#) and MultiCrop Thresher. With UK Universities, physiology at pollination phase, crop modeling, transpiration efficiency, heat physiology and social science and farmer surveys were conducted. Multiple partners supported the development of drought tolerant varieties in nine Latin American countries. New donors include Foundation Centre Haïtien d'Innovation sur les Biotechnologies et l'Agriculture Soutenable (CHIBAS)-Haiti.

2.2.2. Cross-CGIAR Partnerships

PIM helped contribute to the CGIAR Foresight Report, including a brief on the future of grain legumes and dryland cereals through knowledge-sharing and joint scientific products by establishing community of practice on foresight and a Blog under EnGendering Data. A special issue on demand orientation in seed systems was developed between GLDC, PIM, MAIZE, and RTB. Partnerships with RTB focused on MEL-based social network analysis for better performing CRP aimed at identifying GLDC structures and operations have contributed to publishing knowledge/science products that effectively increased multi-disciplinary publications, besides evaluating how the CRP-GLDC adds more collaborations to the knowledge exchange networks.

ICRISAT and ICARDA collaborated on phenotyping of fall armyworm, and the framework for measuring sustainability and resilience; CIMMYT supplied Drought Tolerant Maize varieties to IITA for cropping systems activities; IITA and ICRISAT partnered on DSSAT and APSIM models for simulation of crop performance in Nigerian savannas; ICRISAT, ICRAF, IITA, and ICARDA collaborated on mainstreaming gender in Research for Development to improve GLDC-based farming systems; and with ICRAF to advance the crop modelling of agroforestry systems in Tanzania.

With CRP-Livestock, released a drought tolerant and dual-purpose groundnut variety, Kalinga Groundnut-101 (ICGV 02266) in India which included fodder quality as one of the selection criteria for GLDC Product profiles. Crop breeders engaged with EiB to update their knowledge and share best practices in crop breeding. Collaboration with CIMMYT led to the development of specialized phenotyping net house facility for screening Fall armyworm in sorghum, millet, and maize at ICRISAT in India.

Bean Program engaged with CGIAR initiative design teams to mainstream the PABRA approach in Accelerated Breeding Initiative (ABI) and Seed systems. Interacted with CIMMYT as the lead center for AVISA project and Alliance to continue the AVISA bean research activities in future.

2.3. Intellectual Assets

CRP-GLDC did not manage any intellectual assets. Partner institutions are directly responsible for managing and disseminating their intellectual assets, as evidenced by the submitted [Innovations and Outcome Impact Case Reports](#) (Ref. Table 3&4).

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

A tool to assist better target and tailor the recommendations for tracking progress of implemented solutions (practices, technologies, policies) in a multi-dimensional sustainability context was developed. This tool enabling the monitoring of impact on KPI's and potential trade-offs was tested at a small scale in India and Niger and is ready for scaling. The online automated version of the tool will be available in public domain by end of 2021. Impact evidencing and consolidation of evidence of the CRP-GLDC has been completed with publication of a [document](#). For impact evidencing on NRM, activities have been reported on the MEL platform and institutional documents and a working paper are being finalized for publication. Analysis of GLDC innovations including chickpea in Ethiopia and Myanmar, cowpea in Nigeria, and Legumes in Nigeria, Tanzania, and Uganda highlighted that successful adoption depends not just on the right technologies, but also on the enabling environment. This clearly identified the market demand, besides the establishment of successful partnerships and institutional linkages to overcome constraints in production and delivery of improved seed to smallholders. Fostering conducive policies to support national seed systems were integral to the viability and sustainability of seed systems.

2.5. Efficiency

CRP-GLDC participated in a shared work with MEL by partnering with other CRP's to fully automate the uploading of performance indicators towards greater CGIAR reporting that were previously done manually. This involved inputs in the development of modules, testing, and pilot use. To capitalize on the interconnectedness of processes within CRP-GLDC operations, MEL team operated collaboratively on data curation of knowledge products, inputs to digital platforms, and building consolidated knowledge products that can be accessed via the CRP-GLDC [Research Communications page](#). Close coordination among partners allowed for greater promotion of GLDC blogs and other products, while also offering the CRP-GLDC communication platforms to promote GLDC-relevant materials developed by partners, particularly with FP6 team/PABRA. Innovation profiles that were collected during the CRP-GLDC submission for CGIAR @ 50 preparations, but not selected in the final list were developed into innovation communication packages, thereby capitalizing on information and references already collected. Close interactions between the PMU and RMT helped track the progress through a mid-term report and any shortcomings were addressed at an early stage for finalizing the 2021 annual report.

2.6. Management of Risks to your CRP

While the CRP-GLDC continued to operate with the unfunded FP2, projects worth US\$ 39.52 M supported through W3/Bilateral funds were mapped to FP2 in 2021. Not having FP2 was partly mitigated by having a cross-cutting theme on MPAB since 2019. Restrictions for travel due to the impact of COVID-19 prevented face-to-face scientific meetings with GLDC Partners, the Independent Advisory Committee (IAC), and Research Management Committee (RMC) and the annual review meeting. Hence, the anticipated unspent PMU operational budget was strategically invested into the activities of FP4 and FP5 in order to achieve the planned 2022 milestones due to an early closure of the CRP-GLDC a year earlier in December 2021.

2.7. Use of W1-2 Funding

The W1-2 funds were mainly used for the following research activities: (1) End-user trait preference assessment of GLDC crops, (2) rural aspiration studies for targeting and scaling agricultural innovations, (3) assessing the potential impact of GLDC crops on urban food and nutrition security, (4) Assessing the nutritional/dietary and NRM impacts of GLDC crop varieties, (5) revision of GLDC's theory of change and impact pathways, and (6) MEL-based social network analysis to evaluate the performance of the CRP-GLDC. These funds supported clusters of activities where a significant part used to support enabling adoption of innovations at farming systems level. The W1/W2 funds were used to develop and deliver the GLDC crop cultivars in the CRP-GLDC target countries, besides leveraging for additional funds from various donors for the planned research activities. While the W1/W2 funds supported the partnership with ILRI and Crop Network Groups, the bilateral projects were aligned to complement the W1/W2 funds. For example, Feed the Future Peanut Innovation Lab (PIL) funds supported the development of markers for Groundnut Rosette Disease in collaboration with national programs in Malawi, Zambia and Uganda. These funds were also used for process innovations to enhance the operational efficiency and increase the genetic gain of GLDC crop cultivars that include deployment of genotyping tools, rapid generation advancement and MET. The Innovation fund of the CRP-GLDC also supported NARS and ARI partnerships in research areas where the FP lacked expertise. The FP6 was fully funded by W3 and bilateral funds.

3. Financial Summary

The total budget of CRP-GLDC for 2021 was expressed at US\$ 7.79M inclusive of an additional FinPlan of cumulative unspent of US\$ 785,978 from 2018-20.

The cumulative utilization of funds (2018-21) is recorded at 99.2%. The total unspent is recorded at US\$ 2,61,640 (0.80%) on 31.12.2021. The permitted accrual of US\$ 60,000 was carried forward to 2022 to fulfil the reporting obligations.

A total unspent amount of US\$ 2,01,640 (2018-22) will be off-set against the final disbursement from SMO.

Part B. TABLES

Table 1: Evidence on Progress towards SLO targets (Sphere of interest)

SLO Target (2022)	Brief summary of new evidence of CGIAR contribution Put N/A if the specific SRF target is not applicable to your CRP. Spell out all acronyms. <i>Max. 150 words per entry.</i>	Geographical scope (with location) Global, Regional (e.g., West Africa), Multi-national, National (e.g., Philippines) Required.
SLO1 : Reduce Poverty		
1.1. ADOPTION: 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In GLDC target countries, an estimated 21.9 million smallholder farmers have adopted improved GLDC crops, cultivated in about 20.5M hectares or 43% of the total land grown to grain legume and dryland cereals. Woldeyohanes et al. 2021	Regional: South Asia, sub-Saharan Africa
1.1. ADOPTION: 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	299,350 farm households adopted and applied improved agronomic practices including doubled-up legume systems where improved crop varieties of pigeonpea, groundnut and soybean are configured in cropping patterns that capitalize on the synergies between crop pairs e.g., pigeonpea & groundnut, pigeonpea & soybean as part of sustainable intensification. https://bit.ly/3tXvHj9 https://pdf.usaid.gov/pdf_docs/PA00X689.pdf	Regional - East, Southern and West Africa
1.1. ADOPTION: 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	A total of 10,296 tons of certified and quality declared seed (QDS) were produced and sold to farmers by seed enterprises. The countries involved were Kenya, Rwanda, Tanzania, Zambia, East DRC, Ghana and Guinea. Approximately 10.5 million (52% women) have accessed high-iron bean varieties, increasing the number of countries with high iron beans from 7 to 12. *Evidence to be published by 2022	Multi-national: Kenya, Rwanda, Tanzania, Zambia, East DRC, Ghana, Guinea
1.1. ADOPTION: 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	250 household farms with positive soil P balance, partly driven by improved soil-crop-livestock management practices (southwest Burkina Faso). https://doi.org/10.1016/j.ecolind.2021.107385	Sub-national: Southwest Burkina Faso

SLO Target (2022)	Brief summary of new evidence of CGIAR contribution Put N/A if the specific SRF target is not applicable to your CRP. Spell out all acronyms. <i>Max. 150 words per entry.</i>	Geographical scope (with location) Global, Regional (e.g., West Africa), Multi-national, National (e.g., Philippines) Required.
1.1. ADOPTION: 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	Around 375 farms have practiced soil-water conservation (SWC) measures (at least one among 6; SWC: terraces, grass strips and half-moon micro basins, trenches, tied ridge and mulching). That would improve water and nutrient uses efficiencies (North-Shewa Amhara region, Highlands of Ethiopia). https://mel.cgiar.org/reporting/report/type/crp/id/7380/del_id/15061	Sub-national: North-Shewa Amhara region, Highlands of Ethiopia
1.2. EXIT POVERTY: 30 million people, of which 50% are women, assisted to exit poverty	Adoption of improved soybean varieties and agronomic practices in Malawi led to a 4.16 % reduction in poverty, which translates to over 150,000 people lifted out of poverty. In this study the international poverty line of US\$1.90 per capita per day was used as standard. Tufa et al. (2021)	National: Malawi
1.2. EXIT POVERTY: 30 million people, of which 50% are women, assisted to exit poverty	Adoption of improved GLDC varieties is estimated to have generated additional income of US\$4.7 billion in GLDC's 13 priority countries through yield gains and additional areas under improved varieties. An estimated 6.8 million people have been assisted to exit poverty. Woldeyohanes et al. 2021	Regional: South Asia, sub-Saharan Africa
SLO2: Improve Food and Nutrition Security for Health		
2.2. MINIMUM DIETARY REQUIREMENTS: 30 million more people, of which 50% are women, meeting minimum dietary energy requirements	Adoption of improved GLDC varieties has assisted an estimated 19 million people (50% women) to meet their dietary energy requirements and 38 million people (48% women) to meet their dietary protein requirements through the supply of additional nutrients. Similarly, the number of women of reproductive age whose dietary protein requirements can be met with the additional protein supplied is 3.8 million Woldeyohanes et al. 2021	Regional: South Asia, sub-Saharan Africa
2.3. MICRONUTRIENT DEFICIENCIES: 150 million more people, of which 50% are women, without deficiencies in one or more essential micronutrients	The consumption of high-iron beans (HIB) increased by 0.46% in Uganda, 0.12% in Burundi, 9.8% in Zimbabwe and 2.1% in Malawi. The surge in HIBs intake in Malawi is due to the collaboration with complementary projects implemented in the country. Leveraging initiatives targeting mother care groups and adolescents, particularly	Multinational: Uganda, Burundi, Zimbabwe, Malawi, Kenya, Rwanda, Tanzania

SLO Target (2022)	Brief summary of new evidence of CGIAR contribution Put N/A if the specific SRF target is not applicable to your CRP. Spell out all acronyms. <i>Max. 150 words per entry.</i>	Geographical scope (with location) Global, Regional (e.g., West Africa), Multi-national, National (e.g., Philippines) Required.
	women and children in poor setting of Malawi, has enabled the project to reach vulnerable populations. Across seven countries: Burundi, Kenya, Malawi, Rwanda, Tanzania, Uganda, and Zimbabwe, an additional 1.15 % of the people consumed HIBs in 2020. 10.5 million people (52%) were consuming high iron beans.	
SLO3: Improve Natural Resources and Ecosystem Services		
3.1. WATER AND NUTRIENT EFFICIENCY: 5% increase in water and nutrient efficiency in agroecosystems	Empirical analyses of rain-fed cropping systems in southwest Burkina Faso showed that cereals-legume intercropping increased the economic efficiency of crop production about 40% – 133% compared to monocropping, suggesting a high potential and feasibility to improve crop production efficiency at scale by transiting from the current monocropping areas (85%) to intercropping. https://doi.org/10.1016/j.ecolind.2021.107385	Sub-national (Southwest Burkina Faso)
3.2. REDUCED GREENHOUSE GAS EMISSION: Reduction in ‘agriculturally’-related greenhouse gas emissions by 5%	Climate change mitigation increased soil organic carbon in the top 20 cm to 6.5, 12 and 10.5 t C ha ⁻¹ for Climate Smart Agriculture (CSA), Mbeya-fertilizer and Maize-pigeonpea intercrops, respectively over a period of 2-6 years compared to conventional farmer practices. Nyagumbo et al., 2021	National: Malawi
3.3. ECOSYSTEM RESTORED: 55 M ha degraded land area restored	Not aligned to CRP-GLDC	
3.4. PREVENTION OF DEFORESTATION: 2.5 M ha forest saved from deforestation	Not aligned to CRP-GLDC	

Table 2: Condensed list of policy contributions in this reporting year (Sphere of Influence)

Col 1	Col 2	Col 3	Col 4	Col 5 to 8				Col 9
Title of policy, legal instrument, investment, or curriculum to which CGIAR contributed (max 30 words) <i>Spell out acronyms in every row</i>	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	
CGIAR Common Bean technology and innovation packages help revive school and community garden clubs in Kenya	With the reintroduction of 4K Clubs in Kenyan schools, quality seeds of improved common beans, and associated technologies have been shared to promote better access of people to nutritious food.	1	Increased availability of diverse nutrient-rich foods; Increased access to diverse nutrient-rich foods;	0	1	1	0	https://mel.cgiar.org/blog/edit/id/463

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 drop down for: 1, 2, or 3
Wide adoption of 304 Improved legume varieties across 15 countries in Africa, India and Bangladesh	https://hdl.handle.net/20.500.11766.1/87323f	1
Adoption of improved chickpea in Ethiopia reduced poverty level of 59% of households who were above the poverty line	https://hdl.handle.net/20.500.11766.1/e355d2	1
Dissemination of improved soybean varieties to smallholder farmer in Malawi reduced poverty level by 4,16% (150,000 people lifted out of poverty	https://hdl.handle.net/20.500.11766.1/76035d	1
Improved production, income, and livelihoods of 219,694 smallholder farmers in 110 sites across Burkina Faso, Ethiopia, Kenya, Mali, and Niger through the DryDev Program	https://hdl.handle.net/20.500.11766.1/6f06ce	1
Adoption of improved Groundnut Varieties in the Tropical Legume Project (TL III) across the project states in Nigeria	https://hdl.handle.net/20.500.11766.1/15579a	1
High iron beans developed by CGIAR and partners support women in Burundi to save time and improve children's nutrition	https://hdl.handle.net/20.500.11766.1/b79fee	1

Table 4: Condensed list of innovations by stage for this reporting year

Title of innovation	Innovation Type	Stage of innovation	Geographic scope (with location)
Generic algorithm for multicriteria ranking of crop technological options based on the “Technique for Order of Preference by Similarity to Ideal Solution” using ShinyApps https://mel.cgiar.org/innovation/getinnovationview/id/818	Research and Communication Methodologies and Tools	2: validation of tool/app is on-going	Regional (drylands of South Asia and sub-Saharan Africa)
Micronutrient rich pearl millet varieties for Sahelian agroecology in Nigeria https://mel.cgiar.org/innovation/getinnovationview/id/798	Genetic (variety and breeds)	Stage 2: successful piloting	National: Nigeria
Drought and disease tolerant groundnut variety with good haulm quality released in India. https://mel.cgiar.org/innovation/getinnovationview/id/800	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Chickpea Variety - NBeG 857 (ICCV 13116) suitable for cultivation in the South Zone (SZ) of India https://mel.cgiar.org/innovation/getinnovationview/id/801	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Kabuli Chickpea Variety - GLK 17301 (ICCV 171301) suitable for cultivation in the North West Plains Zone (NWPZ) of India https://mel.cgiar.org/innovation/getinnovationview/id/802	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Chickpea Kabuli Variety - GLK 1617 (ICCV 15303) suitable for the North West Plain Zone (NWPZ) of India https://mel.cgiar.org/innovation/getinnovationview/id/803	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Ashenafi (ICEAP 00554) - A medium duration and wilt tolerant pigeonpea variety released for cultivation in Ethiopia https://mel.cgiar.org/innovation/getinnovationview/id/804	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: Ethiopia
New pigeonpea variety TDRG 59 for India https://mel.cgiar.org/innovation/getinnovationview/id/805	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Release of Sorghum hybrid CSH 42 in India https://mel.cgiar.org/innovation/getinnovationview/id/806	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: India
Release of Pearl millet hybrid Nafagnon in Burkina Faso	Genetic (variety and	Stage 3: available/ ready for uptake	National: Burkina Faso

Title of innovation	Innovation Type	Stage of innovation	Geographic scope (with location)
https://mel.cgiar.org/innovation/getinnovationview/id/807	breeds)		
Development of Target Product Profiles for six crops in Asia by taking inputs from all stakeholders and establishing quantified attributes for developing new products to replace current best cultivars https://mel.cgiar.org/innovation/getinnovationview/id/809	Other	Stage 3: available/ ready for uptake	Global
Target Product Profiles of ICRISAT mandate Crops in Eastern and Southern Africa https://mel.cgiar.org/innovation/getinnovationview/id/810	Other	Stage 3: available/ ready for uptake	Regional: East and Southern Africa
Policy recommendations to harness the potential of youth in Nigeria https://mel.cgiar.org/innovation/getinnovationview/id/821	Social science	Stage 1: Discovery/proof of concept	National: Nigeria
Identity marker nuances in adoption of tandem technologies: Policy recommendations to improve agricultural innovations adoption in Rajasthan, India https://mel.cgiar.org/innovation/getinnovationview/id/822	Social science	Stage 1: Discovery/proof of concept	National: India
Finger millet variety AGRY-2 - Chepesi (SEC 195 Snapping) released for cultivation in Kenya with projected spillover in eastern and southern Africa https://mel.cgiar.org/innovation/getinnovationview/id/863	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Regional: eastern Africa, southern Africa
Finger millet variety EUFM-8 (LLAMA) released for cultivation in Kenya https://mel.cgiar.org/innovation/getinnovationview/id/864	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: Kenya
Finger millet variety UFM 6 (KNE 628) released for cultivation in Kenya https://mel.cgiar.org/innovation/getinnovationview/id/865	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: Kenya
Dual purpose Pearl millet hybrid variety VPMH-7 (ICMA 94555) released for cultivation in India with projected spillover adoption in South Asia https://mel.cgiar.org/innovation/getinnovationview/id/866	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National: Kenya

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

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
1	Outcome 1. 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 availability of diverse nutrient-rich foods	Key outcomes include improved targeting and priority setting of research for greater technology adoption, food and nutrition security, resilience, and poverty reduction. The initial work informed GLDC management decisions on priority setting of crops and technologies, and the subsequent multidimensional evaluation has also been completed and the results are being shared more widely through publications.	Multidimensional ex-ante evaluation of GLDC research and technology options completed and results shared with GLDC staff and partners	Completed	Journal article	https://doi.org/10.1016/j.mex.2021.101519
1	Outcome 1. 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	Conducive agricultural policy environment	Session among flagship programs were conducted to learn from past initiatives and the current scaling approaches and how they can be improved.	Market and end-user preference studies are enhancing our understanding of end users' trait preferences for an inclusive and equitable innovation design and dissemination.	Partially completed	Reason for non-completion: 7. Others- COVID19 travel restrictions	
1	Outcome 2. 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	A significant body of work has been undertaken on rural aspirations focusing on the drivers of technology adoption aimed at targeting GLDC research. A special issue on "Rural aspirations – livelihood decisions and rural development trajectories" has been published in the European Journal	Verification of varying targets and improvements in research outcome match for adoption and marketing	Completed	Articles, reports, cap dev activities reported	https://link.springer.com/journal/41287/volumes-and-issues/33-4 , https://www.sciencedirect.com/science/article/pii/S2211912420300936?vi

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			of Development Research. The collection outlines current views on aspirations and their relevance for development research, projects, and approaches. A case study of the chickpea success story in India showed that demand- and market-led breeding strategies need to consider the CGIAR's key function of public integrated agricultural research for development (IAR4D) to generate public goods in service of development outcomes. Pursuing research that is riskier and not always commercially viable can generate a spectrum of technological options that could help poor farmers. Being more resilient, this is also key to serving a greater diversity of heterogeneous agro-ecological niches, market contexts and farmers' aspirations.				a%3Dihub https://www.cifor-icraf.org/event/rural-aspirations/ , https://mel.cgiar.org/reporting/download/report_file_id/27155 ; https://doi.org/10.1177/00307270211043542
1	Outcome 3. 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	Work is underway to establish inclusive and equitable technologies and innovation systems for accelerated and broadened impact across the agri-food system. Market studies in general and gender studies are enhancing our understanding of end users' trait preferences for an inclusive and equitable innovation design and dissemination.	Functioning innovation systems established across GLDC sites and sustainably operating. Scaling out supported and system fine-tuned to new target areas	Partially completed	Reason for non-completion: 7- Others: Most activities continuing beyond GLDC on bilateral projects.	https://bit.ly/3DPge7k
1	FP1.04. Strong project design, execution, monitoring and evaluation systems and	Conducive agricultural policy environment	Implementation of GLDC's impact estimation strategy near finalization. This include working paper estimating the adoption of GLDC varieties in target	The working strategy for evidencing the outcomes and impacts of GLDC implemented	Completed	Working paper	https://worldagroforestry.org/publication/adoption-improved-grain-

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
	tools consistently applied in GLDC scaling projects, with demonstrable progress on enhanced adoption and impact		countries (completed); working paper to review potential contributions of GLDC crops to carbon sequestration (working progress under finalization); estimates of poverty impacts resulting from improved GLDC varietal adoption (under finalization); and estimates of nutritional impacts resulting from improved GLDC varietal adoption.				legumes-and-dryland-cereals-crop-varieties-synthesis-evidence
1	Outcome 4. 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	GLDC Flagship Program's joint discussion around learnings and way forward towards implementing scaling initiatives of GLDC technologies.	Scaling toolkit institutionalized within GLDC	Completed	Report	https://mel.cgiar.org/reporting/download/report_file_id/25200
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Sustainable intensification systems with diversified crop combinations including intercropping cereals and legumes; agroforestry systems; and doubled-up legume systems developed and promoted in Burkina Faso, Malawi, Mozambique, Nigeria, and Senegal. Resilient and high-yielding varieties that fit well in these cropping systems together with appropriate input bundles and production practices were promoted to increase resilience and productivity on smallholder farms. GLDC activities in Malawi and Mozambique reached 177,700 households benefitted 725,000	5,000 farmers in project sites increase the diversity within cropping systems and use water and soil management practices developed jointly by farmers and researchers	Completed	Project reports, Publications	https://doi.org/10.1017/S0021859621000617 https://doi.org/10.1111/sum.12715 https://doi.org/10.1016/j.fcr.2021.108057 https://doi.org/10.1016/j.agry.2020.102918 https://doi.org/10.1016/j.agee.2020.106928 https://mel.cgiar.org/reporting/repor

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			individuals who used improved technologies including varieties, inputs bundles and production practices on 590,000 ha				t/product_id/1746 https://mel.cgiar.org/report/reports/cluster_id/478 https://mel.cgiar.org/preplanning/relatedfiles/id/478/entity/actionsite https://dec.usaid.gov/dec/content/Detail.aspx?vID=47&ctID=ODVhZjk4NWQtM2YyMi00YjRmLTkxNjktZTcxMjM2NDBmY2Uy&rID=Ntc0ODc2
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Decision support tools developed to evaluate the performance of legume varieties and farm management options across agro-ecologies and socio-economic conditions in Burkina Faso, Ethiopia, and Nigeria. More than 750 households who grow GLDC targeted crops have adopted improved seeds and cereal-legume intercropping systems as well as specific recommendations on varieties and sowing dates for the region.	Agricultural system simulation models (agent-based model, nutrient balance/flow models) used to assess ex-ante impacts of innovation practices on crop production efficiency and household livelihoods, and best-bet options identified	Completed	Project reports and publications	https://doi.org/10.1016/j.ecolind.2021.107385 https://mel.cgiar.org/reporting/report/type/crp/id/7380/del_id/15061
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially	Efficient companion crops, resilient varieties, input bundles, cropping patterns and sequences were evaluated in partnership with farmers in Burkina Faso, Malawi, Mozambique, Nigeria, and Senegal to strengthen the capacities and skills of farmers, create	Participatory field trials under smallholder conditions in different cropping systems under different environments	Completed	Project reports and publications	https://mel.cgiar.org/reporting/report/product_id/1746 https://mel.cgiar.org/reporting/report/product_id/2574 https://mel.cgiar.org/reporting/report/product_id/2574

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
		those including smallholders	awareness and increase system productivity. In addition, hand push planter for cowpea and soybean were promoted among women in Mozambique which reduced planting time by half compared to planting using a hoe and increased yields by up to 60%. Over 1,128 farmers (48% women) were trained, and 622 on-farm demonstration plots managed by farmers were established across agro-ecologies.	evaluated			http://bulletin.iita.org/preplanning/relatedfiles/id/478/entity/actionsite http://bulletin.iita.org/index.php/2021/07/30/mechanical-legume-planter-reduces-drudgery-for-female-farmers-in-mozambique/ https://dec.usaid.gov/dec/content/Detail.aspx?vID=47&ctID=ODVhZjk4NWQtM2YyMi00YjRmLTkxNjktZTcxMjM2NDBmY2Uy&rlD=Ntc0ODc2
3	FP3.O2. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Seventeen graduate students (9 MS and 8 PhD) with 24% women were trained in Cropping System management in Malawi, Mozambique, Nigeria, Uganda, and Senegal.	At least 10 M. Sc. Students trained in sustainable cropping systems management	Partially completed	Reason for non-completion: 7- Others: Students at various stages of their studies	
3	FP3.O1. Cropping systems sustainably intensified and diversified	Reduced production risk	(A) - Pest and disease management components: 1) Strains of downy mildew and blast pathogens of pearl millet were evaluated to assess their virulence spectrum; 2) biological nitrogen fixation (BNF), P-solubilization and antagonistic potential (on Botrytis	Effective 1) pest and disease management components evaluated for controlling the target pests, and 2) resource and soil management	Partially completed	Reason for non-completion: 7- Others: Most activities continuing beyond GLDC on bilateral projects	

Flagship	FP outcomes	Sub-IDs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			grey mold (BGM), wilt and dry root rot) of diazotrophic bacteria was assessed on elite chickpea lines; 3) Secondary metabolite(s) from <i>Streptomyces</i> sp. were characterized for suppressing soil borne diseases of sorghum; 4) Fall army worm (FAW) population dynamics was monitored using pheromone traps; 5) Low-toxicity pesticides and bio-pesticides were evaluated against FAW in sorghum; 6) Selected prominent sorghum lines were evaluated for resistance to FAW with artificial infestation under greenhouse conditions (B) - Resource and soil management options: 1) Efficient diazotrophic bacteria isolated from sweet sorghum bagasse were evaluated for P-solubilization and yield enhancement traits in sorghum; 2) The variability of the adaptation of sorghum and cowpea to the traditional intercropping system was evaluated in Burkina Faso	options evaluated for improved resilience			
3	FP3.O1. Pest and diseases controlled safely and with reduced agro-chemical inputs	Reduced production risk	(A) - Efficacy of Integrated Pest Management (IPM) modules: 1) Efficacy of integrated management of pearl millet blast evaluated by combining chemical and biological fungicides with host plant resistance; 2) Persistence of the released biocontrol agents - exotic hymenopteran parasitoid <i>Therophilus javanus</i> evaluated in Burkina Faso and Niger. 3) Elite sorghum lines were screened	Efficacy of effective 1) IPM modules and 2) NRM options confirmed in the target regions	Partially completed	Project reports, scientific articles Reason for non-completion: 7- Others: Most activities continuing beyond GLDC on bilateral projects	https://doi.org/10.1038/s41598-021-88644-3 https://doi.org/10.1146/annurev-ento-021220-084539

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			for their performance against fall army worm (FAW) in combination to studies of the biology of FAW on different hosts. (B) - Efficacy of natural resource management (NRM) options: 1) The performance of selected test cultivars of sorghum bred for intercropping with cowpea was evaluated in Burkina Faso				
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	1. Understanding the climate and market risks farmers face in SSA and SA to co-design better farm-level interventions was implemented in the year under review through several capacity enhancement training and promote technology dissemination via field day and extension guide for smallholder farmers/extension agents on integrated soil fertility management practices. 2. Farming systems sustainability assessment framework selected as 'Golden Egg' by CGIAR was tested, validated, capacity of extension systems strengthened, and NARS partners to use these tools for enhancing resilience of rural livelihoods SA and SSA. 3. A new tool - Women's Empowerment in Nutrition Index (WENI) has also been validated for rural India. 4. Health and Nutrition Literacy promoted through Knowledge Hub targeting GLDC regions. Awareness on	Portfolios of household activities, enterprises and management practices that materially and equitably enhance livelihoods (as defined at sub- IDO level) while minimizing negative externalities.	Completed	Project reports, scientific articles	https://livestocklab.ifas.ufl.edu/media/livestocklabifasuf/edu/pdf-/ICRISAT_Westafrica_IFSD2021_abstract_Shalanderk_final.pdf http://glfdc.cgiar.org/crp-glfdc-golden-eggs-contribute-to-healthy-diets-management-tools-and-scaling-methods/ https://access.onlinelibrary.wiley.com/doi/pdf/10.1002/csc2.20048

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			innovative practices around improved nutrition, health and wellbeing created using MOOC.				
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Enhanced genetic gains	Drone imaging tools are used in association with EIB to develop indices for sorghum and other GLDC crops. Drone initiative in India and in Senegal making progress to give access to this technology for breeding teams. Calibration and validation for sorghum agronomical traits viz., biomass, leaf area index (LAI), plant, and panicle counting, and plant height completed to support breeding decisions in West and Central Africa (WCA). It is extended to other commodities with support from bilateral projects in South Asia.	Sorghum crop indices measured routinely, and new indices being explored to support breeding decisions	Completed	Journal article	https://doi.org/10.3390/agronomy11050850
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Technologies that reduce women's labor and energy expenditure developed and disseminated	The traits amenable to harvest etc. are combined with production and resilience traits and lines are tested by the GLDC crop breeding programs. The finger millet cultivars with 'easy snapping' traits are developed for commercialization. The easy snapping trait is combined in the background of good agronomic performance.	Snap millets that are easy to harvest, easy to shell, machine amenable varieties for harvesting, pesticide use etc.	Completed	Report, blog	https://www.icrisat.org/malawi-officially-releases-its-first-improved-chickpea-and-finger-millet-varieties/
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Reduced market barriers	Target population of environments (TPE) analysis is completed in chickpea and groundnut in South Asia and ongoing in the West and Central Africa region. TPE analysis of chickpea and groundnut in India has been used to strategize the multi-environment testing (MET) by the breeding teams	Target population of environments (TPE) analysis has been scaled up to more breeding teams (assuming funding was allocated)	Completed	Published papers, reports	https://doi.org/10.1016/j.fcr.2021.108160

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			from 2020 onwards and the results from these METs were obtained and advancement decisions made in 2021 for the TPEs. Based on the lessons the TPE analysis is expanded to West and Central Africa (WCA) and East and Southern Africa (ESA) regions.				
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Enhanced genetic gains	The breeding lines shared by ICRISAT, IITA and ICARDA are tested by NARS in several target countries. Multi-environment tests (METs) were conducted in collaboration with NARS across the four trait clusters viz., (a) productivity (b) resource-use efficient (c) market traits, and (d) traits that support agri-food systems.	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.	Completed	Reports, data	https://excellenceinbreeding.org/toolbox/tools/breeding-management-system-bms
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Enhanced genetic gains	Quality check is under validation for the GLDC priority crops. The quality control (QC) panels developed under FP5 are under validation with the service provider e.g., InterTek	Crop breeding programs develop and use robust quality control (QC) mechanisms to safeguard genetic purity of products, reputation and impacts for crop commodities	Partially completed	Reason for non-completion: 7- Other- The validated QC panels in under progress and is close to completion.	
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Enhanced genetic gains	Breeding lines and populations of GLDC crops are evaluated for biotic and abiotic stress resistance/tolerance. The traits that are key to agri-business opportunities were targeted and the material with these traits shared with partners for testing.	NARS partners supplied with advanced breeding lines/segregating population for enhanced biotic and abiotic stress tolerance from GLDC -	Completed	Reports=, data	https://excellenceinbreeding.org/toolbox/tools/breeding-management-system-bms

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
				crops X 2 priority trait clusters (1° & 2°)- 30 lines per trait X 2 regions supplied.			
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	Stakeholder engagements of the crops to provide feedback to the breeding program to refine the target product profiles. Market studies have been completed in Myanmar, India, Tanzania, Nigeria, and Mali to revise the crop product profiles of sorghum, pearl millet and groundnut.	Revise 2 crop product profiles each for sub-Saharan Africa, and South Asia, revised based on market studies	Completed	Reports	https://www.icrisa.org/cereal-legume-value-chain-stakeholders-in-wca-meet-to-develop-demand-driven-and-gender-responsive-product-profiles/
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Reduced production risk	Drought and disease tolerant groundnut variety, Kalinga Groundnut-101 (ICGV 02266) released in India. Ashenafi (ICEAP 00554) a medium maturing pigeon pea cultivar is released in Ethiopia to fit the cropping season. Salinity tolerant (PDL-1) and extra-early maturing (L4729) lentil varieties released in India. Resilient GLDC cultivars were released in Burkina Faso, India, and Malawi following multi-environment testing (MET) and farmer participatory testing trials.	Two resilient varieties per region (ESA, WCA and SA) released by NARS partners in any of the target countries (India, Myanmar, Ethiopia, Uganda, Burkina Faso, Ghana)	Completed	Institutional reports	https://bit.ly/3z7cgU9 ; https://bit.ly/3oowC98 ; https://bit.ly/3loWklF ; https://bit.ly/3dmvCMz ; https://bit.ly/2ZWY987 ;
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Increased availability of diverse nutrient-rich foods	High oleic groundnut varieties (Girnar 4, Girnar 5), high oil groundnut variety (Chhattisgarh Mungfali-1 (ICGV 06420). Biofortified pearl millet, sorghum and lentil varieties are commercialized in India with elevated Fe and Zn content. Biofortified pearl millet is also	Four new varieties with enhanced nutrient levels (Fe, Zn, oil, protein, high oleic) developed and released	Completed	Institutional reports	https://bit.ly/3Glvp8u ; https://bit.ly/3rKGts5 ; https://bit.ly/3opEgaK ; https://bit.ly/3Gd1

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			commercialized in Niger.				MWU
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 resilience of agro-ecosystems and communities, especially those including smallholders	A new disease-resistant sorghum hybrid with 23-34% higher yield, best suited for brewing, food, and forage and adaptable to diverse agro-ecologies in Zimbabwe and southern Africa was developed in partnership with Seed Co, a private seed company.	Improved legumes and dry land cereals meet current and emerging and diverse demand for food and feeds leading to increased competitiveness of GLDC commodities.	Completed	Reports	https://bit.ly/3hd4T7u
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Reduced pre- and post-harvest losses, incl. climate change	GLDC breeding programs made new crosses and developed new populations targeting water-deficit stress tolerance, nutrient use efficiency, heat stress tolerance, and new diseases, and combining these traits with agronomic traits. New tools are used in developing such populations like rapid generation advance, and seed-chip genotyping.	New populations/lines for adaptation to heat and water deficit stress and emerging diseases in climate change scenarios developed.	Completed	Reports	https://bit.ly/3lJZyN
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 of beneficiaries to adopt research outputs	Network groups for crop variety development and collaborated line selection sessions conducted. Participatory breeding methods such as farmer participatory varietal trials are routinely done for the GLDC breeding teams, and since 2020 TRICOT (research method that engages farmers in testing and selecting new crop varieties and technologies) testing has also been used.	Participatory breeding methods and Innovation platforms used as early as 2018 in partnership with FP2 and FP3 involving communities and partners in target countries. The new varieties will be the building block for such activities.	Completed	Institutional reports	https://bit.ly/32TKboE ; https://bit.ly/3psDDFm ; https://bit.ly/3Du9mej
4	FP4.O1. New varieties & allied innovations	Enhanced genetic gains	The breeding lines shared by ICRISAT, IITA and ICARDA are tested by NARS in	Phase I genetic materials deployed in	Cancelled	Reason for cancelling: 7-Other-Merged with 2021 reporting of	

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
	improving productivity & production potential, agribusiness opportunity & stabilize food supply.		several target countries.	GLDC crop improvement by CGIAR centers - annually 8 crops X 3 trait clusters X 2 regions tested by NARS.		identical milestone	
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	Stakeholder engagements of the crops to provide feedback to the breeding program to refine the target product profiles.	Review 2 GLDC crop product profiles for SSA and SA guided by the market segmentation in target countries.	Cancelled	Reason for cancelling: 7-Other-Merged with 2021 reporting of identical milestone	
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Reduced production risk	Two resilient varieties per region (ESA, WCA and SA) released by NARS partners in any of the target countries (India, Myanmar, Ethiopia, Uganda, Burkina Faso, Ghana)	Two resilient varieties per region (ESA, WCA and SA) released by NARS partners in any of the target countries (India, Myanmar, Ethiopia, Uganda, Burkina Faso, Ghana)	Cancelled	Reason for cancelling: 7-Other-Merged with 2021 reporting of identical milestone	
4	FP4.O1. New varieties & allied innovations improving productivity & production potential, agribusiness opportunity & stabilize food supply.	Increased availability of diverse nutrient-rich foods	Four new varieties with enhanced nutrient levels (iron, zinc, oil, protein, high oleic) developed and released.	Four new varieties with enhanced nutrient levels (Fe, Zn, oil, protein, high oleic) developed and released	Cancelled	Reason for cancelling: 7-Other-Merged with 2021 reporting of identical milestone	
4	FP4.O2. Robust and responsive global to national breeding systems produce and	Enhanced institutional capacity of partner	About 40 scientists representing 25 public and private sector organizations selected material for their programs during May 1-5 following COVID	NARS partners trained in participatory breeding methods, as well as gender and its	Completed	Institutional reports, blog	https://bit.ly/2YGUHh2

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	deliver novel varieties and allied innovations at appropriate scale and scope	research organizations	protocols.	role on adoption of new varieties. Other skills set included Marker assisted breeding in partnership with FP5 At least. (Annually at least 100 staff trained 10 per crop for Africa and Asia respectively)			
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 development organizations and in poor and vulnerable communities	Trainings conducted in 2021 with adjustments considering the pandemic. Cap dev team can report further on this.	NARS staff trained in new advances and analytics, limited infrastructure development. Annually at least 100 staff trained 10 per crop for Africa and Asia respectively. Both online and off-line programs were conducted by GLDC breeding team to train the NARS staff. Besides, post-docs and research scholars are trained to conduct research on GLDC crop commodities.	Partially completed	Reason for non-completion: 7- Other: Trainings are still being conducted within the timeframe.	
5	FP5.O1. Prebreeding products through use of genebanks and other sources and modern tools to increase genetic diversity in breeding	Increased conservation and use of genetic resources	Developed segregating pre-bred populations in cowpea, finger millet, pigeonpea and pearl millet, some of which have been made accessible through the genebank.	Development of segregating populations for development of intermediate products for 1 priority traits in 2	Partially completed	Reason for non-completion: Internal resources: Key staff, infrastructure or equipment was not available at the time needed	

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	programs globally			crops.			
5	FP5.02. 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	Identified marker trait associations in all crops by using diverse and bi-parental populations. In some cases, these markers have been validated and currently used for introgression of traits.	Promising markers are validated and those found useful are promoted to forward breeding programs as required by breeding pipelines for target GLDC countries.	Partially completed	Reason for non-completion: Internal resources: Key staff, infrastructure or equipment was not available at the time needed	
5	FP5.03. Outcome 5.3: 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	Enhanced institutional capacity of partner research organizations	A climate change facility has been developed at ICRISAT while genomic selection has been optimized in chickpea, pigeonpea, and groundnut	1) One quality lab each at ICRISAT, IITA and ICARDA strengthened for priority nutritional quality traits of GLDC crops 2) deploy genomic selection tools for at least 3 key traits in groundnut, sorghum, and chickpea.	Partially completed	Reason for non-completion: Internal resources: Key staff, infrastructure or equipment was not available at the time needed	
6	Outcome 1: Increased livelihood	Increased livelihood opportunities	Completed and is in pre-print form, awaiting publication. Analysis was carried out using the (International Model for Policy Analysis of Agricultural Commodities and Trade) IMPACT model developed by IFPRI jointly in consultation with other centers of the CGIAR. Demand is fully expected to climb in all countries where bean is currently an important crop.	Researchers wrote a report on foresight analysis that predicts demand for bean based on CIAT research.	Completed	Blog, policy brief	https://bit.ly/3GjbtU4
6	Outcome 4: Enhanced	Increased	Initial efforts to establish the rapid	Researchers advanced	Completed	Reports, blogs	https://bit.ly/3Dmz

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
	genetic gain	livelihood opportunities	generation advance (RGA) setup for common beans has been done, further progress to be reported. 12 climbing bean varieties released in Rwanda: ;RW-CB 185, RW-CB 183, RW-CB 182, RW-CB 188, RW-CB 181 (HIB, large red mottled), RW-CB 1811, RW-CB 1812, RW-CB 184 (HIB, large red mottled), RW-CB 186 (HIB, large red), RW-CB 189 (HIB, large brown), RW-CB 191, RW-CB 1810, RW-CB 187.	and established RGA-rapid generation for climbing beans.			gl8
6	Outcome 1: Increased livelihood	Increased livelihood opportunities	At the Alliance-Kawanda, populations developed through the Rapid Cooking Bean project (RCBP) supported by the Australian Centre for International Agricultural Research were advanced. Genomic analysis of 358 varieties in the African bean panel based on 33 field trials in East Africa was conducted and generated a Founder 2 population. The Founder 2 population had been genotyped and phenotyped for grain yield, cooking time (CKT), iron and zinc.	Researchers developed and shared first crosses specifically for fast cooking time.	Partially completed	Reports Reason for non-completion: Other, please state: Reports soon to be published	
6	Outcome 3: Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	Heat tolerant Andean (HTA) lines were yield tested at 22C nights with positive results. Progress was made to understand the Genotype-by-Environment interactions for drought stress response to present and future climates across the Accelerated Varietal Improvement and Seed Systems in Africa (AVISA) project countries using the Decision Support System for Agrotechnology Transfer (DSSAT) v4.7 model together with historical and	Researchers confirmed ten heat-tolerant lines selected from interspecific populations.	Partially completed	Reports Reason for non-completion: Other, please state: Publications submitted undergoing review.	

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			future climate data. The study categorized Ethiopia (White Pea), Tanzania (EAREM, YB), and Uganda (EAREM) into different environmental groups (EGs) and suggests that identifying genotypes with tolerance to severe terminal drought, with co-benefits in relation to adaptation to moderate and extreme terminal drought will be most useful. Findings have been submitted to the Environmental Research Letters Journal.				
6	General	3.3.1	As part of an effort to develop target Populations of Environments (TPE), simulations of drought stress were completed based on calibrations with variety Calima. A broader study with calibrations based on 11 genotypes is on-going.	Researchers conducted foresight studies which included further elements such as climate, population, markets, adoption/ consumption preferences.	Completed	Report, blog	https://bit.ly/3GjbtU4
6	General	C.1.3	Researchers conducted foresight analysis using CIAT data to estimate competitiveness of beans in relation to other crops.	Researchers conducted foresight analysis using CIAT data to estimate competitiveness of beans in relation to other crops.	Completed	Report, blog	https://bit.ly/3GjbtU4
6	Outcome 1: Increased livelihood	1.3.1	Progress delayed due to limits imposed by pandemic. Lines are expected in 2022. Pandemic has limited the number of workers that can enter installations.	Researchers produced first breeding lines with non-darkening trait locus introgression in	Partially completed	Reason for non-completion: Other, please state: Publications submitted undergoing review.	

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
				commercial Andean grain types			
6	Outcome 2: More efficient use of inputs	1.3.4 D.1.2.	in collaboration with other initiatives, there were 1157 bean demonstration sites displaying different varieties, recommended fertilizer application rate and recommended plant population growth were established. In collaboration with MSIDP there were 957 demonstration sites of improved bean varieties (NUA 45, SER 83, Napilira and VTTT 924/4-4) combined with fertilizer application and recommended planting density. Of these, 488 (51%) were hosted by female farmers and 469 (49%) were hosted by male farmers.	Researchers quantified potential for enhanced root penetration from <i>P. coccineus</i> .	Partially completed	Reason for non-completion: Other, please state: Reports being finalized	
6	Outcome 4: Enhanced genetic gain	1.4.3	mineral content (Fe and Zn) of existing and new germplasm from different sources were analyzed and an inheritance and Genome Wide Association Study (GWAS) conducted by a PhD student. The Thesis entitled "Genetic diversity, association mapping analysis and inheritance of seed iron and zinc concentration of common bean (<i>Phaseolus vulgaris</i> L.) in Ethiopia" - submitted to University of Ghana. Promising genotypes from this study may be used in future crosses and national variety trials.	Researchers tested genomic selection	Partially completed	Reason for non-completion: Other, please state: Reports being finalized	
6	Outcome 4: Enhanced genetic gain	1.4.3	A total of 501 yellow bean trader samples collected by a team of Alliance of Bioversity and International Centre for Tropical Agriculture (Alliance) and	Researchers and partners evaluated at least 10,000 DNA samples at Intertek.	Partially completed	Reason for non-completion: Other, please state: Reports being finalized	

Flagship	FP outcomes	Sub-IDOs	Summary narrative on progress against each FP outcome this year.	Milestone	2021 milestone status	Provide evidence for completed milestones/Reason for uncompleted milestones	Links to evidence
			TARI researchers and 12 reference materials (samples of known released yellow bean varieties) provided by TARI) were sent to the Alliance-Kawanda, in Uganda. These were analyzed at Intertek in Sweden.				

Table 6: Numbers of peer-reviewed publications (Sphere of control)

Type of publications	Number	Percent
Peer-Reviewed publications	85	100%
Open Access	71	83%
ISI	81	95%

Full list of publications available at:

https://mel.cgiar.org/reporting/download/report_file_id/28534

Table 7: Participants in CapDev Activities

Number of trainees	Female	Male
In short-term programs facilitated by CRP	4376	4449
In long-term programs facilitated by CRP	15	16
* PhDs	11	13

Full list of capacity development activities available at:

https://mel.cgiar.org/reporting/download/report_file_id/28535

Table 8: Key external partnerships

Lead FP	Brief description of partnership aims (max. 30 words)	List of key partners in partnership. Do not use acronyms.	Main area of partnership (may choose multiple) Dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify
1	A post-doctoral fellow from JIRCAS is scheduled to undertake fieldwork in India for life cycle assessment of BNI sorghum technology	JIRCAS	Research
1	Joint publication of a Special Issue on Aspirations	Future Rural Africa Research group	Research
1	BBC feature on healthier urban food choices in light of COVID disruption	Billian Music foundation	Delivery
1	Proposal development for further exploration of work on aspirations	Bangor University, Mercy Corps	Partnerships
1	Understanding past adoption success stories to learn for future approaches	Institute of Development Studies	Research
1	GLDC impact estimation	Swedish University of Agricultural Sciences	Research
3	ICRISAT implemented its activities in partnerships with MSU with the main aim to complement each other in their efforts to reach beneficiaries. MSU brings to the partnership, long-term on-farm experiments that are used by ICRISAT to understand the performance of the systems being tested using APSIM modelling techniques.	Michigan University, Lilongwe University of Agriculture and Natural Resources, Department of Agricultural Research Services and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Research
3	Integrated assessment and modelling of agricultural livelihood systems, farming system design for sustainability	Rural Development Institute (IDR), University Nazi BONI (former University of Polytechnic Bobo-Dioulasso - UPB), Burkina Faso.	Research, Delivery, Capacity Development

Lead FP	Brief description of partnership aims (max. 30 words)	List of key partners in partnership. Do not use acronyms.	Main area of partnership (may choose multiple) Dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify
3	Investigate the role of circular agriculture for ensuring sustainable intensification	Zurich University of Applied Science.	Research
3	Apply big data analytics and tool for SI innovation out-scaling	SCIO Systems (https://scio.systems/).	Big data analytics and tool development
3	Co-supervise and collaborate doctoral research in sustainable/ecological agriculture	Center for Development Research (ZEF), University of Bonn.	Research, Capacity Development
3	Soybean variety evaluation and inputs omission trials	Soybean Innovation Lab, University of Illinois	Research and delivery
3	Modelling the effects of cropping sequence on component crop performance	Centre for Dryland Agriculture, Bayero University, Kano, Nigeria	Research
3	Collaborative work on criteria and indicators and framework for sustainable intensification and sustainability assessment:	ICRISAT, ICARDA, Wageningen University & Research (WUR), Swedish University of Agricultural Sciences (SLU), Crea2solutions	Research
3	Systems modelling to co-design sustainable farming systems.	ICRISAT, Indian Council of Agricultural Research and Commonwealth Scientific and Industrial Research Organization (CSIRO)	Research/Delivery/Capacity Development
3	Innovation in the application of integrative data analysis for crop-soil-climate models to integrate these data sources with spatial and temporal variation being simulated to produce maps of crop performance.	Michigan state university (MSU) and Africa Rising; WCA - ATSAP and TAAT; India meteorology department (IMD); Indian Council of Agricultural Research (ICAR), Mahalanobis National Crop Forecast Centre (MNCFC), India and the communities of practice (AGMIP, Big Data for Agriculture)	Research/Delivery/Capacity Development
3	Contextualizing research, capacity building, linking with farmer communities.	National agricultural research institutes (NARS) in Burkina Faso (INERA), Mali (IER), Niger (INRAN), India (ICAR), Tunisia, Syria, Sudan.	Research/Delivery/Capacity Development

Lead FP	Brief description of partnership aims (max. 30 words)	List of key partners in partnership. Do not use acronyms.	Main area of partnership (may choose multiple) Dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify
3	System dynamics modelling for value chain analysis to identify entry points and support enabling policies.	ICRISAT and Massachusetts Institute of Technology (MIT)	Research
3	Science-driven and farmer-oriented insect pest management for cowpea agro-ecosystems in West Africa.	Feed the Future Innovation Lab for Legume System Research, Michigan State University	Research/Delivery/Capacity Development
6	Food Systems and expanding bean corridor in semi-arid zones of Kenya	World Food Programme	Delivery and policy advocacy
6	Research Bean along the value chain e.g. breeding /capacity building	Benin national research institute	Research and delivery
6	Grain import and support community and PABRA to implement bean corridor in Zambia and soon other countries	SharingourBest Company	Delivery
6	Testing Agro-inputs in Kenya and exchange of information on fertilizers and weather	Yara Ltd	Delivery
6	Bean value chain development focus on bean corridors	2 Scale – IFDC (International fertilizer development Center	Delivery
6	Small and medium enterprises' s business incubation	Aceli Africa	Capacity development
6	Grain bulking and processing	Ndarugu Metropolis	Delivery
6	Variety testing/release, seed Production and multiplication	Consortium of Seed Companies in Kenya	Delivery
6	Grain Export	Best in Rwanda Group	Delivery

Lead FP	Brief description of partnership aims (max. 30 words)	List of key partners in partnership. Do not use acronyms.	Main area of partnership (may choose multiple) Dropdown: Research/Delivery/Policy/Capacity Development/Other, please specify
6	Variety testing/release, seed Production and multiplication	Seed Co Ltd	Delivery
6	Variety testing/release, seed Production and multiplication	Zimbabwe Super Seed	Delivery
6	Bean seed and grain production and commercialization /value addition	Smiling Through Investments	Delivery

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
Development of the final 'CGIAR Foresight Report' in collaboration with CGIAR foresight team which involves all CGIAR centers	Collaborating CRP: PIM Collaborating CGIAR center: all	Knowledge-sharing and joint scientific products through the established community of practice on foresight.
MEL-based social network analysis for better performing CRP	RTB	Identify CRP-GLDC structures and operations that have contributed to publishing knowledge/science products and which of these have been more effective in increasing multi-disciplinary publications and evaluate how GLDC as a CRP adds more collaborations to the knowledge exchange networks.
Special Issue on demand orientation in seed systems	MAIZE, PIM, RTB	Broader coverage of specific issues in different types of seed systems
New partnership on urban food systems	World Agroforestry, ICRISAT, and TMG Berlin	Spin off from GLDC's investment in urban food systems
Partnering for DSSAT and APSIM models simulation of crop performance in Nigeria savannas	IITA, ICRISAT Nigeria	Scientific
Collaborative work on the framework for measuring sustainability and resilience of farming systems	ICRISAT, ICARDA	Scientific
Mainstreaming gender crosscutting theme into research and development activities to improve GLDC-based farming systems	ICRISAT, ICRAF, IITA, ICARDA	Scientific
Shared work by FP3 with ICRAF in Tanzania to advance the crop modelling of agroforestry systems	ICRAF	Scientific
Jointly develop specialized nethouse facility for phenotyping Fall armyworm in sorghum, millet, and maize at the ICRISAT station in Patancheru, Hyderabad	CIMMYT, ICRISAT	Scientific
Working on collaborative project to raise funds for research in Mozambique for pulses	Alliance Bioversity-CIAT, CIP, IITA, CIMMYT, IMWI and ICRISAT	Funding, scientific
Under AVISA project in Tanzania	Alliance Bioversity-CIAT, CIMMYT, IITA	Scientific and efficiency
Demand-led breeding to modernize breeding in Africa collaborating with University of Queensland	Alliance Bioversity-CIAT, GLDC, Africa Plant Breeding Association	Scientific and efficiency

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 & updates for 2021 mid-year	Links to MELIA publications
Analysis of the nutritional and production system impacts of the introduction of the improved lentil varieties in India	Completed	Correlates of adoption/impact study	Based on survey data that has already been collected in 2019 and 2020 from India, 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 the major lentil-growing provinces of India. Depending on availability of resources, an attempt will also be made to combine the datasets from Bangladesh and India to make a regional analysis. First, we carried a study on the nutritional impacts of the short season lentil varieties in India and then, did another regional study on the impacts of the short season lentil varieties on the production system will be carried by combining the data from both India and Bangladesh.	https://doi.org/10.1016/j.foodpol.2018.11.004
Assess the adoption and welfare impacts of improved sorghum and finger millet varieties in Ethiopia and Tanzania	Partially completed	EPIA: Ex-post Impact assessment	The research carried out under ICRISAT's HOPE II with national partners (EIAR and TARI), computed the impact of adoption, while counting for possible errors from access to technology transfer and improved seed. Farmers' survey was conducted in 2020; data analysis started and write up will be conducted in 2021. Further, surveys on other value chain actors (seed producers, traders etc.) scheduled in 2021 has been delayed.	https://doi.org/10.3390/su132313463 https://doi.org/10.1016/j.gfs.2020.100458
Assess the nutritional/dietary impacts of GLDC crop varieties	Completed	EPIA: Ex-post Impact assessment	The objective of the activity is to estimate GLDC's impact on the SLO nutrition targets specified in the proposal. There are three elements of the estimation approach: a) Assess key nutrient gaps in GLDC target countries; b) Estimate additional nutrients made available via adoption of GLDC crops (joint work with Michael and Wanjiku) vis-à-vis gaps; and c) Use adoption to estimates and evidenced assumptions vis-à-vis consumption to estimate target contribution. A complementary study is also being carried out under FP4: Based on the analysis of farm households' nutrition security and determinants in the three GLDC focus countries, crop diversification	https://doi.org/10.5716/WP19006.PDF

Studies/learning exercises planned for this year (from POWB)	Status	Type of study or activity	Description of activity / study & updates for 2021 mid-year	Links to MELIA publications
			came out strongly as a pathway for reducing nutrition insecurity. Hence, protocols were developed for promoting small households' fruit and vegetable gardens, and for assessing the effects of the consum	
Finalization of execution of Integrated and multi-faceted impact assessment and learning strategy for GLDC	Partially completed	EPIA: Ex-post Impact assessment	Finalize execution of strategy to broadly estimate the impacts of GLDC vis-à-vis the CGIAR's Strategic Results Framework (SRF) targets. Three key components for 2021: 1. finalizing 2020 activities (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; 2. Estimating productivity and income impacts; 3. Documenting delivery, demand, and work to bring about an enabling environment.	https://mel.cgiar.org/reporting/download/report_file_id/27640
Identify preferred traits across the value chain actors for groundnut and sorghum in Tanzania	Partially completed	Correlates of adoption/impact study	The objective of this study was to evaluate farmer's preference for traits of improved sorghum and groundnut varieties by assessing various attribute combination that farmers prefer for breeding purposes. A farmer survey was conducted in 2020; data analysis started and write up will be conducted in 2021. Further, surveys on other value chain actors (seed producers, traders etc.) will be done in 2021.	https://mel.cgiar.org/reporting/download/report_file_id/24483 ; https://mel.cgiar.org/reporting/download/report_file_id/24481
Sustainability assessment of smallholder's farming system: Assessment of the impacts of sustainable intensification options	Completed	EPIA: Ex-post Impact assessment	This framework/tool has been tested at a small scale in India and Niger and is almost ready to be scaled following but needs further testing and validation across the regions and was identified as a 'Golden Egg'. CGIAR's two initiatives development teams (IDTs) have shown interest to adopt it at large scale to be useful for researchers, development, and policy actors to identify entry points and design domain-specific and more effective interventions and policies to improve sustainability and resilience of farming systems in SA and SSA. The tool assists to better target and tailor recommendations as well as track progress of implemented	http://glcd.cgiar.org/crp-glcd-golden-eggs-contribute-to-healthy-diets-management-tools-and-scaling-methods/ ; https://ageconsearch.umn.edu/record/315206/files/0-

Studies/learning exercises planned for this year (from POWB)	Status	Type of study or activity	Description of activity / study & updates for 2021 mid-year	Links to MELIA publications
			solutions (practices, technologies, policies) in a multi-dimensional sustainability context enabling to monitor impact on KPI's and understand potential trade-offs. The online automated version of the tool will be available in public domain by end of 2021.	0_Paper_19102_han dout_241_0.pdf
Impact of trait and QC SNPs markers applications in modernization of crop improvement programs	Partially completed	EPIA: Ex-post Impact assessment	This study aims to assess the impact of innovative genomic technology towards prioritized trait discovery/ mapping/ dissection, functional validation and deployment of traits and pre-breeding by exploiting natural and/or systematically induced variations for prioritized traits in combination with modern genomics, transgenics, genome editing, phenomics and breeding tools for accelerated, precise, cost-effective, and efficient breeding of new varieties in the future.	http://oar.icrisat.org/11537/1/btn-2020-0066.pdf
Assess the adoption and impacts of improved common bean productivity enhancing technologies on yields and on household welfare	Partially completed	EPIA: Ex-post Impact assessment	Estimates of improved bean variety adoption was conducted by using DNA fingerprinting method of variety identification and analyze the impact of adoption on household food security and aggregated consumption expenditure.	https://agrilinks.org/post/yellow-bean-corridor-seed-grain-trade-potential
Analyzing bean market segments, the preferences and demand for important bean traits	Partially completed	Other MELIA Activity-Comms-related	The aim of this study is to identify and define market segments for bean produced in both countries and estimate the demand for preferred traits, customers' profile for each trait and inform breeders of potential product profile concepts.	https://pdf.usaid.gov/pdf_docs/PA00XS8V.pdf https://dx.doi.org/10.1186%2Fs13002-021-00442-3
Assessing the impacts of improved common bean variety adoption on bean production and food security	Partially completed	EPIA: Ex-post Impact assessment	The short and medium-term outcomes of the flagship project implement in Burundi have been assessed to improve access to improved technology, its effect on productivity, bean consumption, and household food security.	https://cgspace.cgiar.org/handle/10568/109119
Bean technology adoption and its impacts on smallholder farmers 'productivity, bean consumption and	Partially completed	EPIA: Ex-post Impact assessment	The short and medium-term outcomes of the flagship project implement in Zimbabwe have been assessed to improve access to improved technology, its effect on productivity, bean consumption,	https://cgspace.cgiar.org/handle/10568/80211

Studies/learning exercises planned for this year (from POWB)	Status	Type of study or activity	Description of activity / study & updates for 2021 mid-year	Links to MELIA publications
food security			and household food security.	
Midterm review of operationalization of market led functionality of bean corridors and its effect on private value chain businesses	Partially completed	Program/project evaluation/review	This is part of monitoring project progress towards the goal of market led bean intervention and structure trade to enhance incentives for bean value chain actors. Then the study will generate lessons and provide feedback to researchers on what is working and what can be improved.	https://doi.org/10.3390/su13168897 https://www.crs.org/sites/default/files/analysis_yellow_bean_corridor_in_tanzania.pdf https://hdl.handle.net/10568/80540
Identify a common set of performance indicators that all projects can report on at the CRP level beyond the CGIAR ones	Partially completed	Other MELIA activity	A set of generic indicators mapped to CGIAR SLO's has been completed and will be optimized towards mapping to GLDC research and development activities. A brief will be finalized with the set of performance indicators fitted to CRP-GLDC initiatives.	https://mel.cgiar.org/reporting/download/report_file_id/31504

Table 11: Update on Actions Taken in Response to Relevant Evaluations

Col.1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7	Col.8
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							

Table 12: Examples of W1/2 Use in this reporting period (2021)

Col. 1	Col. 2
Please give specific examples, one per row (including through set aside strategic research funds or partner funds) Max 50 words/example, but please aim for 30	Select broad area of use of W1/2 from the categories below - (drop down) Select <u>only one</u> category in the GUIDANCE.
Research activities on manuscripts to be submitted for publication in peer-reviewed scientific journals	Pre-start up
Special Issue contributions (5 papers) on <u>Rural Aspirations: Livelihood Decisions and Rural Development Trajectories</u> in the European Journal of Development Research	Research
Case study that aims to link rural groundnut production and urban, low-income consumers with aflatoxin-safe, organically produced groundnuts in Nairobi	Delivery
GLDC impact assessment	MELIA
A total of 6000 small seed packs were distributed for the Pan African Variety trials and 2 tons of Foundation seed distributed to the Private Seed companies to conduct trials in Malawi, Zambia, Mozambique and Nigeria.	Research, partnership
Climate resilient and market preferred GLDC cultivars (of groundnut, chickpea, pearl millet, sorghum, and pigeon pea) released in 2021	Delivery
Engage small- and medium- seed companies to deliver the released GLDC cultivars to replace old varieties.	Partnership
Advancement decision used grain nutritional quality as selection criteria	Mainstreaming biofortification
Developing imaging tools for phenotyping to increase efficiency, robustness and reduce cost.	Research
Adaptability evaluation of lines from international partners to determine potential donors and lines for yield-related traits in West and Central Africa	Research, Partnership
Leveraging on the Peanut Innovation Lab initiative, phenotyping of AB-QTL lines for disease resistance and yield component traits, eventually to be evaluated by partners in WCA	Research, Partnership
A new source of drought tolerance (Lodoka) and Striga resistance (ICSV III IN and F6YQ212) in sorghum were identified using Diversity Arrays Technology (DArT) sequencing which will be used to characterize the traits further and map responsible QTLs.	Research

Table 13: CRP Financial Report

Instructions:

Please fill in the table based on the status of CRP's financials:

CRP-GLDC	2020 forecast (W1/W2)	2021 budget (W1/2)	Total Budget 2021	Total Expenditure (W1/W2)	Balance/ Difference	Comments on major changes
Personnel	1,84,623	38,40,182	40,24,804	40,80,563	(55,759)	
Consultancy	-	-	-	-	-	
Travel	-	1,63,255	1,63,255	1,15,942	47,313	
Operational expenses	5,12,970	18,69,147	23,82,118	21,34,014	2,48,104	
Collaborators and partnerships	10,000	92,231	1,02,231	1,42,146	(39,915)	
Capital and equipment	-	52,923	52,923	52,923	-	
Closeout cost	-	60,000	60,000	-	60,000	Approved to spend in 2022
Indirect costs	78,385	9,32,262	10,10,646	10,08,749	1,897	
CRP total <u>budget</u>	7,85,978	70,10,000	77,95,977	75,34,338	2,61,640	

Part C: Additional evidence is accessible through the Management Information System and relevant links in the report

The CRP-GLDC MIS system (mel.cgiar.org) allowed the reporting of data all year round as soon as information was available across research teams. Following are charts that provide a sense of the progress made by the program in target countries.

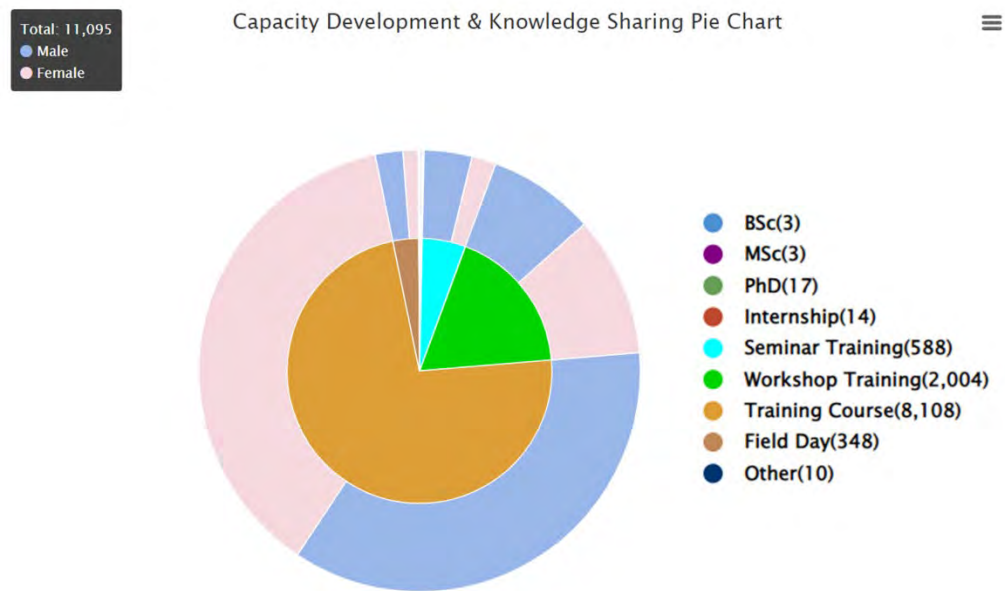


Figure 1. The types of capacity development (CapDev) activities in 2021 disaggregated by gender helped understand the scale of investment towards knowledge sharing. Although mass CapDev took most of the share, reporting takes particular note of long-term training (e.g., BSc, MSc, and PhD) which implements research, and generates knowledge products.



Figure 2. Delivery of results starts from partnerships. In 2021, CRP-GLDC brought together partners from Europe, US, Latin America, and Australia to work together with partners on the ground. The dialogue with partners was an important cross-cutting activity for the research teams.

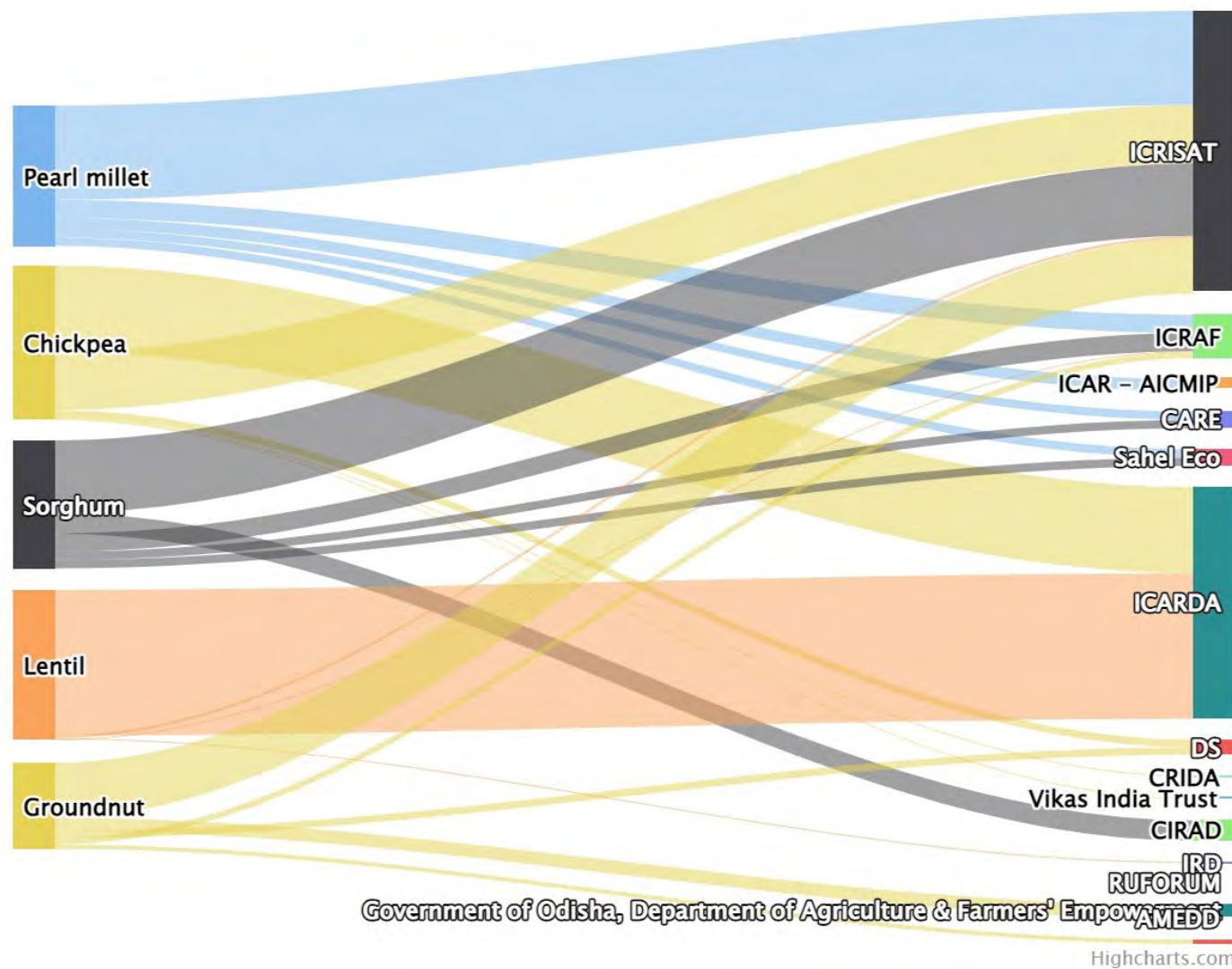


Figure 3. CRP-GLDC's multi-crop approach widens cooperation opportunities among partner institutions, not just among primary implementing CGIAR centers, but also with external partners such as national donors, specialist institutions, and NGOs.

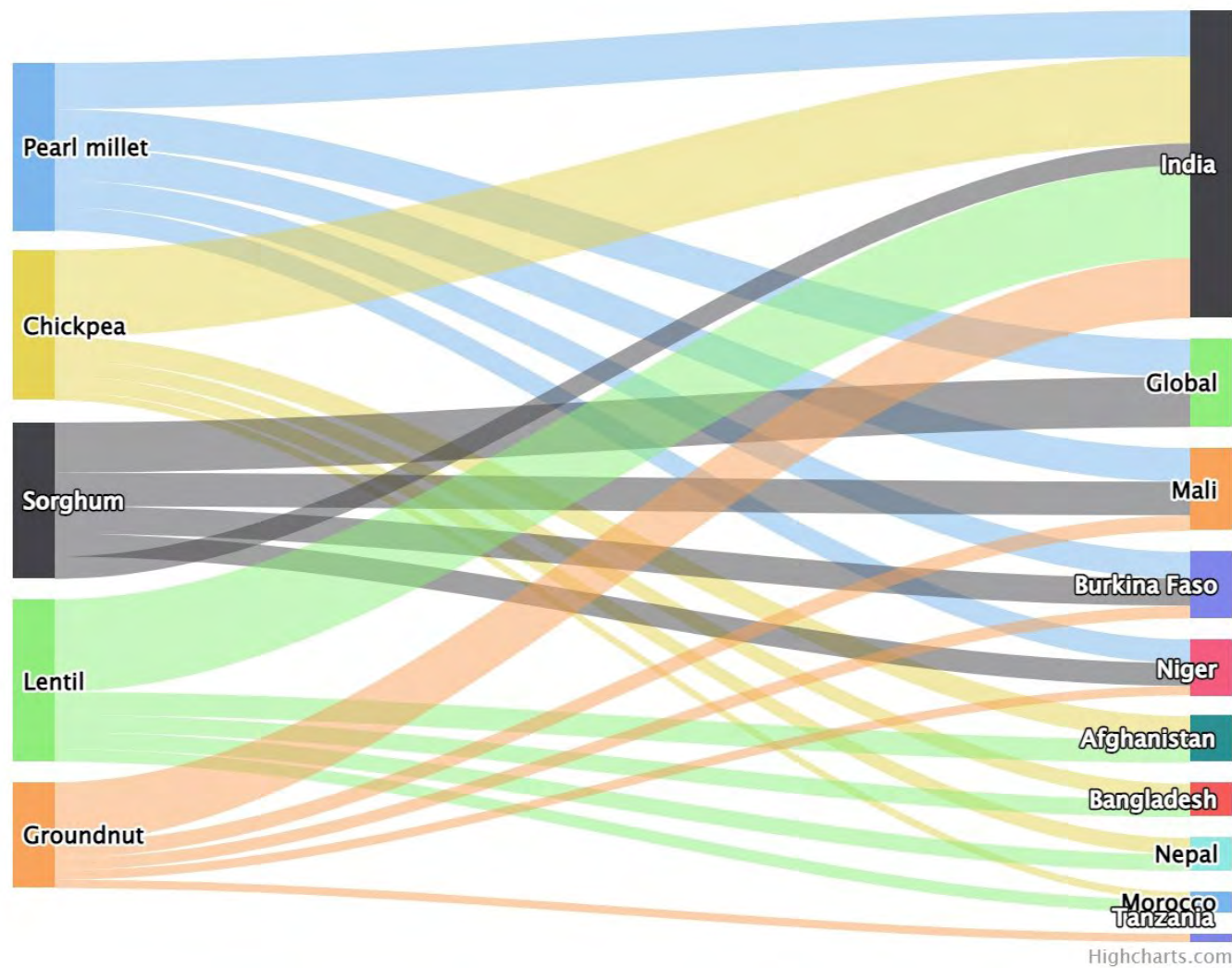


Figure 4. Covering technologies, knowledge products and interventions for ten priority crops, CRP-GLDC co-enables the transformation of underperforming grain legumes and dryland cereal agri-food systems in South Asia and Sub-Saharan Africa.



**RESEARCH
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Grain Legumes and
Dryland Cereals

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Contact us

Kiran K Sharma, Director, CGIAR Research Program on Grain Legumes and Dryland Cereals, Tel (0) +91 84556 83300,
Mobile +91 98495 48540, E-mail: k.sharma@cgiar.org

Neena Jacob, Program Manager, CGIAR Research Program on Grain Legumes and Dryland Cereals, Tel (0) +91 84556 83166,
Mobile +91 97041 11832, E-mail: N.Jacob@cgiar.org

For more information: <http://gldc.cgiar.org>