CRP-GLDC

Annual Report **2020**

CGIAR 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 Centre (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).*

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Abbreviations and Acronyms

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health
ASARECA	Association for Strengthening Agriculture Research in Eastern and Central Africa
AVISA	Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa Project
BGMV	Bean golden mosaic virus
BMGF	Bill & Melinda Gates Foundation
BMS	Breeding Management System
CapDev	Capacity Development
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CEDO	Community Enterprises Development Organization
CENT	Centro Nacional de Tecnología Agropecuaria y Forestal
CIAT	International Institute of Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CLARISA	CGIAR Level Agricultural Results Interoperable System Architecture
CNGs	Crop Network Groups
CRP	CGIAR Research Program
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
CtEH	Crops to End Hunger
CWR	Crop Wild Relatives
DACA	Digital Agro Climate Advisory
DEME	Design, Execution, Monitoring, and Evaluation
DICTA	Direccion de Ciencia y Tecnologia Agropecuaria
DM	Downy mildew
DNA	Deoxyribonucleic Acid
DTM	Drought Tolerant Maize
EACD	Eastern Agricultural Development Company
EAREM	East Africa Red Mottled Beans
EIAR	Ethiopian Institute of Agricultural Research
EiB	Excellence in Breeding platform

ESA	Eastern and Southern Africa
EU	European Union
FAO	Food and Agriculture Organization
FAW	Fall Armyworm
FISH	CGIAR Research Program on Fish
FP	Flagship Program
FPO	Farmer Producer Organization
FTA	CGIAR Research Program on Forests, Trees and Agroforestry
GAC	Global Affairs Canada
G x E	Genotype x Environment
GLDC	Grain Legumes and Dryland Cereals (CRP-GLDC)
GOBii	Genomic Data Management System
GS	Genomic Selection
HIB	High-Iron Beans
HIL	Hindustan Insecticides Limited
HTA	Heat Tolerant Andean
HTP	High Throughput Phenotyping
IA	Intellectual Assets
IAC	Independent Advisory Committee
IBP	Integrated Breeding Platform
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICAR-IIMR	Indian Council of Agricultural Research - Indian Institute of Millets Research
ICAR- IIPR	Indian Council of Agricultural Research - Indian Institute of Pulses Research
ICM	Integrated Crop Management
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICTA	Instituto de Ciencia y Tecnología Agrícolas
IDIAF	Instituto Dominicano de Investigaciones Agropecuarias y Forestales

IDM	Integrated Disease Management
IDO/Sub-IDO	Intermediate Development Objective
IER	Institut d'Economie Rurale
IFAD	International Fund for Agricultural Research
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IMD	India Meteorology Department
INERA	Institut de l'Environnement et de Recherches Agricoles
INIA	Instituto Nacional de Innovación Agraria
INIAF	Instituto Nacional de Innovación Agropecuaria y Forestal
INRA	Institut national de la recherche agronomique, France
INRAN	Institut National de Recherche Agronomique du Niger
INTA	Instituto Nicaragüense de Tecnología Agropecuaria
IPM	Integrated Pest Management
ISABU	Institut des Sciences Agronomiques du Burundi
KAP	Knowledge, attitudes and practices
KASP	Kompetitive allele specific PCR
KSU	Kansas State University
LAC	Latin America and the Caribbean
LMS	Learning Management System
MAIZE	CGIAR Research Program on Maize
MAGIC	Multiparent Advanced Generation Intercross
MARLO	Managing Agricultural Research for Learning and Outcomes
MCT	Multi Crop Thresher
M&E	Monitoring & Evaluation
MEL	Monitoring, Evaluation, and Learning
MELIA	Monitoring, Evaluation, Learning, and Impact Assessment
MET	Multi-Environment Testing
MFN	MasterCard Farmer Network
MIT	Massachusetts Institute of Technology
MNCFC	Mahalanobis National Crop Forecast Centre

MoU	Memorandum of Understanding
MSU	Michigan State University
MPAB	Markets and Partnerships in Agri-business
NARS	National Agricultural Research System
NGOs	Non-Governmental Organizations
NIAB	National Institute of Agricultural Botany
NIRS	Near-Infrared Spectroscopy
NPK	Nitrogen, Phosphorus, Potassium
NRM	Natural Resource Management
OCRI	Oil Crops Research Institute - Chinese Academy of Agricultural Sciences
OICR	Outcome, Impact Case Reports
PABRA	Pan-African Bean Research Alliance
PGP	Plant Growth Promoting
PIM	CGIAR Research Program on Policies, Institutions, and Markets
POWB	Plan of Work and Budget
PP	Product Profile
PPP	Per person per year
PVS	Participatory Variety Selection
QC	Quality Check
QTL	Quantitative Trait Loci
RGA	Rapid Generation Advancement
RGT	Rapid Generation Turnover
RMC	Research Management Committee
RTB	CGIAR Research Program on Roots, Tubers, and Bananas
SA	South Asia
SDC	Swiss Agency for Development and Cooperation
SFSA	Syngenta Foundation for Sustainable Agriculture
SIL	Soybean Innovation Lab
SLO	CGIAR System-Level Outcomes
SLU	Swedish University of Agricultural Sciences
SMEs	Small and Medium Enterprises

SMO	CGIAR System Management Office
SNP	Single Nucleotide Polymorphism
SNRM	Sustainable Natural Resource Management
SOC	Soil Organic Carbon
SRF	Strategic Results Framework
SSA	Sub-Saharan Africa
TAAT	Technologies for African Agricultural Transformation
TARI	Tanzania Agricultural Research Institute
TASTA	Tanzania Seed Trade Association
The Alliance	Alliance of Bioversity International and CIAT
TL III	Tropical Legumes III Project
ToC	Theory of Change
TPE	Target Population of Environments
TSL	The Sainsbury Laboratory
TSSDC	Telangana State Seed Development Corporation Limited
USDA	United States Department of Agriculture
VDSA	Village Dynamics Studies in South Asia
VLS	Village Level Studies
WCA	West and Central Africa
WCA-ATASP	West and Central Africa - Agricultural Transformation Agenda Support Program
WUR	Wageningen University & Research
XRF	X-Ray Fluorescence
ZASFCO Ltd	Zasse Agricultural Seed and Food Company Limited
ZEF	Center for Development Research

Executive Summary

The CRP-GLDC Flagship Program 1 aims to enhance the impacts of research through improved targeting and priority setting. Gender-sensitive prioritization of varietal attributes in target countries defined the end-user preferred traits that should be targeted by breeders. The work on rural aspirations generated evidence on technology targeting and scaling efforts. While the gender and youth research focused on the integration of youth and the effects of migration on feminization of agriculture, studies on adoption and impact generated evidence of progress towards the SLO targets.

The Flagship Program 3 focused on variability among pearl millet blast isolates, scaling up of biocontrol agents against pests and diseases, and microorganisms for plant growth promotion. Sustainable intensification and diversification of integrated cropping systems and high-yielding and early maturing soybean and cowpea genotypes were identified. Sustainability of farming systems at farm and household levels, modelling and development of decision support tools, resilience of the households, diversity of diet and capacity strengthening of key stakeholders were key areas of focus.

The Flagship Program 4 contributed to cultivars releases that combine traits related to production, markets and consumers that contribute to nutritional security, climate resilience, driving new value chains, promoting employment opportunities among youth and women, and contributing to environmental sustainability. For example, partnership with the national programs resulted in the commercialization of 30 GLDC crop cultivars including chickpea (10), lentil (5), groundnut (5), sorghum (2), pearl millet (5), soybean (1) and finger millet (2) in Africa (Burkina Faso, Ethiopia, Malawi, Kenya) and Asia (India). These include first chickpea varieties released by ICRISAT in Malawi with yield potential of 3 t per ha to help crop diversification, besides machine harvestable chickpea in Ethiopia and India with resistance to wilt, drought tolerance and early maturity. The Product Profiles of the GLDC crops were designed and/or revised through stakeholder consultations and feedback from Crop Network Groups and value chain studies. As a part of breeding modernization, ICRISAT established automated seed processing, data collection and seed inventory, besides RapidGen facilities for rapid generation advancement of its crops.

The Flagship Program 5 used crop wild relatives to address priority traits, released and advanced molecular breeding products in groundnut, pearl millet, and chickpea. The deployment of markers including trait-linked Single nucleotide polymorphisms, quality control (QC) and mid-density panels, and protocols for rapid generation advancement in GLDC crop breeding programs were achieved. New tools and breeding technologies such as mutant populations, genome editing, and genetic engineering have provided new approaches for addressing intractable traits such as striga resistance in sorghum and rancidity in pearl millet at ICRISAT.

Under the Flagship Program 6, 2.8 million (M) households (58.5% represented by women) accessed various technologies for varieties, integrated crop management and labor saving technologies, representing a 10.3% achievement above the annual target of 2.5 M. CIAT released twenty-five new bean varieties including 16 stress tolerant and 8 high iron beans (HIB), and produced 5,905.7 t seed for partners. The number of people accessing HIB varieties increased by 49% in 2020 compared to 2019.

PART A. NARRATIVE SECTION

1. Key Results

1.1. Highlight Global Progress and Achievements

1. Common bean improvement research helps reduce poverty in 2.5 M families in Ethiopia

In Ethiopia, beans provide essential nutrition and income to nearly 4 M smallholder farmers. The "White gold" beans are white pea beans, nutrient-rich and market-oriented baking types that when exported, fetch farmers three times more income than crops such as maize. With favorable traits that enable farmers to survive climate and market shocks while also feeding their families, these improved beans have now been adopted by approximately 2.5 M farmers, covering up to 65% of the total national bean area. Together with improved crop management practices, these varieties significantly increased yields from an average of 0.5 t/ha in 2004 to 1.6 t/ha in 2016. For farmers, this has translated to increases in food and other important expenditures by as much as US$ 217 per person per year (PPP).

2. High oleic groundnut varieties commercialized in India meet the enhanced shelf-life needs of food industry and consumer health benefits

The two high oleic groundnut varieties Girnar 4 (ICGV 15083) and Girnar 5 (ICGV 15090) are among the 17 biofortified varieties of eight crops that the Indian Prime Minister dedicated to India during the 75th anniversary of the Food and Agriculture Organization (FAO) on October 15, 2020. These varieties contain about 80% oleic acid, making them a healthier choice, and with the longer shelf life desired by the confectionary industry. The high oleic varieties are currently being tested in Myanmar and Bangladesh for release. Further, the government of Telangana state in India has committed its support and began engaging in seed production of high oleic varieties by the public sector Telangana State Seed Development Corporation Ltd (TSSDC) to promote the high oleic value chain in India. Private seed businesses (like Hindustan Insecticides Limited - HIL) have taken up seed production of these varieties.

3. More than one million smallholder farmers cultivating high-yielding, climate-resilient varieties revive bean production in Zimbabwe

The fast-track land reforms of 2000 in Zimbabwe ignited a reduction in bean production as large-scale commercial farming gave way to small scale cropping. Hence, a project was launched in 2015 aimed at reviving bean production and productivity through the dissemination of four high-yielding resilient bean varieties. These had reached 36% more farming households by 2019. The adopting households now harvest 347 kg more beans per hectare, thereby enabling them to consume 3.6 kg more beans PPP.

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

1.2.1. Overall CRP Progress

FP1: Priority Setting and Impact Acceleration

The CRP-GLDC is on track to achieve the key SLO targets such as the adoption of improved varieties, increased yields and incomes and poverty reduction. A systematic review and synthesis of adoption studies showed that over 21.9 M smallholder farmers adopted improved varieties of GLDC with an aggregated planted area of over 20.5 M ha in the target countries (Woldeyohanes et al. 2020). In Bangladesh, the adoption of lentil varieties increased yields by 40% (580 kg/ha) and gross margins by 47% (US$ 501/ha), assisting an estimated 657,600 people to exit poverty. While in Nigeria, the adoption of improved groundnut varieties helped an estimated 1.5 M people exit poverty (Melesse et al. 2020), the adoption of improved chickpea varieties in Ethiopia led to a 58.5% increase in yields and 5% increase in household dietary diversity (Murendo et al. 2020).

FP3: Integrated Farm and Household Management

Over 18,000 adult parasitoids, *Therophilus javanus* have been released in Burkina Faso, Niger and Nigeria, and the technology validated for the deployment in West Africa. In Southern Africa, our team was able to reach 115,206 households, 309,558 farmers including 112,675 women applying improved technologies on 440,743 ha. A comprehensive framework was developed and piloted for assessment of farming systems sustainability and training of stakeholders. A Target Population of Environments approach laid the ground for modern geography-specific crop improvement methodologies across the CGIAR and partner institutions.

FP4: Variety and Hybrid Development

New varieties, allied innovations and responsive national breeding systems, expanded, resilient, and inclusive production, value chain, trading, and consumption of nutritious grain legumes and dryland cereals contributed to Program level outcomes. Several firsts included the release of the chickpea cultivars in Malawi, dual-purpose pearl millet hybrid in Burkina Faso, chickpea varieties with yield potential of 3 t per ha by ICRISAT to help crop diversification in Malawi, besides machine harvestable chickpea having resistance to wilt, drought tolerance and early maturity in Ethiopia and India. The first high oleic groundnut varieties were dedicated by the Indian Prime Minister to the nation during 75th anniversary of FAO. Overall, thirty GLDC cultivars were released by ICRISAT, ICARDA and IITA, including lentil (5), groundnut (5), chickpea (10), sorghum (2), pearl millet (5), soybean (1) and finger millet (2) in Africa (Burkina Faso, Ethiopia, Malawi, Kenya) and Asia (India). GLDC crop product profiles were designed and/or revised through stakeholder consultations, feedback from Crop Network Groups and value chain studies. The improved/new machinery at IITA, ICARDA and ICRISAT improved the efficiency of field trials and, thereby increased the heritability. As a part of breeding modernization, ICRISAT established automated seed processing, data collection and seed inventory, besides RapidGen facilities for rapid generation advancement of its crops.

FP5: Pre-breeding and Trait Discovery

Significant progress has been made in trait discovery, marker applications and the release of molecular-assisted breeding products. Pre-breeding activities in soybean were on the introduction of 63 lines sourced from the Colombian private sector; four lines performed well both under normal and reduced P application. In chickpea, introgression lines with wild relatives showed high levels of

Botrytis grey mold resistance and good agronomic performance. The characterization and advancement of transgenic events with stacked Bt genes for resistance to *Helicoverpa armigera* in pigeonpea, and on reducing/eliminating aflatoxins using Host-Induced Gene Silencing in groundnut continued at ICRISAT with generation advancements. Using CRISPR the primary strigolactone pathway genes were targeted in sorghum for durable pre-germination resistance. Three high oleic molecular breeding lines in groundnut in India and three chickpea molecular breeding lines (2 in India, 1 in Ethiopia) and several other molecular breeding lines were advanced by ICRISAT in groundnut, chickpea and pearl millet. The deployment of molecular markers in routine breeding programs in most crops resulted in more than 2.5 M marker data points generated so far at HTPG. Assays were developed for a small set of unique and polymorphic SNPs and initial validation of QC panels for breeding application in groundnut, pearl millet, sorghum, pigeonpea and chickpea. Besides, 10 trait-linked SNP panels for breeder preferred traits in sorghum, pearl millet, chickpea, pigeonpea, finger millet, soybean and cowpea were also validated for forward breeding. The selection of SNPs for mid-density panel were achieved in sorghum, pigeonpea and groundnut that would significantly support genomic selection and genomics-assisted breeding efforts. RapidGen methodologies for accelerated breeding cycles (4 to 6 per year) in cowpea were developed using 10 genotypes.

FP6: Common Bean for Markets and Nutrition

PABRA promoted varieties and integrated crop management technologies benefited 2.8 million households (10.3% above the target). High Iron Bean varieties were integrated in the COVID-19 emergency plan in Kenya to establish 1 M kitchen gardens with high yielding climbing beans. Private seed entrepreneurs distributed certified, and quality declared seed **(**5,905.7 ton) of new biofortified varieties supported by better messaging in Tanzania, Uganda, Kenya, Burundi and Zimbabwe. Gender and youth empowerment strategies for entrepreneurship and value addition were explored through marketing of new bean varieties and bean-based food products meeting consumer and industry demands. Enhanced root penetration for efficient use of inputs was researched with a novel phenotyping tool to estimate the size of root systems, based on capacitance and an electrical field (Root Capitance Potential). Parental lines derived from the tertiary gene pool improved crop synchronization, grain filling under drought, plant habit as well as higher iron. Value of the tertiary gene pool for the improvement of grain mineral concentration and the agronomic traits, and genetic mapping for agronomic traits in a MAGIC population of common bean (*Phaseolus vulgaris* L.) under drought conditions and Improving African bean productivity in a changing global environment were established. For reducing yield losses, including those caused by climate change, Mesoamerican genes were introgressed into Andean types for disease and heat resistance, resulting in heat tolerant HTA lines. Genetic gains were enhanced on station and on farm with bean varieties with greater yield potential. Multi-site nurseries of 200 lines were established with at least five partners in Africa and over 300 lines were distributed in Latin America and the Caribbean.

1.2.2a. Progress by Flagships

FP1: http://gldc.cgiar.org/progress-in-fp1-priority-setting-and-impact-acceleration-2020/

FP3: http://gldc.cgiar.org/progress-in-fp3-integrated-farm-and-household-management-2020/

FP4: http://gldc.cgiar.org/progress-in-fp4-variety-and-hybrid-development-2020/

FP5: http://gldc.cgiar.org/progress-in-fp5-pre-breeding-and-trait-discovery-2020/

FP6: http://gldc.cgiar.org/progress-in-fp6-common-bean-for-markets-and-nutrition-2020/

1.2.2b. Relevance to COVID-19 by Flagship

FP1: Priority Setting and Impact Acceleration

A news article published in collaboration with the CGIAR Research Program on Forests, Trees and Agroforestry (FTA) outlines the use of recovery funds in a way that improves the African food system towards better outcomes. A study was conducted to assess the awareness and perception about the pandemic, the coping mechanisms and the type of disruptions in the production systems of groundnut value actors in Ghana. Besides, it also looked at its effects on household agricultural production, marketing, household consumption and nutrition outcomes. This study generally showed that while awareness about the pandemic was very high among groundnut value chain actors, the percentage of actors who were aware about the preventive measures and their perception of the pandemic-related disruptions to the groundnut supply chain differed across the actors. This emphasized the need for education on the preventive measures in order to contain the spread of COVID-19 which may reduce labor availability and crop productivity.

FP3: Integrated Farm and Household Management

While the pandemic delayed some activities that will be accomplished by mid-year, others had to be cancelled/postponed due to travel restrictions/lockdown (e.g., collection of new isolates of pearl millet downy mildew and blast pathogens from farmers' fields, exchange visits for researchers/technicians, training sessions and field days. However, the use of radio messages to support farmers across project locations on extension advisories was explored. Extension agents in the farming communities as well as lead farmers were provided important information through phone calls and messages to convey to farmers. Where possible, online meetings were conducted to discuss issues and disseminate information. We also produced quick assessments to understand the effects of COVID-19-induced lockdowns on agricultural systems and rural livelihoods in South Asia that suggested context-specific policy responses at different levels from household to regional. A couple of suggested strategies like promoting local agri-food systems, mapping skills and identifying alternative deployment of returnee migrants to rural areas and the cautious easing of restrictions to enable farm harvest and movement of food commodities were useful in building government responses to mitigate the effects of COVID-19 in India. In Mali, farmers had to reduce the net sown area under maize and cotton due to the non-availability of markets because of the pandemic-related restrictions.

FP4: Variety and Hybrid Development

In FP4, there have been delays owing to COVID-19, particularly in variety releases, conducting trials and seed chain and capacity building activities. Improved phenotyping facilities are required for diseases, and for assessing nutrient-use efficiency. Precision experimental field plots need improvement to enhance the efficiency of trialing.

FP5: Pre-breeding and Trait Discovery

No research in FP5 was relevant to or was seriously affected by the COVID-19 pandemic.

FP6: Common Bean for Markets and Nutrition

During the pandemic situation, PABRA used digital platforms to communicate with partner organizations and farmers and field extension activities were sustained by information disseminated through WhatsApp platform, radio and TV stations (Capitalizing on digital tools to sustain bean production, trade and consumption amidst COVID-19 - (pabra-africa.org). Alongside these media channels, extension teams carried out field work adhering to the health guidelines laid down in each country, including social distancing/minimizing physical contact, use of facial masks, handwashing/hygiene, among others. PABRA continued to expand the MasterCard Farmer Network (MFN) in Uganda and Tanzania while complying with standard operational procedures, using virtual meetings to keep close interactions with Small and Medium Enterprises (SMEs), and provide technical backstopping as they adapted to fluctuations in the bean trade locally and regionally. PABRA sensitized farmers, consumers and processors on the nutrition and health benefits of beans to encourage more production and consumption during COVID-19. The nutritional and health benefits of beans consumed in different ways was explained through media and other digital platforms. In Kenya, PABRA leveraged Global Affairs Canada (GAC) efforts and partnered with the Ministry of Agriculture, Livestock, Fisheries and Cooperatives to contribute to the National Action Plan aimed at tackling food crisis accelerated by the impact of COVID-19. Under a new initiative officially launched in September 2020 in Kenya, three High Iron Beans (HIB) varieties were integrated in the emergency plan to establish one million kitchen gardens to enhance household nutrition.

1.2.3. Variance from Planned Program for this Year

1.2.3a. Have Any Promising Research Areas Been Significantly Expanded?

In FP1, the urban food systems work was revisited to consider the COVID-19 pandemic situation. In FP3, the joint development of a phenotyping facility by ICRISAT and CIMMYT was instrumental in screening sorghum and Maize lines, respectively for the Fall Armyworm (FAW) and helped in strengthening collaboration with the CRP-MAIZE. The household and farming systems level studies for agricultural sustainable intensification were extended to make quick assessments to understand the effects of COVID-19 in India. In FP4, modernizing GLDC crop breeding was identified as a priority to realize enhanced rate of genetic gain where additional activities were supported. A new investment was made in Africa to improve the breeding and testing processes, and operational efficiency across five GLDC crops, supported by the AVISA grant from the Bill & Melinda Gates Foundation (BMGF) and the Crops to End Hunger (CtEH) initiative. In FP5, application of markers in breeding programs were expanded on trait-linked SNPs, QC SNPs and mid-density SNP panels. Rapid generation advancement protocols were extended to cowpea and lentil. The focus on high priority and urgent traits such as blast in pearl millet was increased. In FP6, a new technical team supported the deployment of climate information services in Burundi, Eswatini, Ghana, Madagascar, Malawi, Tanzania and Zimbabwe.

1.2.3b. Have Any Research Lines Been Dropped or Significantly Cut Back?

In FP3, the collection of new isolates of pearl millet downy mildew and blast pathogens from farmers' fields, exchange visits and field work on assessment of whole farm model decision support could not be done at village/farm levels. GIS-based work to quantify landscape-scale indicators was carried over to 2021. In FP5, based on the mid-term CRP reviews in 2019, research areas such as native genetic and discovery for pod borer and herbicide tolerance activities using crop wild relatives (CWR) were deprioritized.

1.2.3c. Have Any Flagships or Specific Research Areas Changed Direction?

The urban food systems work under CoA1.2 has been adjusted to consider implications due to COVID-19. In FP5, considering the urgent need for developing QC and mid-density SNP panels in GLDC crops, analysis of existing sequence data in pearl millet, sorghum, pigeonpea, finger millet, chickpea and groundnut was enhanced to identify unique polymorphic SNPs to be used as QC panels that were validated in global lines of groundnut and sorghum. For deploying Genomic Selection, the work on developing mid-density panel was initiated on similar lines as QC with the EiB platform. Panels for sorghum, groundnut and pigeonpea with ~5000 SNPs each were provided to EiB for assay development. In FP6, instead of a physical training, a digital training was done due to the COVID-19 pandemic.

1.2.4. Altmetric and Publication Highlights

In 2020, CRP-GLDC produced 121 peer-reviewed journal articles, of which 90% were International Scientific Indexing (ISI) and 80% were open access. This publication category includes over 700 knowledge products with reporting relevance to CRP-GLDC, including major types of reports, working papers, data and news items. Of these, 94% have Altmetric scores, and the highest engagements come from Mendeley readership and engagements via Twitter. Ignoring internal reports and other materials with access restrictions, the Altmetric statistics for GLDC materials can be augmented by aggressive promotion of knowledge products mature for public use, such as news items, journal articles and blogs via outlets with large potential traffic like Facebook and Twitter.

The top 10 knowledge products with highest Altmetric scores ranging from 39.00 to 134.03 were all journal articles, mostly published by open access journals. For instance, Lekha et al. (2020) feature an innovative way to address the cost and limitations of current pigeonpea hybrid breeding with a two-line hybrid system that makes seed production simpler. By integrating transcriptomics, proteomics and metabolomics, the molecular mechanism underpinning fertility transition responses was discovered, thereby providing a process-oriented hybrid breeding framework for pigeonpea. In a multi-perspective article based on experiences in GLDC operating regions in SA, ESA and WCA, Ojiewo et al. (2020) explain the delivery of genetic gains in farmers' fields, i.e., seed systems research to bridge the gap between trait discovery, deployment and delivery through innovative partnerships and action learning. This article presents advances in groundnut research for development from crop production and stress management to food and nutrition value and aflatoxin. LaRue et al. (2020) delve into aspirations to understand the direction of rural development in order to avoid randomly applying interventions. Aspirations among youth are key to understanding the trajectory of rural farming in the future and informing current policies to take them into account.

In 2020, CRP-GLDC made investments to upgrade the Publications page on the CRP-GLDC server where three repositories (MELSpace, ICRISAT OAR and CGSpace) were linked to show knowledge products in one place. This exercise improved the harvest rate and usability of the page.

1.3. Cross-cutting Dimensions

1.3.1. Gender

Gender integration and social inclusion approaches involving inclusive and equitable participation in agricultural research and technology development besides benefit sharing were applied to broad areas of research and activity themes. Studies on 'Youth realities, aspirations, and opportunity structures in agriculture' resulted in a youth strategy paper that highlighted the understanding of context-specific definitions of 'youth' so that young people are not excluded from programs. The findings show that while there were opportunity structures such as diverse agro-climatic conditions, high demand for agricultural products both in domestic and international markets, increased availability of improved varieties and a digital revolution for technology and information diffusion that could support meeting some of the identified potential and aspirations of youth, there are still critical areas of deficit. Local norms handicap female youth, giving males more access to and benefit from available opportunities. Unlocking the potential of female and male youth in dryland areas requires focusing on three pillars: (i) Inclusive participation, where both male and female youth are targeted in consideration of their needs and realities, (ii) Equity, where female and male youth are enabled to access and use resources and opportunities relevant to agricultural transformation, and (iii) Facilitating youth agency by providing them a conducive environment (social, economic and supportive policies) to exercise their potential as active agents of change. The strategy concluded that socio-cultural, economic and technical barriers to youth engagement in agriculture need to be addressed through cultural transformation and rebranding of agriculture to spur their participation.

Two studies conducted by ICARDA and ICRISAT contributed to efforts on gender integration in the breeding program. For example, the lentil breeding program has released a new variety in Ethiopia that accounts for less shattering to reduce drudgery for women. The result of the trait preference studies conducted by ICRISAT in three countries in WCA contributed to the development of crop market-driven, gender-responsive product profiles where women and men faced similar production constraints, they shared similar varietal trait preferences, whereas differences were apparent with variations in the conditions of production and roles or responsibilities of male and female producers.

Intensive outmigration in dryland areas affects women's roles in agriculture and related activities, with broader implications for productivity and gender equity. Access to assets by women in rural communities, while being a major challenge is also a pathway to empowerment. The study on effects of men's outmigration on women's roles in agriculture, and it wider impacts in the context of dry areas (rangeland, irrigated production and rainfed) revealed that women are carrying out more labour, both on and off farms. The feminization of agrarian labour may reduce women's earnings to the detriment of household incomes, making them more susceptible to economic, social, and cultural marginalization. This highlights the importance of developing interventions specially tailored to mitigate the negative effects on women while protecting them by leveraging the positive effects of feminization of agricultural labour. The study recommends developing interventions targeted at structural changes; not just on those at the individual and household levels, that might offer only a limited change in women's well-being. Using data from the Village Dynamics Studies in South Asia (VDSA), a survey was conducted to understand women's access to and control over assets in the semi-arid tropics of India. The data provides evidence that the gender asset gap is a good indicator to track progress on gender equality and women's empowerment. However, there is no such evidence on ownership and control of assets disaggregated by gender (Rustagi and Menon 2011; see also Padmaja and Bantilan (2015). Preliminary analysis of such data reveal that women rarely have sole ownership of agricultural land or have no awareness of their land rights. Gender-disaggregated asset data facilitates gender equality and women's empowerment through improved control over

assets, various processes of formalisation, land titling, state-supported enterprise development, community participation, formation of Self-Help Groups (SHGs) and the provision of micro credit to women.

Mainstreaming gender awareness and contributions along the bean value chain continues through a series of activities. PABRA partners implemented bean production activities in Eastern Uganda in collaboration with the Eastern Agricultural Development Company (EADC), a women-led social enterprise, due to the low participation and involvement of women in the EADC platforms. The starting point was to train women as model farmers to promote climate-smart technologies, including NAROBEAN-1, a climate-resilient HIB variety. Between April and September 2020, 6,160 (3,265 women) model farmers were integrated as change agents in their communities. The cumulative number of trained change agents was 19,213 (42.4%; 8,143 women) model farmers across PABRA members.

1.3.2. Youth and Other Aspects of Social Inclusion / "Leaving No-one Behind"

Opportunities should intentionally be planned with and extended to female and male youth groups from different social spectra. Combining elements of the 'developmental' and 'opportunity structure' approaches, we suggest a dynamic process in aspiration formation, recognizing that aspirations develop within a set of constraints that impact gender stereotypes and personal perceptions. The following two major studies were carried out in WCA and ESA:

1. The studies in ESA were conducted in the drylands of Ethiopia, Uganda and Tanzania using common focus group discussions, key informant interviews and life history interview guides. Interestingly, the local communities define 'youth' differently, where age may not be considered as a strict criterion. Marriage, leaving school and certain traditional rites of passage, for example, may mark a transition to adulthood, even for adolescents. Contrary to prevailing stereotypes, many young people want to stay in the countryside and work in agriculture and consider it a fallback option. Female youth are discriminated against in various ways since land inheritance is transacted mainly through the boy child or through marriage; unmarried females tend not to inherit land. Teenage girls who are married or are mothers tend to see themselves as adults, as do their communities which often keep young mothers from taking advantage of youth programs. Barriers to youth involvement in agriculture for both males and females include the lack of land, capital, extension services and information about modern technologies. While the strategy paper calls for context-specific local definitions of 'youth', other recommended interventions include technical, business and market training, besides providing convenient finance credit or grants (e.g., interest-free and without collateral). Youth should also have access to profitable technologies such as drought-resistant, fast maturing grain and legume varieties, besides help in establishing enterprises based not just on farming, but also on post-harvest transformation, transportation and marketing.

2. Youth studies in WCA were conducted on 'Transforming and harnessing the potential of rural youth in agri-food value chains in Mali and Nigeria' that identified, characterized and mapped the opportunities and segments of agri-food value chains for youth. Findings show that 75.76% of youth are mainly engaged in the production segment of agri-food value chains. Processing was observed to be the segment where majority of female youth were engaged, but mostly using manual traditional food processing methods. The study concludes that active involvement of youth in all the agri-food value chains is necessary for the sustainability of agriculture. To make the production segment more vibrant and attractive to youth, policies should be designed to support and incentivize their full participation in all segments. The study recommends

interventions in infrastructure, regulations and specific training in agricultural practices targeted at harnessing their full potential, so that no one is left behind.

FP6 has been building the capacity of young farmers in seed production, mechanization and market linkages in collaboration with TARI, Maruku. For example, Pastory Tarasisi, a recipient of the training along with four youths, is addressing issues of seed availability and accessibility in his ward in Missenyi District in Tanzania where 1,250 farming households were reached with quality seeds. He also offered threshing services to 50 farming households in eight villages, from which he earned Tsh. 1.6 million (approximately US$ 690) in just six months. Another example of engaging Kenyan youth in bean business to boost income is that of Florence Malemba, an extension officer who is also the focal point for bean growers. In 2020, with the support of certified Nyota seed, she provided training to other youth interested in agriculture and showcased how it was possible to make money and feed from farming.

1.3.3. Capacity Development

The CRP-GLDC has benefited 7,416 people (37% females) so far through trainings, workshops and mentoring support to 11 PhDs and 12 MSc students. E-Learning saw a global boost due to COVID-19 where FP5 alone reached over 3,500 people with online trainings and webinars. The Capacity Development Task Force set up an E-Learning portal (Learning Management System or LMS) to facilitate a flexible and user-friendly environment for both learners and facilitators. The site currently has 180 registered users with an aim to increase it to 500 by the end of 2021. Besides seven free courses, the learning material relates to 'Breeding Approaches for Enhancing Genetic Gains in Food Legumes', 'Sustainable Food and Agriculture', 'Creating Impact at Scale' and 'Designing of Resilient Farming Systems'. The task force upgraded and transformed the AGskillED platform into an aggregation platform for mobile based e-learning courses for farmers and frontline extension staff; it is available on Android Play Store. Another important contribution was an e-learning course on Creating Impact at Scale, where participants across centers and NARS received insights on concepts related to theories of change and applied them to their ongoing project or proposals.

FP6 enhanced the skills of 1,260 people (547 women, 43.4%) in bean-based flour production for private millers in the Democratic Republic of Congo (DRC), besides conducting virtual trainings on designing and developing bean seed road maps for young breeders and research technicians on breeding and experience sharing between senior and young breeders.

Information and knowledge was made available to farmers, private lead firms, SMEs, research and extension, and NGOs through virtual and on location trainings, printed promotional materials, and social and mass media. A total of 3,519,744 people (51.7% females) benefited, surpassing the annual target of 3 million by 17.3%, mostly through TV in Burundi and from virtual and online trainings.

1.3.4. Climate Change

Sustainable intensification systems with diversified crop mixes, cropping patterns and sequences that capitalize on synergies between and among crops and systems were developed. Technologies that increase resilience and enhanced resource use efficiency in the systems are being promoted to increase productivity on smallholder farms. In collaboration with the CRP-CCAFS, a framework to quantify vulnerability and resilience was developed by accounting for a smallholder household's ability to adapt and respond to climatic risk. A suite of systems modelling tools/framework for co-designing resilient farming systems such as farm household typologies, whole farm system model as decision support and farming systems sustainability assessment framework were tested and

validated. The capacity of extension systems and NARS partners in India and Niger to use these tools was strengthened. Crop modelling tools developed to identify G×E×M options to enhance resilience and productivity of sorghum in India enabled target stakeholders to understand spatial variability.

FP6 continued work to address drought tolerance where replication data for bean experimental lines was selected for tolerance to drought, high temperatures, low P and high aluminium in the soil and high Fe/Zn grain content. Journal articles were published on genetic mapping for agronomic traits in a MAGIC population of common bean (*Phaseolus vulgaris* L.) under drought conditions and Improving African bean productivity in a changing global environment.

Climate change remains at the core of the SDC project where work continues on profiling promising and acceptable Integrated Crop Management (ICM) technologies for bean production that address improving production and productivity and adapting to climate change.

Since climate variability is negatively impacting production, PABRA has developed a Digital Agro Climate Advisory (DACA) to help bean farmers manage risks associated with climate shocks through climate information and advisories.

1.3.5 Markets and Partnerships in Agri-Business (MPAB)

This cross-cutting area published a paper in the Journal of Global Food Security (Mausch et al. 2020) in collaboration with FP1 that sets out a framework to find ways of exploring market opportunities in transforming agri-food systems. Related work includes a study of the opportunities for GLDC that arise from growing markets for functional foods and plant-based meats (Conti et al. 2020); a study of opportunities for influencing consumption patterns in low-income urban areas (Hauser 2020) and a study exploring potential opportunities arising from the new flour blending policy in Kenya (Melesse 2020). Related work has investigated, in collaboration with FP4, the adoption process associated with the rapid spread of chickpea varieties in Andhra Pradesh (MPAB team 2020), and in collaboration with ILRI the processes of technological change associated with fodder production. While work on farming systems and value chain modelling in collaboration with FP3 was delayed due to personnel changes, it is back on track with new expertise drawn from CSIRO.

2. Effectiveness and Efficiency

2.1. Management and Governance

During 2020, guidance and approval were solicited from the Independent Advisory Committee (IAC) which includes seven non-CGIAR members and five ex-officio CGIAR members, including the Director General of the lead center. Two meetings of the IAC were held virtually due to the COVID-19 pandemic, on 15 June and 15-16 October 2020. The second meeting also included an interactive review session with the FP leaders and cross-cutting theme leaders. Currently, there is a vacancy on the IAC due to the resignation of a member, which will be discussed in the next IAC meeting in the first half of 2021.

The Director of CRP-GLDC, who was also the Deputy Director General for Research at ICRISAT, 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 2020, five 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. These CRP leadership positions combine management responsibilities with active research leadership.

2.2. Partnerships

2.2.1. Highlights of External Partnerships

Partnerships have been solidified and broadened with the German university networks (future rural Africa research group) and Institute of Development Studies (University of Sussex, UK) through joint implementation of activities on rural aspirations. Gender research partnerships with social sciences departments at Makerere University in Uganda, Sokoine University in Tanzania and Haramaya University in Ethiopia have generated evidence and reports on youth studies. These studies have enhanced the capacity of the teams in applying data collection tools and analyses. The Swedish University of Agricultural Sciences (SLU) is leading the systematic review on the effects of GLDC crops on soil health. Key synthesized evidence from this work will be used to estimate GLDC's contribution to SLO target 3.2. In FP3, we have collaborated with Institut National de Recherche Agronomique du Niger (INRAN), Niger; Institut de l'Environnement et de Recherches Agricoles (INERA), Burkina Faso; Kwara State University (KWASU), Nigeria; Universite Dan Diko Donkoulodo de Maradi (UDDM), Niger; Michigan State University (MSU), USA; Wageningen University, Netherlands; University of Strathclyde, Scotland; Texas Tech University, USA; Soybean Innovation Lab (SIL), USA; Makerere University, Uganda; University of Nazi BONI, Burkina Faso; Center for Development Research (ZEF), Germany; Zurich University of Applied Science, Switzerland; Massachusetts Institute of Technology (MIT), USA; CSIRO, Australia; and the Indian Council of Agricultural Research (ICAR), India.

2.2.2. Cross-CGIAR Partnerships

Collaborative activities with the CRP-PIM contributed to the draft CGIAR Foresight Report which included knowledge-sharing and joint scientific products through the established of a community of practice on foresight. A joint publication resulted from collaborations with FTA and one on mainstreaming orphan crops based on a collaboration with FTA and the CRP-A4NH. Partnership with EiB helped in the development of gender-responsive product profiles. With the CRP-RTB, the focus was on the analysis of MEL-based social networks aimed at identifying CRP-GLDC actions that have contributed towards knowledge products and analyzing the ones that are effective in increasing multi-disciplinary publications, besides evaluating how the CRP-GLDC adds more collaborations to the knowledge exchange networks. There have been cross-learnings with CRP-MAIZE for the control of FAW and the supply of DTM varieties. While ICRISAT, ICARDA and CRP-CCAFS developed and validated the framework for measuring sustainability and resilience, ICRISAT, ICRAF, IITA and ICARDA collaborated on mainstreaming gender into R4D to improve GLDC farming systems. The sorghum and millet CNGs established in ESA with ASARECA are moving towards a sustainable model, besides enhancing engagement with private seed companies and food industries like ADVANTA Seed Company and Neilsen Seeds. A new partnership with the Tanzania Seed Trade Association (TASTA) has been established to engage with small and medium seed businesses for de-risking the diversification of their crop portfolio into GLDC crops. Two women-led seed companies in Tanzania, i.e., Zasse Agricultural Seed and Food Company Limited (ZASFCO Ltd) and Namburi Agricultural Company Ltd, were trained on varietal prioritization in seed business. Value chain studies to guide crop product profiles are underway in Myanmar in collaboration with the Syngenta Foundation for Sustainable Agriculture (SFSA). A new partnership between Corteva, EiB and ICRISAT for the overall

improvement of pearl millet, besides a MoU between IITA and Bayer Crop Science are providing new opportunities.

2.3. Intellectual Assets

CPR-GLDC did not manage any intellectual assets directly but through partner institutions as evidenced by the submitted Innovations and Outcome Impact Case Reports (Ref. Table 3).

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

The CRP-GLDC completed 10 of the 15 MELIA studies (Table 10). The impact of GLDC adoption was computed while accounting for possible errors from access to technology transfer and improved seed for groundnuts in Nigeria, chickpea in Ethiopia and sorghum and finger millet varieties in Ethiopia and Tanzania. New studies are ongoing to assessing GLDC impacts on CGIAR SLO nutrition targets, natural resource management in farming systems in Africa and South Asia, and livelihood and ecological impacts on fallow periods, particularly for ICARDA lentils.

Around scaling efforts, studies are looking at difference-in-differences design of a large-scale rural development program that scaled some GLDC crop varieties and management practices; analyzing 18 impact studies to ascertain the potential of GLDC varieties to intensify smallholder agriculture and improve livelihoods in semi-arid regions of SSA and SA, besides reviewing GLDC scaling projects against idealized scaling frameworks at the GLDC proposal stage.

An online open access tool for farming system sustainability assessment has been developed and is undergoing validation in India. Collaboration with SMO led to the integration of MEL and MARLO towards the CGIAR Results Dashboard. Further work will lay the foundation for a one-CGIAR Result-Based Management approach.

2.5. Efficiency

CRP-GLDC planned a mid-term review of its POWB 2020 to provide an overview of the activities affected due to COVID-19. While the review process supported the advancement of 2020 reporting, it also provided FP leaders with a status update that was useful for the preparation of the POWB for 2021. This approach could lessen the limitation of developing the POWB for the following year before reporting for the preceding year. Investment of funds on additional activities in 2020 focused on either new high-impact activities or those linked to already completed or ongoing activities which build on existing results to develop outputs further. Activities that aggregate existing results e.g., data and findings to come up with more mature knowledge products were also prioritized. The implementation of a knowledge management activity within FP1 to document the increased collaboration among CRP-GLDC scientists using publications has supported a more efficient way to collect publications from global databases and inform librarians and scientists to update their records. This strategy can support the One CGIAR in more timely reporting of research results. Instead of launching an independent campaign for the 2020 Open Data Day, CRP-GLDC capitalized on a joint campaign with partner CRPs and CGIAR centers led by the MEL Platform, amplifying the exposure of blogs and testimonies from GLDC scientists while exercising cross-CGIAR collaborations. While the pandemic has stopped or postponed several events, the CRP-GLDC supported major events held virtually, on topics such as genomics in modern breeding programs for food security, health and nutrition and genome editing in agriculture.

2.6. Management of Risks to your CRP

While the CRP-GLDC continued to operate with the unfunded FP2 in 2020, projects worth US$ 2.58 M supported through W3/Bilateral funds were mapped to FP2. Not having FP2 was partly mitigated by having a cross-cutting theme on MPAB since 2019. In view of the changes in implementing the current research portfolio due to the disruptive impact of the COVID-19 pandemic, a mid-term review of the POWB 2020 was conducted with special consideration of and assessment of impacts of COVID-19 and possible corrective measures. The review focused on: (i) work plan deviations resulting in either ongoing activities being switched to new COVID-19 activities or the incorporation of pandemic-related research in ongoing activities, and (ii) corresponding measures at the milestone, activity, output and deliverable levels, and financial resources. However, due to the impact of COVID-19, the CRP-GLDC reported an unspent 2.49% of the total CRP-GLDC budget of US$$ 8.14 M which will be carried forward to 2021 in order to complete the planned milestones and MELIA studies of 2020.

2.7. Use of W1-2 Funding

The W1/W2 funds were essentially used to carry out the planned research activities of POWB 2020. In addition, FP 1 undertook multidimensional ex-ante impact evaluation to identify the most promising GLDC research options by developing TOPSIS_ShinyApp that breeders and other practitioners can use for multi-criteria ranking of GLDC technologies. These funds were also used to: (1) conduct research on aspirations aimed at targeting and scaling agricultural innovations; (2) assess the potential impact of GLDC crops on urban food and nutrition security; (3) characterize the youth in the drylands of Tanzania, Uganda and Ethiopia; (4) conduct a multifaceted impact assessment of GLDC innovations; (5) revise GLDC's theory of change and impact pathways and (6) analyze the MEL-based social network to evaluate the performance of the CRP-GLDC. In FP3, these funds supported studies on the adoption of innovations at farming systems level. In FP4, these funds were used to commercialize GLDC crop cultivars to meet market/industry needs; climate resilient cultivars such as early maturing soybean, groundnut and chickpea, and forage cultivars of sorghum and pearl millet to support crop-livestock systems and cultivars with host-plant resistance. Partnerships with the private food industry and seed sectors, genotyping and drone-based imaging service providers, and knowledge sharing through CNGs were also supported. In FP5, funds were mainly utilized to support and leverage W3/bilateral projects in the strategic/priority/critical focus areas including the development of QC panels and enabling technologies. In FP6, these funds were spent to advance work on iron and zinc biofortification and crop resilience.

3. Financial Summary

The CRP-GLDC budget of US$ 10.731 M was expressed in PoWB 2020. However, the final allocation received was US$ 9.855 M (92% of the original FinPlan), of which US$ 8.140 M was channeled via W1/W2 and US$ 1.715 M via W3.

The W1/W2 budget of US$ 8.140 M was spent at 98% and the remaining unspent budget of 2% (US $ 170 K) will be carried forward to 2021 to implement the ongoing activities of 2020 on the request of CRP-GLDC participating centers.

The total budget for W3/bilateral was planned at US$ 52.637 M and was utilized at 78% in 2020.

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
SLO1 : Reduce Poverty			
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	It is estimated that over 21.9 million smallholder farmers have adopted improved GLDC varieties in GLDC's 13 target countries, with 13 million additional households doing so from 2011 onwards. (Woldeyohanes et al. 2020).		Regional: Sub-Saharan Africa and South Asia
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In Nigeria, an adoption and impact study of improved groundnut varieties found that 30% of the groundnut producers (or 1.8 million households) have adopted improved varieties (Melesse et al. 2020).		National: Nigeria
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In Ethiopia, an adoption and impact study of improved chickpea varieties showed that 58% of the chickpea producers (585,000 households) have adopted improved varieties (Murendo et al. 2020).		National: Ethiopia

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In Bangladesh, an adoption and impact study of improved lentil varieties found that 49% of the lentil producers (or 645,000 households) have adopted improved lentil varieties (Yigezu et al. 2020).		National: Bangladesh
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	Activities reached 115,206 households; 309,558 farmers including 112,675 women applied improved technologies (including good quality seed of improved legume varieties and improved management practices) on 440,743 ha of land. No new evidence in 2020.		Multi-national: Malawi, Mozambique
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	Access to quality seed of GLDC crop cultivars is enhanced in Africa and Asia. No new evidence in 2020.	The ongoing adoption studies will be completed and documented in 2021.	Regional: Africa, Asia
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In 2020, PABRA promoted varieties and integrated crop management technologies benefiting 2.8 million households (10.3% higher than the target). Cumulative over the six-year period (2015-2020), the interventions have reached a total 21.5 million households (58.2% women), which is 113% of the target for the project phase by 2020. Evidence: https://doi.org/10.1007/s12571-017-0753-4, Technical Report		Regional: Africa
1.1. ADOPTION : 100 million more farm households have adopted improved	In Ethiopia, the adoption of improved varieties benefited close to 2,508,000 million farming families, enabling		National: Ethiopia

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
varieties, breeds, trees, and/or management practices	them to enjoy extra expenditure on food and non-food items worth US$ 164 per person per year (PPP), and by US$ 247 PPP for those families that combined varieties with fertilizers. Evidence: https://doi.org/10.1007/s12571-017-0753-4, Technical Report		
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In Burundi, the adoption of improved bean varieties has been impressive; nearly half of the bean area remains planted to landraces with low yielding capacity. A 2020 study shows that shifting one hectare of land fully from landraces to improved varieties would give households about 190 kg of additional harvest, which would give the country approximately 113,836.41 tons of additional produce. 4.5 million people from families who adopted improved beans had more food available during lean seasons—when food consumption drastically reduces. Evidence: https://doi.org/10.1007/s12571-017-0753-4, Technical Report		National: Burundi
1.1. ADOPTION : 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	In 2020, a total 1709.8 tons of new biofortified varieties were produced by 5 countries -- Tanzania, Uganda, Kenya, Burundi and Zimbabwe. To accelerate seed access, the varieties were disseminated in small sized packs (0.1, 1.0, 2.0 and 5.0 kg) through purchase and free modalities. The dissemination was led by private seed enterprises in partnership with NARS and NGOs engaged in nutrition and health or education or during seed fairs/farmers' field days. As of 2020, 17-year		Multi-national: Tanzania, Uganda, Kenya, Burundi, ZImbabwe

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
	cumulative investments worth US$16 million in bean variety improvement and crop management practice generated benefits close to US$200 million for more than 5.3 million rural households. No new evidence in 2020, will be reported in 2021.		
1.2. EXIT POVERTY : 30 million people, of which 50% are women, assisted to exit poverty	In Nigeria, results from an adoption and impact study (Melesse et al. 2020) suggest that an estimated 290,000 households (or 1.5 million people) have been supported to exit poverty through the adoption of improved groundnut varieties.		National: Nigeria
1.2. EXIT POVERTY : 30 million people, of which 50% are women, assisted to exit poverty	In Bangladesh, results from an adoption and impact study (Yigezu et al. 2020) suggest that an estimated 160,000 households (or 657,600 people) have been assisted to exit poverty through the adoption of improved lentil varieties.		National: Bangladesh
SLO2 : Improve Food and Nutrition Security for Health			
2.1. YIELD INCREASE : Improve the rate of yield increase for major food staples from the current <1% to 1.2-1.5% per year	An adoption and impact study on improved chickpea varieties in Ethiopia showed that adoption led to a 58.5% increase in chickpea yields (Murendo et al. 2020).		National: Ethiopia
2.1. YIELD INCREASE : Improve the rate of yield increase for major food staples from the current <1% to 1.2-1.5% per year	High Iron Bean varieties were integrated in the emergency plan to establish one million kitchen gardens to enhance household nutrition. The initiative was officially launched in September 2020 and included a demonstration of three such varieties promoted in		Regional: Africa

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
	Kenya. Climbing bean was emphasized as one of the crops suited for a kitchen garden because it occupies little space with very good yields. https://doi.org/10.1177/0030727018813698		
2.2. MINIMUM DIETARY REQUIREMENTS : 30 million more people, of which 50% are women, meeting minimum dietary energy requirements	An adoption and impact study of improved chickpea varieties in Ethiopia showed that adoption led to a 5% increase in household dietary diversity. To represent that the SLO contribution is relevant to the entire country, the sampling study randomly selected four kebeles in each district, and within these about 60 households were randomly selected. A total of 1193 farm households were surveyed using a standardized survey instrument. Accordingly, the results are fairly nationally representative and should be interpreted as the potential impacts of improved chickpea adoption in the whole of Ethiopia. (Murendo et al. 2020).		National: Ethiopia
SLO3 : Improve Natural Resources and Ecosystem Services			
3.1. WATER AND NUTRIENT EFFICIENCY : 5% increase in water and nutrient efficiency in agroecosystems	N/A		
3.2. REDUCED GREENHOUSE GAS EMISSION : Reduction in 'agriculturally'- related greenhouse gas emissions by 5%			

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. Put "No new evidence in 2020" if the target is potentially relevant, but there is no new evidence available**.** Spell out all acronyms. *Max. 150 words per entry.*	**Expected additional contribution before end of 2022** (if not already fully covered) **Optional narrative. Evidence not required.** *Max. 100 words*	**Geographical scope (with location)** Global, Regional (e.g. West Africa), Multi-national, National (e.g. Philippines), Sub-national
3.3. ECOSYSTEM RESTORED : 55 M ha degraded land area restored	N/A		
3.4. PREVENTION OF DEFORESTATION: 2.5 M ha forest saved from deforestation			

Table 2: Condensed List of Policy Contributions in this Reporting Year (Sphere of Influence)

Title of policy, legal instrument, investment or curriculum to which CGIAR contributed	**Description** of policy, legal instrument, investment or curriculum to which CGIAR contributed (30 words)	**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	
Gendered Youth Realities, Aspirations, Opportunity Structures and Transitions to Adulthood in the Semi-Arid Tropics: CRP-GLDC Strategy for Targeting and Engagement	The strategy aims to concurrently achieve the following outcomes: Expanded, resilient and inclusive production, value addition, trading and consumption of nutritious grain legumes and dryland cereals in target countries, and improved capacity and inclusivity of agri-food system stakeholders to collaboratively develop innovations that respond to the needs of women, men and youth in GLDC-based livelihoods and value chains. The CRP-GLDC Youth Strategy which is the most significant tool developed within this policy case has been informing the implementation of CRP-GLDC initiatives, and will contribute the further CGIAR initiatives especially the CGIAR Gender Platform.	Maturity level 1 (the youth strategy document is completed and currently under technical editorial review)	Sub-IDO C.1.3 Conducive agricultural policy environment	1	1	NA	NA	https://hdl.handle.net/20.500.11766.1/eb15b9
Trans-regional trade policy brief on bean flows between	Supportive gender-sensitive policy tools for efficient and equitable seed systems, better management	Maturity level 1	Sub-IDO 1.2.2. Reduce market barriers	1	1	1	1	https://hdl.handle.net/20.500.11766.1/391a57

Title of policy, legal instrument, investment or curriculum to which CGIAR contributed	**Description** of policy, legal instrument, investment or curriculum to which CGIAR contributed (30 words)	**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	
Tanzania and its surrounding countries, and the effect on economic development	of environmental stresses and adaptation to climate change developed and widely disseminated.							
Tanzania ministerial and political head orders the promotion of high iron beans consumption in schools	Recognizing the two varieties of beans with high iron and zinc developed by Tanzania Agricultural Research Institute, the consumption of these food crops have contributed to reducing the problem of anemia.	Maturity level 1	Sub-IDO 2.1.3. Optimized consumption of diverse nutrient rich foods	1	1	1	1	https://hdl.handle.net/20.500.11766.1/cde7cf
Contribution to the Tanzania National Biofortification Guidelines, the Tanzania country strategy that enhances the consumption of beans and dry bean products	The National Biofortification Guidelines ensures the production, availability and utilization of a variety of food crops, especially biofortified foods including high-iron beans, to improve the nutrition status of the community.	Maturity level 1	Sub-IDO 2.1.2. Increased access to diverse nutrient-rich foods	1	1	1	1	https://hdl.handle.net/20.500.11766.1/6b56fb
Implementation of Malawi Multi-sectoral Adolescent Nutrition strategy 2019-2023 utilizes CGIAR	Biofortified crops were a part of the four strategies of Malawi's nutrition policy.	Maturity level 1	Sub-IDO 2.1.3. Optimized consumption of	1	1	1	1	https://hdl.handle.net/20.500.11766.1/015a40

Title of policy, legal instrument, investment or curriculum to which CGIAR contributed	**Description** of policy, legal instrument, investment or curriculum to which CGIAR contributed (30 words)	**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	
biofortified bean varieties and associated production technologies			diverse nutrient rich foods					
Malawi Multi-sectoral Maternal, Infant and Young Child Nutrition Strategy 2019-2023	The strategy promotes the use of local foods such as biofortified beans to improve maternal and child survival, early child development as well as school performance.	Maturity level 1	Sub-IDO 2.1.3. Optimized consumption of diverse nutrient rich foods	1	1	1	1	https://hdl.handle.net/20.500.11766.1/46e3ff
Malawi Multi-Sector Nutrition Education and Communication Strategy (NECS) II 2019-2023	Among the key messages of this strategy is the consumption of fortified and biofortified foods every day, including high-iron beans to prevent micronutrient deficiencies.	Maturity level 1	Sub-IDO 2.1.3. Optimized consumption of diverse nutrient rich foods	1	1	1	1	https://hdl.handle.net/20.500.11766.1/29e979
Biofortified Beans Technology Package from CGIAR contributes to Burundi strategy to improve Nutrition, Income, and Food Security	Malnutrition is worsening in Burundi, with micronutrient deficiencies increasing from 45% to 61%. Crop biofortification is a proven key intervention that can ameliorate micronutrient deficiencies.	Maturity level 1	Sub-IDO 2.1.2. Increased access to diverse nutrient-rich foods	1	1	1	1	https://hdl.handle.net/20.500.11766.1/1ba324

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

Column 1	**Column 2A**	**Column 2B**
Title of Outcome/ Impact Case Report (OICR)	**Link** to full OICR	**Maturity level** drop down for: 1, 2, or 3
Efficient legume seed systems benefitting more than 22 million smallholder farmers in about 4.4 million hectares in the 15 countries in the semi-arid tropics	https://hdl.handle.net/20.500.11766.1/c44580	2
More than 4,000 smallholder farmers empowered through crop variety technology delivery and trainings via Farmers Producers Organizations in Andhra Pradesh, India	https://hdl.handle.net/20.500.11766.1/7b5a96	2
High oleic groundnut varieties commercialized in India meet the enhanced shelf-life needs of food industry and consumer health benefits.	https://hdl.handle.net/20.500.11766.1/0448af	2
Climbing bean technology that upscaling from Rwanda increases availability of nutrient-dense food among 90,000 families as it conquers bigger share of bean area in Burundi	https://hdl.handle.net/20.500.11766.1/aef5b4	2
Common bean improvement research helps to reduce poverty for 2.5 million families in Ethiopia	https://hdl.handle.net/20.500.11766.1/dc7710	2
More than one million smallholder farmers cultivating high-yielding, climate-resilient varieties revive bean production in Zimbabwe	https://hdl.handle.net/20.500.11766.1/49bed3	3
FAO-IFAD-WFP awarded GENNOVATE among the 15 best practices for gender transformative approaches for food security, nutrition and sustainable agriculture following its validation with 7,500 participants	https://hdl.handle.net/20.500.11766.1/6f263f	1
Monitoring, Evaluation and Learning platform adopted within and outside CGIAR	https://hdl.handle.net/20.500.11766.1/e51ee7	1
Registration of eleven local varieties of rice and beans distributed by more than 3,000 farmers in Nepal	https://hdl.handle.net/20.500.11766.1/21e5ff	2

Table 4: Condensed List of Innovations by Stage for this Reporting Year

Title of innovation with link (e.g. to CLARISA dashboard, MARLO).	**Innovation type**	**Stage of innovation**	**Geographic scope (with location)**
Development and piloting of a comprehensive framework for farming systems sustainability assessment https://mel.cgiar.org/innovation/getinnovationview/id/314	Research and Communication Methodologies and Tools	Stage 1: discovery/proof of concept	Global
Standardization of different artificial diets for rearing protocols and development of integrated pest management strategies for fall armyworm https://mel.cgiar.org/innovation/getinnovationview/id/655	Production systems and Management practices	Stage 1: discovery/proof of concept	Global
Bio-control agents of pests and diseases in Benin and Burkina Faso https://mel.cgiar.org/innovation/getinnovationview/id/461	Production systems and Management practices	Stage 2: successful piloting	Regional (West Africa)
Plant growth promoting microorganisms (PGP) for sweet sorghum for India https://mel.cgiar.org/innovation/getinnovationview/id/462	Production systems and Management practices	Stage 2: successful piloting	National (India)
Scaling community seed banks to implement seed production https://mel.cgiar.org/innovation/getinnovationview/id/528	Social science	Stage 2: successful piloting	Global
Hand Push Legume Planter Seeder (HPLS) to improve cropping efficiency in Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/538	Production systems and Management practices	Stage 2: successful piloting	National (Mozambique)
New sorghum variety Jaicar Nutrigaze for fodder yield, digestibility and resistance to biotic stress factors in the dry mid-altitudes of India https://mel.cgiar.org/innovation/getinnovatio	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)

Title of innovation with link (e.g. to CLARISA dashboard, MARLO).	**Innovation type**	**Stage of innovation**	**Geographic scope (with location)**
nview/id/546			
Sorghum variety Telangana Jonna 1 for cultivation in dry mid-altitudes of India for grain yield, with biotic stress resistance and high digestibility https://mel.cgiar.org/innovation/getinnovationview/id/547	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Finger millet inbred variety Katope for cultivation in low to mid-altitudes in Malawi and Kenya https://mel.cgiar.org/innovation/getinnovationview/id/548	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi; Potential spillover effect: Kenya)
Finger millet inbred variety Kambulanje for cultivation in low to mid-altitudes in Malawi and Uganda https://mel.cgiar.org/innovation/getinnovationview/id/549	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi, Potential spillover effect: Uganda)
Groundnut inbred variety CG15 for cultivation in low to mid-altitudes in Malawi and Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/550	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi, Mozambique)
Groundnut inbred variety CG16 for cultivation in low to mid-altitudes in Malawi and Mozambique https://mel.cgiar.org/innovation/getinnovationview/id/551	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi, Mozambique)
Groundnut inbred variety CG17 for cultivation in low to mid-altitudes in Malawi and Zambia https://mel.cgiar.org/innovation/getinnovationview/id/552	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi, Zambia)
Chickpea inbred variety ICCV 97105 for cultivation in mid-altitudes in Malawi, Kenya, and Tanzania	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi; Potential spillover effects: Kenya, Tanzania)

Title of innovation with link (e.g. to CLARISA dashboard, MARLO).	**Innovation type**	**Stage of innovation**	**Geographic scope (with location)**
https://mel.cgiar.org/innovation/getinnovationview/id/553			
Chickpea inbred variety ICCV 96329 for cultivation in medium to high altitudes in India, and Malawi https://mel.cgiar.org/innovation/getinnovationview/id/554	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Malawi, Potential spillover effect: India)
Pearl millet inbred variety TSFB 15-4 for cultivation in India https://mel.cgiar.org/innovation/getinnovationview/id/556	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Pearl millet inbred variety TSFB 15-8 for cultivation in India https://mel.cgiar.org/innovation/getinnovationview/id/557	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Pearl millet hybrid variety IKMH18001 for cultivation in the Sudanian Zone https://mel.cgiar.org/innovation/getinnovationview/id/558	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Burkina Faso, Niger, Nigeria, Senegal)
Pearl millet inbred variety IKMV18004 for cultivation in the Sudanian Zone https://mel.cgiar.org/innovation/getinnovationview/id/559	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Burkina Faso, Mali, Niger, Nigeria)
Pearl millet inbred variety IKMV18001 for cultivation in the Sudanian Zone https://mel.cgiar.org/innovation/getinnovationview/id/560	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Burkina Faso, Mali, Niger, Nigeria)
Chickpea inbred variety NBeG 452 for cultivation in the dry lowlands in India https://mel.cgiar.org/innovation/getinnovationview/id/561	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Chickpea inbred variety Phule Vishwaraj for cultivation in dry lowlands in India https://mel.cgiar.org/innovation/getinnovatio	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)

Title of innovation with link (e.g. to CLARISA dashboard, MARLO).	**Innovation type**	**Stage of innovation**	**Geographic scope (with location)**
nview/id/562			
Chickpea inbred variety Eshete for cultivation in dry mid-altitudes in Ethiopia and India https://mel.cgiar.org/innovation/getinnovationview/id/563	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	Multi-national (Ethiopia, India)
Chickpea inbred variety RVG 204 for cultivation in the dry lowlands of India https://mel.cgiar.org/innovation/getinnovationview/id/564	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Kabuli chickpea inbred variety JGK 6 for cultivation in dry lowlands in India https://mel.cgiar.org/innovation/getinnovationview/id/565	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Kabuli chickpea inbred variety NBeG 810 for cultivation in low altitude areas in India https://mel.cgiar.org/innovation/getinnovationview/id/566	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Kabuli chickpea inbred variety RLBGK 1 for cultivation in dry lowlands in India https://mel.cgiar.org/innovation/getinnovationview/id/567	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Groundnut inbred variety ICGV 06189 for cultivation in low humidity mid-altitude areas in India https://mel.cgiar.org/innovation/getinnovationview/id/570	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Groundnut inbred variety Chhattisgarh Mungfali-1 for cultivation in low to mid-altitudes in India https://mel.cgiar.org/innovation/getinnovationview/id/571	Genetic (variety and breeds)	Stage 3: available/ ready for uptake	National (India)
Integrated and adaptive delivery system for climate-resilient common bean varieties https://mel.cgiar.org/innovation/getinnovatio	Research and Communication Methodologies and Tools	Stage 4	Multi-national (Burundi, Congo DRC, Kenya, Tanzania)

Title of innovation with link (e.g. to CLARISA dashboard, MARLO).	**Innovation type**	**Stage of innovation**	**Geographic scope (with location)**
nview/id/652			
Women as model farmers and change agents; effective integration into the development of climate-smart bean technologies and information in Rwanda https://mel.cgiar.org/innovation/getinnovationview/id/653	Other type: Digital solutions for gender equity	Stage 3	National: Rwanda
High iron beans (HIB) for enhancing nutrition security amidst COVID-19 crisis and limited space in Kenya https://mel.cgiar.org/innovation/getinnovationview/id/654	Other type: Adaptive agri-solutions	Stage 3	National (Kenya)

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

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
1	01. Improved targeting and responsiveness of research to market and household demands in the face of climate change for greater technology adoption, food and nutrition security, resilience, and poverty reduction	Increased availability of diverse nutrient-rich foods	Progress has been made to support targeting of GLDC technologies in 2020; more specifically, a web application that can be used for the multi-dimensional ranking of GLDC technologies was developed. In addition, some work was conducted to identify key traits of GLDC crops preferred by consumers. Such knowledge will support the development of improved varieties that are responsive to market demands.	Multidimensional ex-ante evaluation of GLDC research and technology options completed and results shared with GLDC staff and partners	Extended	Reason for extending: 1. Research/science - inherent risk in unknown cutting-edge research or science	
1	02. Market and household demand identified, and trade-offs assessed for more inclusive value chains that improve income and nutrition status in target regions	Increased livelihood opportunities	Great progress was made in reaching broader audiences with conversations and articles while advancing the activities on aspirations as well as urban food environments. The collaboration with Markets and Partnerships in Agribusiness (MPAB) crosscutting theme has been intensified to further emphasize the value chain aspects of the cluster and the implications of an agri-food system framing (Global Food	Underlying principles established for diversity assessment and matching of technologies across contexts	Complete	Published options of how to meet the needs of diverse target groups in GLDC research and scaling	https://doi.org/10.1057/s41287-021-00361-9 https://doi.org/10.1057/s41287-020-00352-2 https://doi.org/10.1016/j.gfs.2020.100465

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			Security paper). The special Issue around aspirations is on track and GLDC contributions have been submitted.				https://doi.org/10.1016/j.gfs.2020.100439 https://bit.ly/2NxODSl https://bit.ly/2Vb6Mqg https://bit.ly/3awqcel
1	03. Inclusive and equitable technologies and innovation systems established for accelerated and broadened impact across the agri-food system	Improved capacity of women and young people to participate in decision-making	Great progress was made towards achieving the FP outcome for 2020. In order to effectively and efficiently reduce hunger and poverty, meet the needs/demands of the target population, accelerate the adoption and impacts of GLDC technologies, the gender component was integrated into breeding objectives which informed the understanding of end users' trait preferences, assessed through a number value chains, and sex and age disaggregated studies to achieve an inclusive and equitable	Inclusive and equitable innovation system for accelerating impacts for women and young people designed and piloted, including policy interactions	Complete	Reports on innovation systems for empowering women and youth; sex disaggregated and gender relevant datasets; policy brief [paper] on gender and social analysis informing intervention design	https://bit.ly/3bUqTBA https://bit.ly/2NrDPFF https://bit.ly/2NsTCUJ

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			innovation design and dissemination.				
1	04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress in enhanced adoption and impact	Conducive agricultural policy environment	This was completed as a working paper in 2019. GLDC has developed a scaling framework that integrates nine components required for successful scaling of its innovations. We tested the utility of this framework using case studies of four large scaling projects. The framework was useful because it provided a systematic way to review the design of the projects and their scaling methods. This highlighted potential design flaws as well as opportunities for testing alternative scaling methods. The framework was less useful for evaluating project performance.	The Scaling toolkit for Design, Execution, Monitoring, and Evaluation (DEME) content agreed upon to support improved horizontal and vertical scaling of GLDC commodities and management practices	Complete	Scaling toolkit framework	https://bit.ly/39OzODo
1	04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress in enhanced adoption and impact	Conducive agricultural policy environment	This was completed as a working paper in 2019. The framework identifies several possible gaps in the design of the four scaling projects. In some cases, components in the scaling framework are missing. Three examples of missing components are marketability,	Evaluation documenting the strengths, shortcomings and key lessons learnt on GLDC scaling approaches and impacts	Complete	Evaluation report	https://bit.ly/3sUGHKO

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			policies and institutions, and upstream research. The framework defines marketability as "ready access to markets with profitable and predictable returns". This component is fundamental for scaling new technology designed for commercial markets. Yet it was deliberately omitted from the TL III project on the grounds that "research on markets, policy and seed regulation … are being adequately covered by other initiatives or that sufficient information is now available". Similarly, the framework defines policies and institutions as "an enabling environment with supporting institutions and appropriate incentives/absence of bottlenecks."				
1	04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable	Conducive agricultural policy environment	This milestone is cancelled.	At least two GLDC new scaling projects supported to apply scaling toolkit	Cancelled	Reason for cancelling: 7. Other please state: Impact estimation strategy	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
	progress in enhanced adoption and impact					prioritized	
1	04. Strong project design, execution, monitoring and evaluation systems and tools consistently applied in GLDC scaling projects, with demonstrable progress in enhanced adoption and impact	Conducive agricultural policy environment	Three studies are underway, with the core adoption piece being finalized as a working paper. Provisional results indicate that evidence on adoption is significant but that there are estimates with greater and lower levels of reliability. That said, it does appear that GLDC's adoption targets have been met and likely even exceeded.	The working strategy for evidencing the outcomes and impacts of GLDC implemented	Extended	Reason for extending: 7. Other please state: The activity is ongoing as per timeline	
3	O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Sustainable and diversified cropping systems - intercropping, rotation and doubled-up legume systems developed and promoted in Burkina Faso, Malawi, Mozambique, Senegal and Rwanda. The activities in Malawi and Mozambique cumulatively benefitted 476,591 individuals in the last five years. In Mozambique, 309,558 farmers (36% women) applied improved technologies and diversified their production systems on 440,743 ha across agro-ecologies, whereas in Malawi, 85% of the	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	Extended	Reason for extending: 2. Financial - funding not fully confirmed or at risk of being cut	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			313 households interviewed diversified their crop and variety portfolio. This milestone extends to 2021.				
3	O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Datasets collected from Burkina Faso, Ethiopia and Nigeria were used to develop simulation models to assess or predict the performance of legume varieties, combinations, and farm management options. RandomForest and Sentinel imagery were used to improve maps generated by nutrient flow models for soil organic carbon (SOC) and Nitrogen, Phosphorus, Potassium (NPK) at farm level. This milestone extends to 2021.	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	Extended	Reason for extending: 2. Financial - funding not fully confirmed or at risk of being cut	
3	O1. Cropping systems sustainably intensified and diversified	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Efficient companion crops, varieties, cropping patterns and sequences were evaluated in partnership with farmers in Burkina Faso, Malawi, Mozambique and Senegal to strengthen the capacities and skills of farmers, create awareness and increase system	Participatory field trials under smallholder conditions in different cropping systems under different environments evaluated	Extended	Reason for extending: 5. Weather - for example, drought or heavy rain affecting field trials	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			productivity. Over 1,857 farmers (59% women) were trained and 500 on-farm demonstration plots managed by farmers were established across agro-ecologies. This activity is extended to 2021.				
3	O2. Pest and diseases controlled safely and with reduced agro-chemical inputs	Reduced production risk	Pathogenic variation in *Magnaporthe grisea* identified 4 interesting isolates for use in screening of pearl millet lines, towards developing resistant lines. Surveys in Burkina Faso indicate that traditional intercropping systems as well as local varieties are most widespread, albeit with low average yields. The parasitic wasp *Therophilus javanus* can reduce pod borer populations by 86.3%. A total of 18,000 adult parasitoids were released in Burkina Faso, Niger and Nigeria in 2020. Five strains of *Streptomyces* and another 5 strains of *Bacillus* were evaluated as bio-control agents	Effective pest and disease management components evaluated to control target pests, and resource and soil management options evaluated for improved resilience.	Extended	Reason for extending: 3. Partnership - risk that partners won't be able to deliver a key piece on time	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			against Fusarium wilt and PGP agents in chickpea, reducing disease incidence and delayed expression of symptoms of disease.				
3	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	A suite of systems modelling tools/framework for co-designing resilient farming systems such as farm household typologies, whole farm system model as decision support and farming systems sustainability assessment framework were tested and validated, and strengthened the capacity of extension systems and NARS partners to use the tools to enhance resilience of rural livelihoods in SA and SSA. Used systems tools and modelling and spatial analytics across WCA (Northern Nigeria), ESA (Malawi and Tanzania) and SA (India) and supported the development of context specific agronomic packages and targeted recommendations for crop traits and spatial targeting for interventions.	Household modelling and sustainability assessment tools as decision-support for enhanced farming system resilience validated and piloted	Extended	Reason for extending: 3. Partnership - risk that partners won't be able to deliver a key piece on time	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
3	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	To enhance household dietary diversity and nutrition security, 14 improved biofortified cultivars of GLDC crops and women-led nutrition gardens of vegetables and trees piloted got high acceptance in Mali and Burkina Faso. Validated and piloted nutrition education strategies/tools, including nutrition messages and KAPs in India. Strengthened crop-livestock integration across the value fodder chain at large scale in Nigeria. Supported the scaling of Sustainable natural resource management (SNRM) through high resolution remote sensing mapping.	Portfolios of household activities, enterprises and management practices that materially and equitably enhance livelihoods (as defined at sub-IDO level) while minimizing negative externalities	Extended	Reason for extending: 3. Partnership - risk that partners won't be able to deliver a key piece on time	
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Enhanced genetic gains	Progress was made towards TPE analysis: completed for groundnut in India and in progress for pearl millet in India and background information being gathered for pearl millet in WCA.	Initial analysis of stress patterns in TPE on a few crops are available to decide on breeding target	Complete	Publication, reports and technical document	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
4	O2. Robust and responsive global to national breeding systems produce and deliver novel varieties and allied innovations at appropriate scale and scope	Increased capacity for innovation in partner research organizations	The product profiles of GLDC crops were developed and/or revised based on feedback from multi-stakeholder consultations and market and value chain studies.	Revised two crop product profiles each for sub-Saharan Africa, and South Asia,based on market studies	Extended	Reason for extending: 7. Other please state: Ongoing as per timeline	
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Reduced production risk	Early maturing chickpea and soybean cultivars, drought-tolerant groundnut and chickpea cultivars in Malawi and India were commercialized.	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)	Extended	Reason for extending: 7. Other please state: Ongoing as per timeline	https://bit.ly/3eQdv3j
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Increased availability of diverse nutrient-rich foods	High oil groundnut variety and forage cultivars of sorghum and millet with high digestibility (fodder quality) are released.	Four new varieties with enhanced nutrient levels (Fe, Zn, oil, protein, high oleic) developed and released	Extended	Reason for extending: 7. Other please state: Ongoing as per timeline	https://bit.ly/3eQdv3j
4	O1. New varieties and allied innovations improving productivity	Enhanced genetic gains	All the GLDC crop breeding pipelines are full with improved breeding lines that combine one	Phase I genetic materials deployed in GLDC	Extended	Reason for extending: 7. Other please	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
	and production potential, agribusiness opportunity and stabilizing food supply		or more of the four trait clusters, namely, (a) production traits like yield and biotic & abiotic stress tolerance; (b) resource-use efficiency and crop-architecture traits like machine harvestable chickpea and easy snapping finger millet; (c) market traits like yellow grain sorghum, and high oil or high oleic groundnut and (d) traits that support agri-food systems like dual-purpose GLDC crop cultivars.	crop improvement by CGIAR centers -- 8 crops × 3 trait clusters × 2 regions tested by NARS annually		state: Ongoing as per timeline	
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Enhanced genetic gains	Three High Throughput Phenotyping (HTP) phenotyping platforms are being integrated in India and put at the service of breeding teams, not only for sorghum. Drone initiatives in India and Senegal are making progress to enable access to the technology by breeding teams.	Sorghum crop indices measured routinely, and new indices being explored to support breeding decisions	Extended	Reason for extending: 7. Other please state: Ongoing as per timeline	
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Enhanced genetic gains	SNP-based Quality Control markers for GLDC crops are being developed or under deployment. Besides, a stagegate approach to handling breeding lines along different teams and partners of the breeding and testing pipeline	Crop breeding programs develop and use robust quality control mechanisms to safeguard genetic purity of products,	Extended	Reason for extending: 7. Other please state: Ongoing as per timeline	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			is also under implementation.	reputation and impacts of crop commodities			
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Reduced production risk	The GLDC crop cultivars released are early maturing and drought tolerant combined with resistance to biotic stresses like fusarium wilt in chickpea, downy mildew in pearl millet and groundnut rosette disease in groundnut.	New varieties with enhanced adaptation to biotic and abiotic stresses developed	Complete	Publication, reports and technical document	https://bit.ly/3eQdv3j
4	O1. New varieties and allied innovations improving productivity and production potential, agribusiness opportunity and stabilizing food supply	Reduced biological and chemical hazards in the food system	The GLDC cultivars released for cultivation in 2020 include disease-resistant downy mildew in pearl millet, blast in finger millet, fusarium wilt in chickpea and groundnut rosette disease.	New varieties deployed as part of Integrated Pest Management (IPM)/ Integrated Disease Management (IDM) minimize the use of chemicals; will target legumes and susceptible cereals; releasing 2-3 new varieties of each crop biannually per partner country	Complete	Publication, reports and technical document	https://bit.ly/3eQdv3j

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
4	O2. Robust and responsive global to national breeding systems produce and deliver novel varieties and allied innovations at appropriate scale and scope	Enhanced genetic gains	The process innovations developed and/or deployed include speed breeding, multi-environment testing (MET), product profile design through multi-stakeholder engagement and optimizing the breeding schema of GLDC crop commodities.	GLDC crop breeding programs deploy process innovations to enhance selection and operational efficiencies	Complete	Journal article	https://doi.org/10.1016/j.cj.2019.08.003
5	O1. Pre-breeding products using genebanks and other sources and modern tools to increase genetic diversity in breeding programs globally	Increased conservation and use of genetic resources	Pre-breeding activities using CWR in cowpea, soybean, chickpea, pearl millet and pigeonpea resulted in identifying lines with abiotic and biotic stress tolerance. In addition, the focus was on characterization and advancement of stacked (with multiple mode of action Bts) transgenic events for traits (such as Bt gene in pigeonpea, chickpea) for insect resistance and aflatoxin events in groundnut where natural diversity is not available.	Development/ refinement of technologies to overcome barriers to wide crosses in one crop and transgenic Bt events characterized/ advanced in one legume crop	Complete	Journal articles	https://doi.org/10.1002/csc2.20408 https://doi.org/10.1002/csc2.20343 https://doi.org/10.1016/j.tplants.2019.10.012 https://doi.org/10.1111/pbi.13354

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
5	O2. Trait discovery and development based on genomics and phenomics to generate new markers to support trait integration through the use of modern enabling technologies and forward breeding	Enhanced genetic gains	Single nucleotide polymorphism (SNP) markers were deployed for high priority traits as per product profiles in GLDC crops resulting in more than 2.5 million marker datapoints. Molecular breeding lines were released in chickpea and groundnut in Asia and Africa. Quality check (QC) panels for breeding application were developed, validated and deployed in 5 GLDC crops.	Marker development through a variety of genetic resources for one top priority trait in two legumes and two cereals and QC panel developed and validated in three GLDC crops	Complete	Journal articles, reports, technical bulletins	https://doi.org/10.1016/j.cj.2019.07.001 https://doi.org/10.1007/978-3-319-93381-8_6 https://doi.org/10.3389/fgene.2020.00514 https://doi.org/10.3390/genes11091026 https://doi.org/10.1038/s41598-020-73241-7 https://doi.org/10.1007/s00122-020-03702-0
5	03. National researchers able to apply 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 individual capacity in partner research organizations through training and exchange	Most of the data were loaded onto Dataverse and BMS in most GLDC crops.	All GLDC trait discovery programs migrate data to Integrated Breeding Platform (IBP), Breeding Management System (BMS) and Genomic Data Management	Complete	Publications, reports, technical bulletins	http://dataverse.icrisat.org

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
				System to manage genotypic and phenotypic data)			
5	03. 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	Technologies that reduce women's labor and energy expenditure developed and disseminated	QuickCrop, the second-generation transformation achieved in 2 GLDC crops (sorghum and pearl millet) and the expression constructs for gene editing applications were developed for targeting primary strigolactone pathway genes in two sorghum and one pearl millet line. Transformative RapidGen methodologies to accelerate breeding cycles in cowpea were developed using a range of 10 cowpea genotypes and overall, 4-6 generations may be taken in a year. For climate change related research, various activities under simulated temperature, CO_2 and humidity were conducted to study population dynamics, life cycle of pathogens and host response in GLDC legumes.	Proof of concept completed for genome editing and second-generation transformation platforms in two cereals	Complete	Publications, reports, technical bulletins	https://doi.org/10.3389/fgene.2019.01389 https://doi.org/10.1016/j.cpb.2020.100149 https://bit.ly/3upUycj

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
6	General	Adoption of CGIAR materials with enhanced genetic gains	These have been completed for 8 countries: Tanzania, Uganda, Ethiopia, Burundi, DRC, Rwanda, Zimbabwe and Malawi. There are 11 product profiles done by CIAT.	Researchers and partners apply data from annual stakeholder questionnaire used to update breeding profiles	Complete	Product profiles in donor report	SDC Donor Report; https://excellenceinbreeding.org/
6	General	Adoption of CGIAR materials with enhanced genetic gains	Products have been finalized (typesetting) and the policy brief is under review.	Researchers conduct foresight analysis using CIAT data to estimate competitiveness of beans in relation to other crops	Extended	Reason for extending: 7. Other please state: Publication is pending	
6	General	Adoption of CGIAR materials with enhanced genetic gains	A foresight analysis and policy brief is being completed.	Foresight studies conducted include more elements such as climate, population, markets, adoption/ consumption preferences	Extended	Reason for extending: 7. Other please state: Publication is pending	
6	O1. Increased livelihood opportunities through marketing of production and creation of new bean varieties that enjoy	Diversified enterprise opportunities; Increased capacity for innovation in	Seven ICT-based platforms to facilitate bean business actors were designed, piloted and promoted, especially for women farmers: 2 in Ghana, 2 in Kenya	Five multi-stakeholder bean business platforms established by	Complete	Donor report	CAC Donor Report: Annex 1

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
	market ready potential and meet consumer and food industry demands	partner development organizations and in poor vulnerable communities	within the EAREM corridor, 2 in Cameroon and 1 in Uganda. Were engaged with Eastern Agricultural Development Company Ltd (EADC) and Community Enterprises Development Organization (CEDO) on scaling up the bean platform and extending to processing efforts. Major off takers were engaged to start organizing bean platforms in Zambia.	partners using the Corridor model to support trade			
6	O1: Increased livelihood opportunities through marketing of production and creation of new bean varieties that enjoy market ready potential and meet consumer and food industry demands	Enhanced genetic gain	This is an ongoing process. Currently, several tests have been carried out to look at the best materials from the group of most promising coded lines to choose the parents, the source to plant and define the crossing system.	Researchers produce first breeding lines with non-darkening trait locus introgression in commercial Andean grain types	Extended	Reason for extending: 7. Other please state: Ongoing process.	
6	O3: Reduced yield losses, including those caused by climate change	Reduced pre- and post-production losses, including those caused by climate change; enhanced capacity	PABRA continues to develop and widely test consumer preferred high yielding, nutritious, stress tolerant and environmentally friendly bush and climbing bean varieties resilient to climate	Heat tolerance identified in interspecific progenies of common bean and tepary bean	Complete	Report on breeding and phenotyping in MEL	CAC Donor Report: Annex 1

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
		to deal with climate extremes	change and variability. In Zimbabwe, a total of 53 new populations were advanced (29 for heat tolerance and 24 for drought tolerance). A total 38 progenies were established in September 2020 as follows: F_3 (7 progenies), F_4 (16 progenies) and F_5(15 families) p. 37 CAC Annex.				
6	O3: Reduced yield losses, including those caused by climate change	Enhanced genetic gain	A genetic mapping population has been constructed composed of 302 interspecific accessions using the VAP 1 bridging genotype. These materials were sequenced using GBS. Currently, the phenotyping cycle under heat stress conditions is over and association mapping analyses is being carried out to determine if these interspecific regions explain the observed heat tolerance.	Researchers analyze sequence of bridging genotype between tepary and common bean	Complete	Donor report	https://bit.ly/3gqW8qD https://bit.ly/3tzMOEO https://doi.org/10.2135/cropsci2004.6370
6	O3: Reduced yield losses, including those caused by climate change	Reduced pre- and post-production losses, including those caused by climate change; Enhance genetic gain	A paper was published. Data suggests a general quantitative resistance toward root rot disease present in tropical germplasm.	Researchers confirm resistance to root (Pythium) and foliar (ALS, web blight) pathogens derived from *P. coccineus*	Complete	Journal article	https://doi.org/10.3389/fpls.2021.629221

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
				/ P. dumosu			
6	O3: Reduced yield losses, including those caused by climate change	Reduced pre- and post-production losses, including those caused by climate change; Enhanced capacity to deal with climate extremes; Gender-equitable control of productive assets and resources	Innovative delivery systems for climate-resilient varieties, ICM practices and information were strengthened. Twenty-one seed enterprises were established in corridors for the delivery of climate-smart varieties in Rwanda (8), Uganda (3), Tanzania (6), Malawi (2) and Zimbabwe (2). Nine (42.8%) of seed enterprises are owned by women.	Researchers identify and strengthen five functional seed enterprises for delivery of climate-smart varieties and complementary ICM technologies with information targeting hard to reach smallholder farmers	Complete	CAC Donor report	CAC Donor Report: Annex 1
6	O5: Increased availability of nutrient-rich food	Increased availability of diverse nutrient-rich foods	Micronutrient-rich bean varieties with superior agronomic traits were developed and quality seeds disseminated by partners.	1,000 tons of seed of new micro-nutrient bean varieties produced and disseminated by partners	Complete	Donor report	SDC Donor Report
6	O5: Increased availability of nutrient-rich food	Increased availability of diverse nutrient-rich foods	12 consumer-preferred bean varieties that are climate resilient were developed. Ethiopia released 4 climate-resilient, farmer-preferred and market-demanded varieties and Rwanda released 8 new farmer preferred high iron bean (HIB) varieties [p.	Six consumer preferred bean varieties (including biofortified) that are climate resilient and environmentally	Complete	Donor report	CAC Donor Report: Annex 1

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			21 CAC report)]	friendly developed at CIAT and released by partners			
6	O1: Increased livelihood opportunities through marketing of production and creation of new bean varieties that enjoy market ready potential and meet consumer and food industry demands	Increased livelihood opportunities	A major project to apply GS to cooking time has been launched with initial preparation of phenotyping for crosses. This project will extend for 4 years.	Researchers develop and share first crosses specifically for fast cooking time	Extended	Reason for extension: 1. Research/science - inherent risk in unknown cutting-edge research or science	
6	O1: Increased livelihood opportunities through marketing of production and creation of new bean varieties that enjoy market ready potential and meet consumer and food industry demands	Increased livelihood opportunities	6 briefs of 2 to 4 pages each have been prepared and are pending publications.	Report written on foresight analysis that predicts demand for bean based on CIAT research	Extended	Reason for extension: &. Other please state: Publication is pending	
6	O1. Increased livelihood opportunities through marketing of production and creation of new bean varieties that enjoy market ready potential and meet consumer and food industry demands	Increased livelihood opportunities	Empowerment of women and youth to participate and benefit from bean business platforms were promoted. Empowerment strategies to address gender gaps included training of women and youth on entrepreneurship, business skills and value addition to generate bean products like	Capacity building of 750 male and female entrepreneurs and farmers completed with partners	Complete	Donor report	CAC Report

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			bean flour (148 male, 372 female). Women, youth and men (1011) who are opinion leaders were integrated as change agents in the development and delivery of beans, dry bean products and nutrition information in the community.				
6	O2: More efficient use of inputs	More efficient use of inputs	A novel phenotyping tool is being applied to estimate the size of root systems, based on capacitance and an electrical field. A multiparent advanced generation intercross (MAGIC) population of common bean was generated from eight Mesoamerican breeding lines representing the phenotypic and genotypic diversity of the CIAT Mesoamerican breeding program. The principle has been established and will be applied on breeding lines.	Researchers quantify potential for enhanced root penetration from *P. coccineus*	Extended	Reason for extension: 1. Research/science - inherent risk in unknown cutting-edge research or science	https://cgspace.cgiar.org/handle/10568/110291
6	O3. Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	Climate smart, environmental and gender friendly pre-and post-harvest integrated crop management practices were adapted and developed -- Conservation Agriculture (CA) in	A climate smart and environmentally friendly pre-and post-harvest integrated crop	Complete	Donor report	CAC Donor Report: Annex 1

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			Zambia; mulching in Burundi; drought-tolerant varieties in Kenya, Zimbabwe, Uganda; timely planting and proper spacing in all countries and Solar bubble driers in Kenya, Burundi and Southern Tanzania.	management practice developed and recommended to partners			
6	O3: Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	PABRA developed and disseminated appropriate climate smart advisories to smallholder farmers for resilience in bean production. Five climate advisory information products delivered in Kenya (3) and Tanzania (2) based on national meteorological forecasts. In Tanzania, the March - May forecast by the National Meteorological Department was released and shared with bean farmers via WhatsApp on 13 February.	Researchers and partners develop and disseminated five climate advisories for bean production	Complete	Donor report	CAC Donor Report: Annex 1
6	O3: Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	COVID delayed data recovery, but data are being collected and analyzed. Data from two sites are pending.	Researchers confirm 10 heat-tolerant line selected from interspecific populations	Extended	Reason for extension: 7. Other please state: pandemic-related delays	https://bit.ly/3xo78el

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
6	O3: Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	In consultation with USDA, another 3 markers for QTL were implemented to complement the bgm-1 major gene. This is being implemented through selection at Intertek and has made breeding for virus resistance much more efficient.	Improved markers for BGYMV resistance availed, in collaboration with USDA	Complete	Journal article	https://doi.org/10.3389/fpls.2021.628443
6	O3. Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	Two critical sensitive points in seed development were pinpointed, permitting focus on them in the breeding program. The results permit focusing of future work on heat tolerance in key developmental stages.	Researchers characterize limits on photosynthate transport under heat	Complete	BBSRC Report	Report to BBSRC
6	O3. Reduced yield losses, including those caused by climate change	Reduce pre- and post-harvest losses, including those caused by climate change	Genes from Mesoamerican lines have improved heat tolerance in heat-tolerant Andean (HTA) lines, expressed in 3 sites. As in any breeding program, this objective continues but the initial success is significant and a milestone, moving genes across gene pools.	Researchers introgress Mesoamerican genes to Andeans for disease and heat resistance	Complete	KoLFACI Report	Report to KoLFACI
6	O4: Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	A model has been developed and is pending implementation in Kawanda, Uganda. COVID-19 has slowed down implementation.	Researchers advance and establish RGA-rapid generation for climbing beans	Extended	Reason for extension: 7. Other please state: pandemic-related delays	

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
6	O4: Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	An initial attempt was not proving productive, and a review of data quality is being undertaken. This is an ongoing effort, but initial challenges have been a learning process in any case.	Researchers test genomic selection	Extended	Reason for extension: 1. Research/science - inherent risk in unknown cutting-edge research or science	
6	O4: Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	More than 300 lines were distributed to partners in LAC. Data are being collected for analysis. Partners have selected lines for further study.	Nurseries of 200 lines established with at least five partners for multi-site evaluation	Complete	Report to KoLFACI	Report to KoLFACI
6	O4. Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	Research was done and traits were evaluated. Results demonstrate the potential of genomic selection to increase genetic gain in common bean breeding. Prediction abilities improved when more phenotypic data was available and G × E could be accounted for. Furthermore, the developed models allowed us to predict genotypic performance under different environmental stresses. This will be a key factor in the development of common bean	Researchers recover and analyze data from GxE trial	Complete	Journal article	https://cgspace.cgiar.org/handle/10568/110330

FP	FP outcomes 2022	Sub-IDOs	Summary narrative on progress against each FP outcome this year	Milestone	2020 milestones status	Provide evidence for completed milestones or explanation for extended, cancelled, or changed	Links to evidence
			varieties adapted to future challenging conditions.				
6	O4: Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	About 3500 samples were sent from the Colombia- based program. Our needs were not as great as expected. However, the Intertek service has proved invaluable and very cost effective in support of selection.	Researchers and partners evaluate at least 10,000 DNA samples at Intertek	Extended	Reason for extension: 3. Partnership - risk that partners won't be able to deliver a key piece on time	
6	O4: Enhanced genetic gain on station and on farm with bean varieties that display greater yield potential	Adoption of CGIAR materials with enhanced genetic gains	This activity was not pursued in 2020.Covid did not permit progress before the laboratory assistant left for PhD study.	Researchers and partners establish a gene editing system	Cancelled	Reason for extension: 3 Internal resources - risk that key staff, infrastructure or equipment not available at time needed	

Table 6: Numbers of Peer-Reviewed Publications (Sphere of control)

Type of publications	Number	Percent
Peer-Reviewed publications	121	100%
Open Access	97	80%
ISI	112	92%

Full list of publications available at: https://mel.cgiar.org/reporting/download/report_file_id/25723

Table 7: Participants in CapDev Activities

Number of trainees	Female	Male
In short-term programs facilitated by CRP	13,152	21,353
In long-term programs facilitated by CRP	18	30
* PhDs	12	19

Full list of capacity development activities available at:
https://mel.cgiar.org/reporting/download/report_file_id/27400

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**
FP1	Joint publication of a Special Issue on Aspirations	Future Rural Africa Research group
FP1	Implementation of nutrition behavior change intervention towards healthier urban food choices	Billian Music foundation
FP1	Proposal development for further exploration of work on aspirations	Bangor University
FP1	Understanding past adoption success stories to serve as learning for future approaches	Institute of Development Studies
FP1	Partnerships with universities' social sciences departments in Uganda, Tanzania and Ethiopia for evidence generation on the studies among the youth	Haramaya University, Ethiopia Makerere University, Uganda Sokoine University of Agriculture, Tanzania
FP1	GLDC impact estimation	Swedish University of Agricultural Sciences
FP3	Biological control and bio-pesticides in cowpea	Institut National de Recherche Agronomiques du Niger, Niger; Institut de l'Environnement et de Recherches Agricoles, Burkina Faso; Kwara State University, Ilorin, Nigeria; Universite Dan Diko de Maradi, Niger; Michigan State University, USA
FP3	Development and delivery of plant growth-promoting micro-organisms	Department of Chemistry, Norwegian University of Science and Technology, Trondheim, Norway
FP3	Provide tolerant chickpea pod borer material for testing at different centers	Indian Institute of Pulses Research (IIPR), Kanpur, India
FP3	Soil fertility, organic matter management	University of Ouagadougou Prof. Joseph Ki Zerbo
FP3	Climate change research on plant protection	Indian Institute of Rice Research, Hyderabad
FP3	Groundnut aflatoxins management; capacity building of young Chinese scientists	Oil Crops Research Institute (OCRI)-Chinese Academy of Agricultural Sciences
FP3	Co-supervise and collaborate on doctoral research	Center for Development Research (ZEF), University of Bonn
FP3	Research in circular agriculture for sustainable intensification	Zurich University of Applied Science
FP3	Big data analytics	SCIO Systems
FP3	Soybean variety evaluation	Soybean Innovation Lab, University of Illinois
FP3	Capacity and curriculum development	Makerere University, Uganda

Lead FP	**Brief description of partnership aims** (max. 30 words)	**List of key partners in partnership** **Do not use acronyms**
FP3	Collaborative work on criteria, indicators and framework for sustainable intensification and sustainability assessment	International Crops Research Institute for the Semi-Arid Tropics, International Center for Agricultural Research in the Dry Areas, Wageningen University & Research (WUR), Swedish University of Agricultural Sciences (SLU)
FP3	Systems modelling to co-design sustainable farming systems	International Crops Research Institute for the Semi-Arid Tropics, Indian Council of Agricultural Research and Commonwealth Scientific and Industrial Research Organisation
FP3	Innovation in the application of integrative data analysis, which enabled integration of various spatial and temporal data sources to run crop-soil-climate simulation models and produced maps of crop performance	Michigan State University and Africa Rising; West and Central Africa - Agricultural Transformation Agenda Support Program (WCA – ATSAP) and Technologies for African Agricultural Transformation (TAAT); India Meteorology Department (IMD); Indian Council of Agricultural Research, Mahalanobis National Crop Forecast Centre (MNCFC), India and the communities of practice (AGMIP), Big Data for Agriculture
FP3	Contextualizing research, capacity building, linking with farmer communities	National agricultural research systems in Burkina Faso (Institut de l'Environnement et de Recherches Agricoles), Mali (Institut d'Economie Rurale), Niger (Institut National de Recherche Agronomique du Niger), India (Indian Council of Agricultural Research), Tunisia, Syria and Sudan
FP3	System dynamics modelling for value chain analysis to identify entry points and support enabling policies	ICRISAT and Massachusetts Institute of Technology
FP5	Identify novel loci controlling breeding priority traits in pearl millet and sorghum using supervised classification (machine learning) algorithms to improve the efficiency of trait discovery for breeding applications	University of Nebraska, USA
FP5	Evaluation of drought tolerance QTL introgression lines and test hybrids during post-rainy season at multi-locations with ICAR-IIMR	Indian Council of Agriculture Research-Indian Institute of Millets Research (ICAR-IIMR)
FP5	Pearl millet, groundnut, and sorghum crop improvement programs	Excellence in Breeding (EiB), Corteva Agriscience
FP5	Crop improvement programs at IITA	Bayer Crop Science, Excellence in Breeding (EiB)
FP6	To develop drought-tolerant varieties in nine Latin American countries	Agrosavia: Corporación colombiana de investigación agropecuaria; Instituto de Ciencia y Tecnología Agrícolas (ICTA); Instituto Nacional de Innovación y Transferencia en Tecnología Agropecuaria Costa Rica; Instituto Nicaragüense de Tecnología Agropecuaria (INTA); Instituto Nacional de Innovación Agropecuaria y Forestal (INIAF); Instituto Dominicano de Investigaciones Agropecuarias y

Lead FP	**Brief description of partnership aims** (max. 30 words)	**List of key partners in partnership** **Do not use acronyms**
		Forestales (IDIAF), Instituto Nacional de Innovación Agraria (INIA); Centro Nacional de Tecnología Agropecuaria y Forestal (CENTA); Direccion de Ciencia y Tecnologia Agropecuaria (DICTA)
FP6	Negotiations with the Ministry of Agriculture, Natural Resources and Rural Development of Haiti through the CHIBAS Foundation have taken place; they came on board as a donor in 2021	Centre Haïtien d'Innovation sur les Biotechnologies et l'Agriculture Soutenable (CHIBAS, Haiti)
FP6	Physiology at pollination phase, crop modelling, transpiration efficiency, heat physiology and social science and farmer surveys	University of Reading in the UK; link with University of Leeds, SRUC Scotland's Rural College, Rothamstead Research Limited, Lancaster University
FP6	Catalyze the private sector to test, adapt and promote post-harvest grain handling prototypes, including the Multi Crop Thresher (MCT)	Imara Tech, Tanzania
FP6	Conduct gender based PVS on promising bean lines to evaluate farmer and consumer preferences (including organoleptic tests) and identify farmer and market preferred climate smart varieties	Institut des Sciences Agronomiques du Burundi (ISABU)

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
Three webinars to support the 2021 POWB development and refresher demos to augment online planning exercises via the MEL platform were conducted by three CRPs. A learning exercise was conducted to feed into succeeding MEL webinars.	CRP-RTB, CRP-FISH	Efficiency benefits, cross-CRP support for capacity development
Instead of launching an independent campaign for the 2020 Open Data Day, CRP-GLDC capitalized on a joint campaign with partner CRPs and CGIAR centers led by the MEL Platform, amplifying the exposure of blogs and testimonies from GLDC scientists.	CRP-RTB, CRP-FISH, ICRISAT, IITA, CIP, ICARDA, WorldFish	Cross-CGIAR support for shared campaigns, efficiency benefits
Development of the 'CGIAR Foresight Report' in collaboration with the CGIAR foresight team and involving all CGIAR centers.	CRP-PIM CGIAR center: All	Knowledge sharing and joint scientific products through established community of practice on foresight
Understanding the mainstreaming process of niche crops.	FTA and CRP-A4NH	Better understanding of the process through broader crop coverage, more efficient review through cross-funding
Research, delivery, tools and frameworks as well as fundraising, especially around the concept of 'gender responsive product profile development'.	Gender and Breeding Initiative/Excellence in Breeding	Development of gender-responsive product profiles and concepts
MEL-based social network analysis for better performing CRP.	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
Fall Armyworm control.	CRP-MAIZE	Cross-learning from maize and sorghum systems
Collaboration with CIMMYT - Zimbabwe for the supply of Drought Tolerant Maize in the cropping system work.	CRP-Maize with CIMMYT	
ICRISAT and ILRI partnered to enable synergies by integrating GLDC work on whole farm modelling and fodder production potential into PIM activity of cattle value chain competitive assessment in West Africa.	CRPs GLDC and PIM	Opportunity to synergistically use results from farming systems analysis (GLDC) into cattle value chain modelling (PIM) to generate more robust strategies to improve crop-livestock systems and rural livelihoods in west Africa.
Quality control and mid-density SNP panels for breeding applications.	EiB	Scientific
Genomics integration in breeding strategy development.	EiB	Efficiency benefits
Rapid generation advancements in cowpea and lentil.	ICARDA, IITA, ICRISAT	Scientific
Technical and policy support for the registration process for local varieties in Nepal and assisted farmers' associations in submitting registration proposals, leading to registration of eleven varieties of rice and beans.	CRP-PIM	Technical cooperation

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	Links to MELIA publications
Analysis of the advantages and disadvantages of rice fallow vs rice legumes	Complete	Correlates of adoption/ impact study	The study aims to provide credible estimates of the livelihood and agro-ecological impacts of the adoption of improved lentil varieties of ICARDA origin, developed to fit in the short fallow season between two rice crops in South Asia. Using DNA fingerprinting, a SPIA-funded study (Yigezu et al. 2019) estimated the adoption of these varieties at 99% in Bangladesh.	https://doi.org/10.1016/j.foodpol.2018.11.004
Adoption and impacts of improved groundnuts in Nigeria	Complete	EPIA: Ex-post Impact Assessment	The research carried out under ICRISAT's Tropical Legumes III project (TL III) with national agricultural research systems (NARS) in Nigeria, computed the impact of adoption, while accounting for possible errors from access to technology transfer and improved seed.	https://doi.org/10.4236/as.2020.112009
Adoption and impacts of improved chickpea in Ethiopia	Complete	EPIA: Ex-post Impact Assessment	The research carried out under ICRISAT's Tropical Legumes III project (TL III), with the Ethiopian Institute of Agricultural Research, computed the impact of adoption, while accounting for possible errors from access to technology transfer and improved seed.	http://dx.doi.org/10.1016/j.foodpol.2016.11.007
Assessing the impact of the Drylands Development Programme (DryDev) in Burkina Faso, Mali, Niger, Ethiopia and Kenya	Complete	EPIA: Ex-post Impact Assessment	The Dryland Development Programme (DryDev) was assessed in Burkina Faso, Mali, Niger, Ethiopia, and Kenya. This involved a quasi-experimental, difference-in-differences design of a large-scale rural development program that scaled some grain legume and dryland cereal crop varieties, as well as other management practices.	https://www.worldagroforestry.org/output/a-farmer-led-programme-final-report
What do we really know about the impacts of improved grain legumes and dryland cereals: A critical review of 18 impact studies	Complete	Synthesis (secondary) study	Improved grain legumes and dryland cereals (GLDC) varieties hold potential to intensify smallholder agriculture and improve livelihoods in semi-arid regions of sub-Saharan Africa and South Asia. To assess the empirical evidence-base for these potential benefits, 18 GLDC impact studies were reviewed to identify gaps in current knowledge on GLDC impacts.	http://dx.doi.org/10.5716/WP19006.PDF
Review of scaling approaches applied in	Complete	Synthesis (secondary)	Key GLDC scaling projects were reviewed against an idealized scaling framework implied in GLDC's proposal. Recommendations to enhance GLDC's	https://hdl.handle.net/20.500.1176

Studies/learning exercises planned for this year (from POWB)	Status	Type of study or activity	Description of activity / study	Links to MELIA publications
GLDC scaling projects: Tropical Legumes III, Harnessing Opportunities for Productivity Enhancement 2, Feed the Future initiatives and DryDev		study	contribution to transforming agri-food systems are presented.	6/11029
Integrated and multi-faceted impact assessment and learning strategy for GLDC	Complete	Other MELIA activity	Strategy to broadly estimate the impacts of GLDC vis-à-vis the CGIAR's Strategic Results Framework (SRF) targets. Three key components for 2020: mapping the extent of adoption of GLDC technologies; estimating likely resulting impacts on nutrition via a systematic review and estimating likely natural resource management impacts via a systematic review.	https://hdl.handle.net/20.500.11766/10867
Identifying a common set of indicators to report at the CRP level	Extended	Other MELIA activity	The activity to complete the formulation of indicators for CRP reporting, categorized into 4 indicator levels (groups) corresponding to the segments of the impact pathway (Activity/process, outputs, outcomes, impacts). Reference sheets will be prepared and the applicability will be validated at portfolio level, including all source of funding. this MELIA study is set to be completed in the second quarter of 2021.	
Ensure real-time data visualization based on conceptualized indicator framework: CGIAR Level Agricultural Results Interoperable System Architecture (CLARISA)	Complete	Other MELIA activity	The initial phase, carried out in 2019, led to the development and implementation of a mutual visualization dashboard, CLARISA. However, the need for a further integration around CGIAR AR indicators, for better disaggregation of data and new requirements, led the MEL-MARLO team to continue in 2020 activities for greater synergy of systems under the guidance of the SMO team and in partnership with CRPs-GLDC, FISH and RTB.	https://www.cgiar.org/impact/results-dashboard/
Assess the nutritional/dietary impacts of GLDC crop varieties	Extended	EPIA: Ex-post Impact Assessment	CRP-GLDC impact on the CGIAR system-level nutrition targets were estimated using the following elements: a) Assess key nutrient gaps in target countries; b) Estimate additional nutrients made available via GLDC crops adoption vis-à-vis gaps; and c) Use adoption estimates and evidenced assumptions vis-à-vis consumption to estimate target contribution. Based farm households' nutrition	

Studies/learning exercises planned for this year (from POWB)	Status	Type of study or activity	Description of activity / study	Links to MELIA publications
			security and determinants analysis in the three GLDC focus countries, crop diversification came out strongly as a pathway for reducing nutrition insecurity. Hence, protocols were developed to promote small households' fruit and vegetable gardens, and to assess the effects of the consumption of improved legumes and cereal varieties.	
Assessing the impacts of GLDC's natural resource management practices	Complete	Synthesis (secondary) study	The main study involved: a) A systematic review to identify, select and synthesize available natural resource management (NRM) evidence of the impacts in grain legume and dryland cereal (GLDC) farming systems in Africa and South Asia; b) Specifically narrow in on effects on building soil carbon as well as other key indicators such as soil fertility and c) Combine with adoption data to estimate progress against target and other NRM impacts. A complementary study will be carried out adopting a three scales approach including plot, household and landscape to fully assess the social and biophysical aspects of the interventions. The current phase of CRP-GLDC doesn't allow long-term interventions to assess impacts on natural resources. However, mapped projects that have promoted similar cropping systems and interventions can be used for such investigation. The Dutch- funded Drylands Development Program (DryDev) and the MoU and after across the three mentioned scales. The work will be conducted on the DryDev site of Droum in Niger as proof of concept.	https://hdl.handle.net/20.500.11766/12870

Assessing the nutritional impacts of improved short-season lentil varieties in Bangladesh	Complete	EPIA: Ex-post Impact Assessment	The study aims to provide credible estimates of livelihood and agro-ecological impacts of the adoption of improved lentil varieties of ICARDA origin, developed to fit in the short fallow season between two rice crops in South Asia. Using DNA fingerprinting, a SPIA-funded study (Yigezu et al. 2019) estimated the adoption of these varieties at 99% in Bangladesh. The current study attempts to measure the nutritional impacts of the introduction of short season lentil varieties.	https://hdl.handle.net/20.500.11766/12869
Assess the adoption and welfare impacts of improved sorghum and finger millet varieties in Ethiopia and Tanzania	Extended	EPIA: Ex-post Impact Assessment	The research carried out under ICRISAT's Harnessing Opportunities for Productivity Enhancement (HOPE) II project with national partners (Ethiopian Institute of Agricultural Research and Tanzania Agricultural Research Institute) computed the impact of adoption, while accounting for possible errors from access to technology transfer and improved seed.	
Sustainability assessment of smallholder's farming system: Assessment of the impacts of sustainable intensification options	Extended	EPIA: Ex-post Impact Assessment	A comprehensive framework for farming systems sustainability assessment with 5 domains and 115 indicators in South Asia and Sub-Saharan Africa was developed, and the same was implemented and validated in one location in India (Nalgonda) for different functional farm types. Good progress was made in developing an online open access tool for farming system sustainability assessment which will be a global public good.	https://doi.org/10.1016/j.landusepol.2019.104149
Assess the adoption and impacts of improved common bean productivity enhancing technologies on yields and on household welfare	Extended	EPIA: Ex-post Impact Assessment	The study aims to provide reliable estimates of improved bean variety adoption by using DNA fingerprinting of variety identification and analyze the impact of adoption on household food security and aggregated consumption expenditure.	

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**
CRP 2020 Independent Reviews of Quality of Science and Effectiveness by CGIAR Advisory Services (CAS)	Recommendation 6	It is recommended that GLDC clearly articulate its true potential future contribution by modifying its Theory of Change (ToC) and impact pathways to reflect its current operations, allowing it to make realistic projections on the likelihood of ultimate delivery of outcomes.	Completed	To align the research program outputs and outcomes achieved so far with the ToC and impact pathways, CRP-GLDC revised the ToC to adapt corresponding impact pathways in the form of a briefing note, adjusting some of the ambitious targets and pathways originating from FP2 but also beefing up with new elements/strengths from FP6, especially those that serve to fill gaps in FP2.	Director, CRP-GLDC and FP1 team	December 2020	Revision in the original Theory of Change
			Ongoing	Publish a review and reflection paper on the revised ToC in a peer-reviewed journal. This paper will also serve as the post-CRP strategy for scaling some of the GLDC outputs.	FP1 team	October 2021	

Table 12: Examples of W1/2 Use in this Reporting Period (2020)

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 only one category**
Research activities on manuscripts to be submitted for publication in peer-reviewed scientific journals.	Pre-start up
Research activities on developing the TOPSIS_ShinyApp.	Pre-start up
Special Issue contributions (4 papers) on Rural Aspirations in Africa: Livelihood Decisions and Rural Development Trajectories in the European Journal of Development Research.	Research
One paper published jointly with MPAB on agri-food systems and value chain interventions.	Research
Production of a music video on better urban food choices.	Delivery
Symposium on understanding urban food choices.	Partnerships
In-person meeting with the Institute of Development Studies to establish a partnership to improve the understanding of the adoption process.	Partnerships
GLDC impact estimation strategy.	MELIA
Characterizing the virulence spectrum of DM and blast pathogens of pearl millet.	Research
Integrated management of pearl millet blast through fungicides and host plant resistance.	Research
Monitoring the Fall Armyworm using pheromone traps, and evaluation of newer molecules and biopesticides against FAW in sorghum.	Research
Assessing the potential of atoxigenic *Aspergillus flavus* strains in controlling pre-harvest aflatoxin contamination in groundnut.	Research
Development of early detection systems for soilborne groundnut diseases.	Research
On-farm testing of the egg parasitoid *Trichogrammatoidea armigera* against the millet head miner in Niger and Burkina Faso.	Research
Screening of sorghum mini-core for resistance to the Fall Armyworm.	Research
Identify critical weather factors and crop growth stage for disease and insect-pest outbreaks in chickpea and pigeonpea to develop prediction models.	Research
Improve farm productivity of pigeonpea through integrated management of phytophthora blight (an emerging disease of pigeonpea).	Research
Study the mechanism of resistance to *Aphis craccivora* in select cowpea mini-core lines in screen house and screen cage.	Research
Screening the best cowpea accessions (from a previous study) to study the mechanism of resistance to the flower bud thrips *Megalurothrips sjostedti.*	Research

Release of biocontrol agents against *Maruca vitrata* in Mali and Niger, and monitoring establishment.	Research
Adaptive organic resource management targeting soil aggradation and agroecosystem resilience.	Research
Improving productivity, resilience and sustainability of millet-based cropping systems through diversification (Senegal).	Research
Optimizing cereal/legume rotation (Senegal).	Research
CNGs established for sorghum and millets, soybean, groundnut and cowpea in Africa enhance engagement with small- and medium- private seed companies, and enable end-use-driven seed systems like the sorghum brewing industry in Kenya and high oleic groundnut varieties in India. The annual engagement meets continuous capacity building needs.	Partnerships
Speed breeding technologies were deployed in lentil, chickpea and groundnut. In groundnut, under low-cost semi-controlled conditions, 3.5 cycles per year were routinely taken, while controlled conditions in chickpea and lentil resulted in 6 cycles per year. Protocols have also been standardized or deployment is ongoing for other GLDC crop commodities as well.	Research
Improved host resistance reduces input cost and contributes to environmental sustainability as fungicide molecules are released into the production system.	Research
Malawi released the first chickpea cultivars in 2020. The high oleic groundnut varieties commercialized in 2019 in India with enhanced shelf life and consumer health benefits are preferred by the industry, and the machine harvestable chickpea varieties create new employment opportunities for youth and lead to area expansion.	Research
In partnership with HIPHEN, a start-up from INRA-Avignon that assists breeding companies generate indices for breeding plots and EiB, FP4 is developing indices for GLDC crops to use drone-based imaging technologies for crop phenotyping to guide breeding decisions. The tools are expected to optimize resources for phenotyping.	Other: Modernizing crop breeding operations
GLDC cultivars with value added traits are commercialized -- three biofortified pearl millet hybrids are released in different zones of India and multi-cut forage sorghum to support crop-livestock production systems. With ILRI, testing for fodder quality was streamlined in the breeding pipeline of GLDC crops; fodder quality parameters in >11,000 samples of GLDC crops were assessed during 2019 and 2002 for advancement decisions.	Research
Multi-environment testing: Evaluating the product in target agro-ecologies based on characterization of TPEs. Institutionalizing the MET process involved product advancement meetings and assessing the genetic gain from the MET data.	Research
DNA markers' development and deployment applications in breeding programs.	Research
Developing and deploying modern genetics, genomics, resources and enabling tools and technologies for breeding.	Research
Use of induced mutation (including transgenics, genome editing) and wild diversity for intractable traits.	Research

Table 13: CRP Financial Report

CRP-GLDC	Planned budget 2020			Actual expenditure 2020*			Difference			Comments
	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	
FP1	1,261,533	2,844,044	4,105,577	1,261,171	2,631,975	3,893,146	362	212,069	212,431	
FP2	-	2,584,234	2,584,234	-	1,618,468	1,618,468	-	965,766	965,766	
FP3	1,875,742	13,007,056	14,882,798	1,843,729	9,862,133	11,705,862	32,013	3,144,923	3,176,936	
FP4	3,005,820	27,599,656	30,605,476	3,005,820	21,290,085	24,295,905	-	6,309,571	6,309,571	
FP5	1,231,652	4,887,435	6,119,087	1,231,652	4,163,284	5,394,936	-	724,151	724,151	
FP6	-	1,715,000	1,715,000	-	1,277,922	1,277,922	-	437,078	437,078	Funds for FP6 were channeled via W3.
Strategic Competitive Research Grant	415,000	-	415,000	415,000	-	415,000	-	-	-	
CRP Management & Support Cost	350,284	-	350,284	211,872	-	211,872	138,412	-	138,412	
CRP Total	**8,140,031**	**52,637,425**	**60,777,456**	**7,969,244**	**40,843,867**	**48,813,111**	**170,787***	**11,793,558**	**11,964,345**	

*Source [Identify source of information, e.g. Audited lead and participating Center financial report, Q3 report etc.)

Note: The difference in W1/W2 of US$ 170,787* will be carried forward to 2021 for the implementation of ongoing activities of 2020 on the request of CRP-GLDC participating centers.

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.

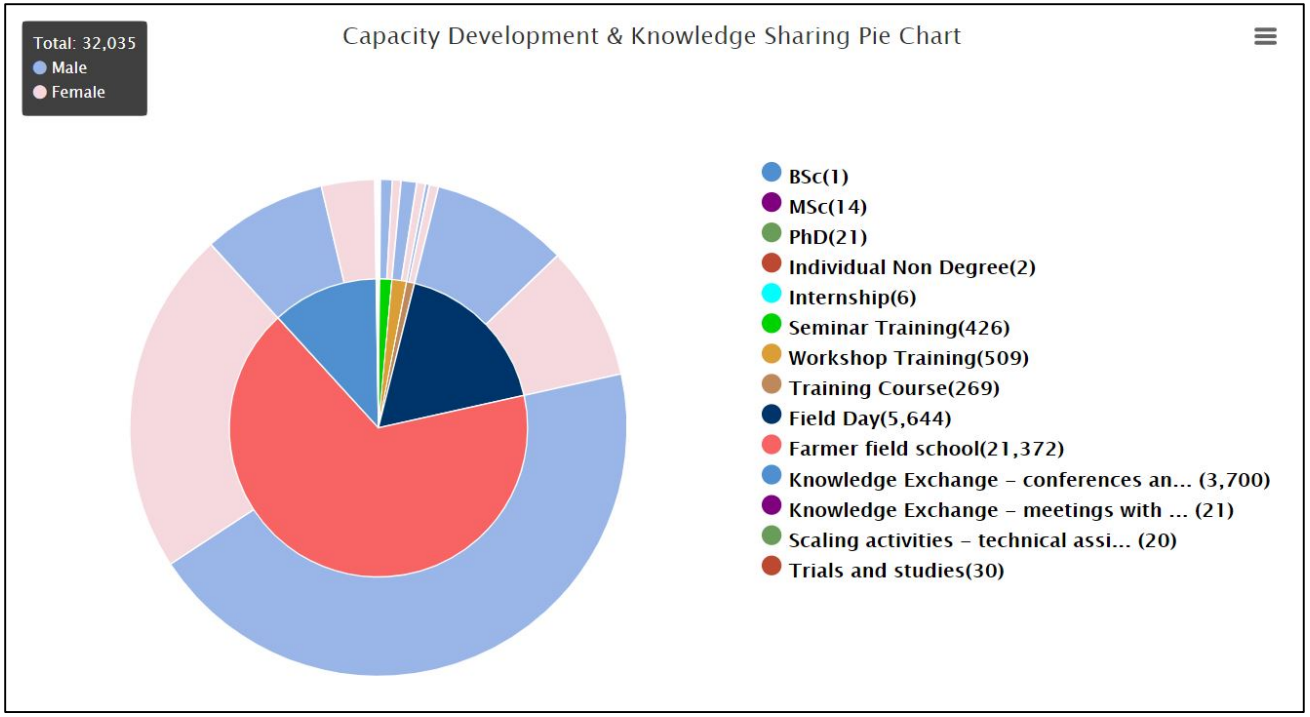


Figure 1. The types of capacity development (CapDev) activities in 2020 disaggregated by gender helped understand the scale of investment towards knowledge sharing. Although mass CapDev took most of the share, reporting takes particular note of long-term training (e.g. BSc, MSc, and PhD) which implements research, and also generates knowledge products.

Geographical distribution of partners

Figure 2. Delivery of results starts from partnerships. In 2020, 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.

Top 5 commodity investments disaggregated by partners

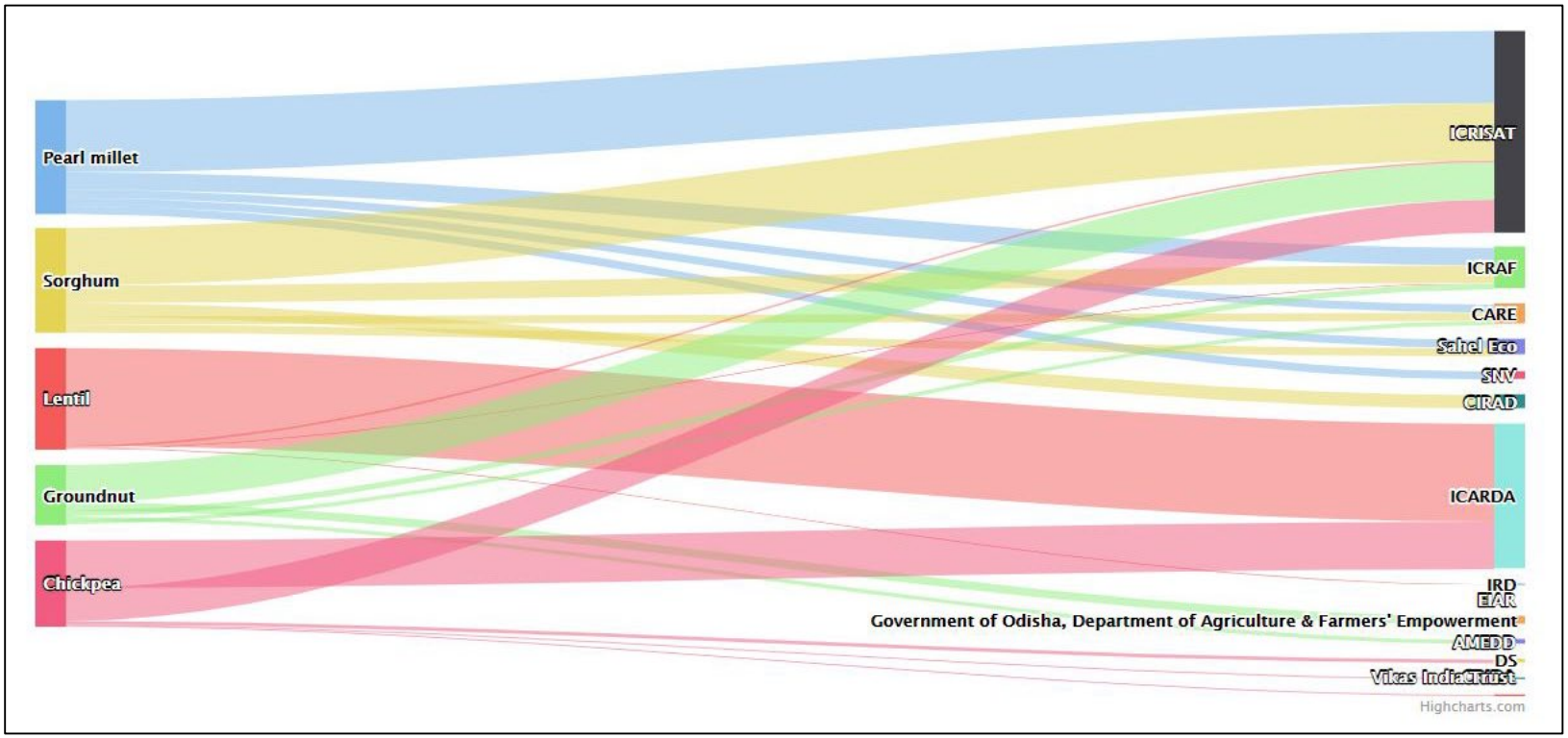


Figure 3. CRP-GLDC's multi-crop approach widens cooperation opportunities among partner institutions, not just among primary implementing CGIAR centers, but also with external partners such as national donors, specialist institutions, and NGOs.

Top 5 commodity investments disaggregated by country

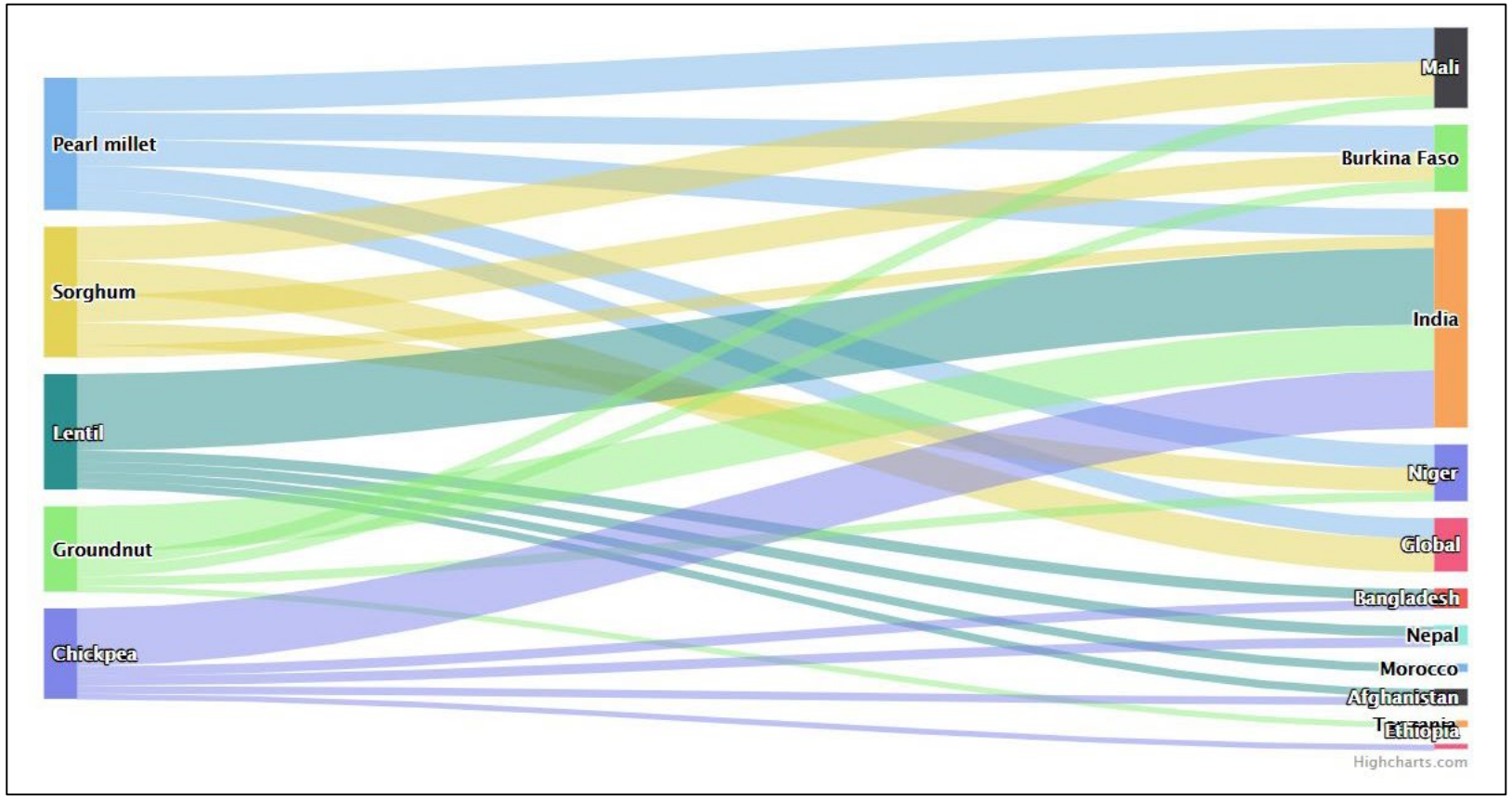


Figure 4. Covering technologies, knowledge products and interventions for ten priority crops, CRP-GLDC co-enables the transformation of underperforming grain legumes and dryland cereal agri-food systems in South Asia and Sub-Saharan Africa.

Commodities count disaggregated by country

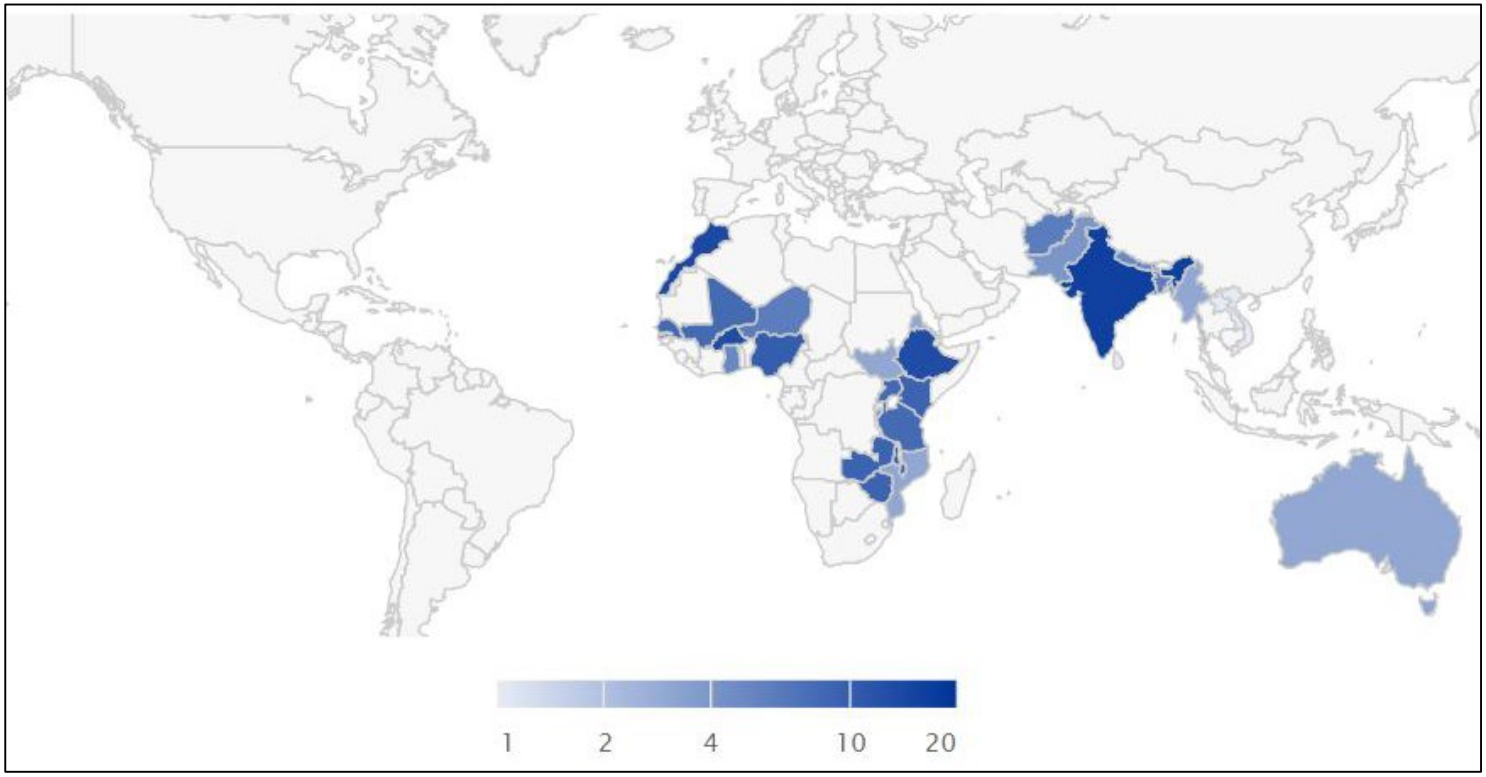
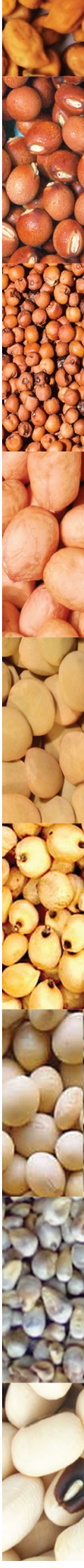


Figure 5. CRP-GLDC delivers international public goods that address the needs of target countries and support others with similar conditions.



RESEARCH PROGRAM ON
Grain Legumes and Dryland Cereals

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