CRP DRYLAND CEREALS AND LEGUMES AGRI-FOOD SYSTEM (DCL)
Intellectual Assets Management Plan

This Intellectual Assets Management Plan for DCL details the effective management of intellectual assets by the CRP with an ultimate aim of maximizing global accessibility and impact.

1. Overview

The CGIAR Research Program (CRP) on Dryland Cereals and Legumes Agri-Food System (DCL) is a multi-commodity program anchored on two classes of nutritional and climate-resilient food crops, dryland cereals and grain legumes. The program has its primary focus on sub-Saharan Africa and South Asia. The program, led by ICRISAT, will be implemented in joint partnership with five Tier 1 (CIAT, ICARDA, ICRAF, IITA, ILRI) and two Tier 2 (Bioversity, IWMI) CGIAR partners, and several strategic non-CGIAR partners, including the NARS in the target countries, sub-Regional Agricultural Organizations, ICAR, CIRAD, three USAID Feed the Future Innovation Labs, Bill and Melinda Gates Foundation, University of Queensland, Syngenta Foundation, DuPont Pioneer (India) and others.

1.1 Relevance of IA management

DCL is committed to the effective and efficient management of intellectual assets at every stage of the CRP life cycle to disseminate effectively research outputs and maximize their impact. All DCL outputs will be managed in line with the CGIAR Principles on the Management of Intellectual Assets[1] (CGIAR IA Principles) and their Implementation Guidelines[1], as International Public Goods, in a manner that fosters less rural poverty, enhances food security, better nutrition and health and sustainably managed natural resources.

1.2 Critical issues to address in CRP implementation from IA perspective

Critical issues to address during CRP implementation and anticipated challenges from an IA management perspective include:

- incorporation of IA management into the project lifecycle;
- align CGIAR IA Principles' requirements with private sector partner interests, as well as with local legislation and local markets/practices;
- available human resources for proper implementation and funding; and
- dissemination of CRP outputs

The above issues can be managed through participation in the project management lifecycle and implementation of IA Principles to other partners as the Lead Center and Participating Centers are already implementing the same. The Lead and Participating Centers hold amongst them the adaptive germplasm resources, expertise and years of experience in crop-improvement research pertinent to the target crops and the target regions of the program. DCL inherits these directly from its predecessor programs, DC, DS and GL. Planned collaborations with the Genebanks and Genetic Gains platforms add to this comparative advantage for crop improvement research. The Lead and Participating Centers have already been brought under the purview of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and all CRP-related germplasm exchanges will be strictly under the Standard Material Transfer Agreements (SMTAs) and with periodical reporting to the Governing Body of the Treaty on such access details. For those partners representing countries that have not ratified the ITPGRFA, DCL will ensure that the MTA templates are in line with the CGIAR IA Principles.

DCL recognizes the national sovereignty of countries over their biological resources, including the genetic resources, affirmed by the Convention on Biological Diversity (CBD) and the principles of access and fair and equitable benefit sharing of genetic resources as stated in the Nagoya Protocol.

DCL also recognizes the indispensable role of farmers in conserving and improving genetic resources. DCL seeks to be respectful of national and international efforts to protect and promote farmers' rights as

[1] as amended from time to time.

envisaged by the Treaty and support the development of appropriate policies and procedures for their recognition and promotion. Further, DCL is fully aware of and complies with all applicable laws protecting and promoting farmers' rights.

DCL will strive to comply with national laws that are relevant for the use of protected intellectual property and also in adhering to various regulatory requirements in all places where it operates.

In terms of agribusiness incubations that support small businesses that can bring new agricultural research and technology to market, the Lead Center has already set an example. Agribusiness and Innovation Platform (AIP) is an initiative of ICRISAT (established in 2004) to enhance its public-private partnerships (PPP) as a model for fostering agri-business to bring R4D innovations of ICRISAT and its partners to the market for faster, wider-scale impact. AIP provides prototype innovations, knowledge and expertise, training and co-location with researchers for close interaction; while the entrepreneurs fine-tune the prototypes and take them to market, including bearing the risks and reaping the rewards involved. AIP helps agribusinesses to significantly increase the resilience of tropical dryland smallholder farming through innovations that stabilize, safeguard and enhance livelihood capital (natural, social, human, physical and financial), biological & systems diversity and land health. AIP includes three programs; Agri-Business Incubation (ABI), Innovation and Partnership (INP) and NutriPlus Knowledge (NPK).

1.3 Challenges for CRP implementation as they relate to IA management

Many modern breeding products and inventions are under proprietary control. Hence patent and proprietary issues and the related Freedom to Operate will be an important part of DCL for ensuring that institutions can access and use technologies under appropriate conditions. DCL endeavours to manage issues of intellectual property with integrity, fairness, equity, responsibility and accountability wherever it operates. Intellectual Property (IP) issues will be managed through various agreements to support access of especially germplasm by partners at the national to regional levels. Most Partners have their own institutional IP policies and in the case of CGIAR Centers, institutional policies for material transfer and acquisition will apply. Incorporation of any third party intellectual assets in DCL activities will be strictly under the CGIAR IA Principles which allows global accessibility of the products/services resulting from the use of such intellectual assets for commercialization, research and development.

DCL will raise awareness and ability to address IP issues within the projects to ensure that research results and intellectual assets are identified systematically and protected if necessary and ensure that third-party intellectual property is accessed and utilized in a fair and transparent way with prior enquiry into 'Freedom to Operate' (FTO) issues. To meet the above needs on IP management, DCL will develop an overall IP policy to pursue a common framework of IP agreements for the implementing partners.

Linkages with the private seed sector are very critical to the transfer and commercialization of technologies from lab to land, as the private sector is closely associated with farmers and end users, and can play a vital role in understanding customer needs and priorities. Examples of partnerships with the private sector will be explored and assessed for adaptation to different circumstances. An example is the "Pearl Millet, Pigeonpea and Sorghum Hybrid Parent Research Consortia" established by ICRISAT in 2000 that brings together a large number of private and public sector partners for the effective dissemination of improved research products to farmers in India. This model is being replicated in Kenya, and is expected to be modelled in other target countries in sub-Saharan Africa. ICRISAT holds the exclusive rights on the materials and publication of research information as international public goods. While the HPRC private sector partners get the material on "non-exclusive" basis under the terms and conditions of SMTA and ICRISAT's MTA, all public sector partners have access to materials for further research and breeding. Also, this arrangement does not preclude ICRISAT to provide access to recipients under emergency conditions to needy countries. ICRISAT's case study on Hybrid Parents Research Consortia (HPRC) was included in the CGIAR Center Case studies under "Limited Exclusivity Agreements" of the

document titled "Examples of restrictions to global access to maximize impact" which was circulated along with the CGIAR IA Principles in March 2012.

1.4 CRP planning and implementation

IP and Legal offices in the Lead and Participating Centers will participate in all program phases, namely, Planning, Implementation, Monitoring and Evaluation and conclusion. Interventions could be either direct and/or through participation in drafting legal documents, including agreements between Lead Center and Participating Centers in addition to Sub-grantees. A fairly comprehensive list of activities for IP and Legal Offices in DCL are provided under Table 1 (Sec.2) below.

To meet the above needs on IP management, DCL will develop an overall IP policy to pursue a common framework of IP agreements for the implementing partners. This will help in making initial IP and FTO assessment for each DCL project. An IP Management Committee will be established by drawing experts from the Lead and Participating Centers for effective project implementation.

Consultants and/or additional staff to carry out specific activities will be appointed on a need basis. The Lead and Participating Centers will raise the capacity building within Centers and with Partners by organizing appropriate Meetings/Workshops, subject to budget availability. Attendance at various national and international fora like ITPGRFA, CBD and Nagoya Protocol will be essential for the effective implementation of CRP activities and outputs, and will be supported by the Lead Center. IP Offices will facilitate, where necessary, the registration of various IP applications e.g. Patent, PVP, Trademarks, etc. in line with the CGIAR Principles on the Management of Intellectual Assets.

2. Types of Intellectual Assets which are expected to be developed as CRP outputs and their dissemination pathways

The five DCL flagships are thematic areas that concentrate distinct disciplinary expertise individually within them while working across a product delivery pipeline whose immediate outputs are improved varieties/hybrids and their associated agronomic management . Integrated operation of the five FPs and their strategic partnerships at the local, regional and global levels is expected to lead to improved livelihoods in the target regions when operating within the context of prevailing farming systems. The program will contribute to improved income (SLO1), food and nutrition (SLO2), and sustainable natural resource management (SLO3).

Table 1. DCL outputs and their dissemination pathways

CRP Output	Description	Dissemination pathway	IP & legal support
Novel germplasm and diversity, techniques to utilize wild species, intermediate breeding materials with broad genetic base and desired traits, and enhanced human capacity in exploiting genetic resources.	The FP2 would contribute to the CGIAR's SRF and the Sustainable Development Goals (SDGs) by making available locally adapted climate resilient, high yielding, nutrition rich and market-preferred varieties and hybrids of DCL crops to farmers through FP 3. The scientific information, technologies and products developed under FP2 would enable FP3 in enhancing the rate of genetic gains.	Provide access as International Public Goods to NARS, private sector partners, networks, etc.	Advice on germplasm access, provide clarifications on SMTA & MTA use, advice on germplasm transfers between countries (CBD). Ensure communication of germplasm access details to GB of the Treaty.
Technologies for rapid achievement of heterosis where applicable	The possibilities of 'seed production technology (SPT)' will also be explored with private partners for efficient hybrid seed production in some of our prioritized target crops.	On-farm management and participatory research with NARS and other partners	Advice on farmers' rights, collection and transfer of germplasm, use of traditional knowledge with PIC. Advice on accessing third party technologies/
Climate-resilient efficient integrated management	Practice for improved crop, livestock, water, land and nutrient productivity/		

practices	efficiency suited to variable and changing climates and farming systems in dryland settings.		collaborations and dissemination of data.
Mechanization and agri-informatics for precision agriculture	Strategies facilitating small holders' use of appropriate mechanization and agri-informatics for precision agriculture and more efficient use of NRs, labor, inputs and energy at the farm scale.	Scaling up and out Networks	Advice on accessing third party technologies/ collaborations. Contract negotiation and drafting, etc.
Structural-genomic technologies/platforms	These would include genome sequencing and high-throughput marker platforms for facilitating application of genomic tools in FP2 and FP 3.	These platforms will be made available for all target groups of DCL. Open Access repositories.	Development of global licenses for dissemination as IPGs. Advice on access to third party tech/ data/software/ info. Agreements to publish information products through publishers and/or scientific journals.
Functional-genomic technologies/platforms	These platforms will enable development or confirmation of functional gene-to-phenotype association information through medium-throughput model-system or target-crop transformation, and/or through reverse or forward breeding with mutant or activation-tagged populations.		
Biochemical platform for nutritional quality analysis	We plan to strengthen two nutritional quality analyses labs, one in IITA and one in ICRISAT Zimbabwe.		
High-throughput phenotyping platforms	Phenotyping activities are currently housed in FP3 CoA3.2, and structured in different connected layers (trait-based, field-based at different level of "data-intensity"), and trait-based phenotyping activities really cater for FP2 needs.		
Nutritional database of DCL crops	Created for use by public and private sector through linkage with A4NH.	Open Access Repositories. Dissemination channels to specific target groups.	Development of global licenses for dissemination as IPGs. Advice on access to third party tech/ data/software/ info. Agreements to publish information products through publishers and/or scientific journals.
Breeding Informatics Tools and Databases	These are aimed at taking breeding informatics to next level by making available modern bioinformatics tools and databases to breeders and genomics scientists.		
Integrated Pest Management (IPM) strategies	for economically strengthening host plant resistance and biological control of pests and diseases and plant parasitic weeds , reducing chemical use in crops and antibiotic use in livestock, to improve productivity and ecosystem services.	OA repositories, partnership approaches and capacity development to NARS, extension specialists, partners and collaborators.	Advice on access to third party know how, and management of confidential/ proprietary information. Advice on global licenses.
Pest risk analysis and assessments of the effectiveness of IPM technologies	changes in pest and natural enemies' profiles and distribution and expression of resistance genes under different climate change scenarios.		
Information materials	on handling and disposing agro-chemicals and alternatives to agro-chemical use.		

3. Planning and tracking relevant intellectual assets and their associated rights

Tracking intellectual assets and their associated rights could be implemented through periodic reporting, and managed manually or using specialized software associated with the DCL MEL system. Some of the specific planning and tracking arrangements that have IP and/or FTO relevance are identified below, where, as part of overall program implementation, DCL will:

- develop tools and approaches to enable efficient and reliable adoption tracking among smallholders
- analyse location-specific demand and constraints using a value-chain framework that enables the systematic identification of demand-driven technologies and partnerships required to deliver impact at scale at the country level
- focus on the classification of the crop agro-ecology mega-environments, the tracking of their climate variability and the characterization of target population of environments
- link with other platforms such as ISSD Africa to form a community of practice for development of resilient productive varieties. This will also support seed-quality assurance systems by providing tools for variety tracking and impact analysis.
- invest in digitization of data management, the use of molecular tools to track variety purity and the use of GIS-based systems for routine seed-crop area assessments and certification
- explore the use of modern ICT including mobile and community media to scale out its outputs. This will include contextualized advisories on crop varieties, water, disease and pest management via mobile phones where real time monitoring of land and water is now available

4. Capacity and decision making

The Lead and Participating CGIAR Centers within DCL have the required capacity to manage the intellectual assets in fulfilment of Sec.8 of the CGIAR IA Principles and Article 8 of the Implementation Guidelines of the CGIAR IA Principles. A significant increase in Centers' IP Capacity was observed following the adoption of the CGIAR IA Principles on March 7, 2012, by recruiting additional legal and/or IP staff from 2012 to 2014. In addition, in 2014, Centers continued to strengthen their internal IP capacity with external support and by enrolling their staff in IP training and seminars[2].

Coordination and decision making will be handled through an IP Management Committee (to be formed in 2016) in coordination with the Research Management Committee and with the Lead Center's IP & Legal Offices and/or in accordance with Lead and Participating Centers relevant IP policies.

5. Budget

Activities with specific relevance to the CRP require budget allocation, which will be made available in the uplift budget scenario.

1. All staffing costs will come from Center budgets through the overheads that cover Support Services.
2. Engagement of consultants will be supported where specifically relevant to CRP activities.
3. Capacity building of staff, Participating centers and NARS Partners through Meetings/Workshops, training and seminars.
4. Facilitation of registration of IP application(s) Patents, plant variety protection and trademarks (as stated under 1.4 above) where relevant to DCL
5. Attending meetings/conference related to International (eg. ITPGRFA, CBD and Nagoya Protocol) and National instruments.
6. Due diligence and FTO will need to be carried out as required either by Centers or through external legal support based on the research activity.

Other resources for developing the activities described in this document or that will be developed in the future will be included in any future annex.

[2] CGIAR Intellectual Assets Report for 2014 (Sec.3.2; page 7), approved by the Consortium Board on 18 June 2015. Consortium Office

CRP Full Proposal Guidance on Open Access and Open Data

Planning and implementation of OA/OD in accordance with the CGIAR OADM Policy and FAIR principles:

All research data products in DCL will be maintained for public use by following CGIAR OADM policy and FAIR principles. DCL will maintain two principal sources of open data, the DCL Atlas, housed in CIAT, and Dataverse, housed in ICRISAT. In addition, a few context-based databases with links to the primary databases will also be maintained by the Lead Center. ICRISAT maintains all its data products using different state-of-the-art data platforms/applications based on the type of data such as Dataverse, Breeding Management System (BMS) of the Integrated Breeding Platform (IBP), Grin-Global, aWhere, ESRI webGIS platform. Dataverse is the primary repository to share various kinds of diverse data sets whereas BMS is being used as the primary database solution for managing crop databases and other breeding-related activities. BMS will be linked to other databases to ensure smooth data sharing with appropriate metadata. For hosting sequence and genotypic data, the platform being developed under "Genomic and Open-source Breeding Informatics Initiative" (GOBII), and collaborations with the Genetic Gains platform will be used. These datasets will be shared using GBrowse and Dataverse. ICRISAT Genebank uses Grin-Global data management system and the same will be continued under DCL. Geospatial data sets will be maintained by the DCL Atlas, and where necessary, linked to ARC Web GIS, Dataverse and aWhere servers. All CRP related articles will be maintained by OAR platform (developed by using e-Prints application). All of these data platforms and repositories are compliant with the CGIAR's standard interoperability protocols and standards.

As no single license is appropriate for all outputs of research projects, suitable open licenses will be used that recognize the legal rights to information products and encourage their use and adaptation. Depending on the nature of information and data produced, appropriate Creative Commons Licenses will be used as recommended by the IP team supporting DCL.

Technical considerations & operations (e.g. technical infrastructure and interoperability, data quality assurance, training):

To have a smooth data management implementation in DCL, the following operational plan will be used:

(a) All project data management plan will be finalised and discussed with researchers at the initial stage of the project / activity / work plan. Workflows and protocols to deal with correct experimental design, survey, basic quality checks, analytical methodologies, information on data types and formats will be finalised in advance. This will help the data team to monitor the activities related to data products and timelines as per the agreed accountability structure. CGIAR data management policy clearly indicates data backup and preservation strategies and necessary data repositories. Subject to data confidentiality and copyrights, all research output will be open for public access. Partners will be provided support for good data management practices. The capacity for optimized design of the study, efficient data-capture protocols, and modern analysis will be enhanced by regular trainings and

workshops. All research data in different formats and types will be collected from the data authors/generators with defined workflow and will be subject to quality control for the accuracy and correctness of data.

Modern and digital ways of data collection will be used to collect various research data sets and it will be ensured that data is collected with geospatial information wherever possible; this will also support the capture of appropriate metadata with more standardised digital format with real-time dashboards, data-quality checks and further integration with other databases. As a push to accelerate digital data collection under DCL, rugged, GPS-enabled and standardised android-based, hand-held devices for field and lab data collection will be used for all data-collection efforts. Online data-capture tools and centralised data servers will be synchronised with all handheld devices in real time. This infrastructure is designed in such a way that it allows dynamic capture of geospatial tags and can push additional data forms and survey design changes in real time without connecting the device to laptop or base computer. These platforms support multilingual data-capture facilities in real time.

All DCL data products will be hosted on the Dataverse platform at the Lead Centre with replicas at the Participating Centres. Summary results will be linked to and captured in the DCL Atlas maintained at CIAT, to enable users to explore data in real time. These data products will be maintained in such a way that they can be discovered by search engines and indexed using standard protocols and APIs. Dataverse has interoperability by following standards like XML, SQL and JSON.

BMS will be used as the core software for managing all breeding nurseries and research trials including those in collaborating research projects. BMS has inbuilt support for crop ontologies developed by Bioversity International and metadata standards which are aligned with the CGIAR metadata guidelines. Use of common crop ontologies will make it possible to integrate different kinds of datasets without ambiguity. Working with such common standards will also make it possible to develop / use standard APIs-based tools to aggregate and collate datasets of varying nature while aiming for common objectives. The Lead Center is working to developing APIs-based dashboards using modern Business Intelligence (BI) tools to collate, merge and monitor research data generation, storage and sharing.

Identification of repository or platform housing information products from DCL projects for indicative datatypes.

Indicative Datatype	Repository or Platform	
	Name/s	URL/s
GIS/ remote sensing	DCL Atlas ESRI Arc Web GIS Dataverse	http://www.eatlasdcl.cgiar.org/ http://csi.maps.arcgis.com/home/ http://biu.icrisat.org/dataverse/gis geoagro.icarda.org (Under customization)
Agronomy (incl. for improved natural resource management, to address climate change)	DCL Atlas ICRISAT Dataverse	http://www.eatlasdcl.cgiar.org/ http://dataverse.icrisat.org https://apps.icarda.org/rdr/Report/Browse.aspxBiometrics unit links
Genebank	Grin-Global	http://germplasm.icrisat.org GeneSys (Amir/Fawzy) (under development)
Genetic/ genomic	CMAP GBrowse	http://cmap.icrisat.ac.in/cmap/index_public.html http://cmap.icrisat.ac.in/gbrowse2 GRS links
Hydrology/ water management	DCL Atlas ICRISAT Dataverse	http://www.eatlasdcl.cgiar.org/ http://dataverse.icrisat.org
Plant breeding (incl. for improved natural resource management, to address climate change)	Breeding Management System	http://bms.icrisat.org/
Socioeconomic (incl. food security, poverty alleviation, livelihoods, nutrition...)	DCL Atlas VDSA Knowledge bank ICRISAT Dataverse	http://www.eatlasdcl.cgiar.org/ http://vdsakb.icrisat.ac.in http://dataverse.icrisat.org
Weather	DCL Atlas ICRISAT Weather Data Module	http://www.eatlasdcl.cgiar.org/ http://cmap.icrisat.ac.in/weather/ http://geoagro.icarda.org/en/default/climate

Coordination and decision making:

The Statistics, Bioinformatics & Data management unit (SBDM) of the Lead Center will support DCL research data management, planning, implementation and execution. The Head, SBDM will work closely with the DCL Atlas Team Leader, based in CIAT, and with counterparts in the Participating Centers for all activities related to data management. This team will be supported by data curators, data analysts and database programmers to streamline and manage data-management activities.

Towards the second half of 2016, a data management plan will be discussed and developed for DCL based on the requirements of the program. Appropriate data templates will be prepared and all data will be recorded in digital form. Goals and timelines for incremental data recording will be defined and communicated to activity leaders. Once data is captured it will be made subject to data curation and quality checks to ensure soundness. This final data set will be further analysed to test framed research questions and hypothesis and uploaded to suitable research data repository. NARS and partnering institutes of the CRP will be linked to central data servers. All partners and collaborators will be encouraged to adhere to the CGIAR OAOD policy. All data sets will be made public as per CGIAR guidelines.

Narrative of required resources

The necessary IT infrastructure will be made of a mix of data servers and cloud space. DCL will use 20% of the time of SBDM-head of the Lead Center, and 15% time of the DCL Atlas Team Leader. In addition, DCL will seek, at any of the Centers involved in the program, the use of 100% time of (1) one data curator/analyst for quality assurance, data curation, check, data formats, data standards and capacity building and strategic implementation of the OA/OD plan, and (2) one database programmer for design and development of dashboards, digital collection data forms, help in standardizing real-time data collection, data sharing and visualization and work on data integration, CG core meta data standards, capacity building, data preservation and training programs. These resources are required from the initial phase of the project. The proposed budget is listed in the table below.

Human, technical and other resources	**Annual amount 2016 – 2017 (transition period)**	**Annual amount 2018+ (after Phase II start)**	**Explanatory notes**
Technology			
Data Repository	1500	2000	Above mentioned Repositories
Publications Repository	1500	2000	OAR maintenance and operations
Hardware/storage (cloud etc)	10000	15000	Server Upgradation and Cloud
Bandwidth	2000	2000	IT Charges
Programming/development			
Annual maintenance fees			
Website development related to repositories			

Operations and Travel	15000	15000	Operations and Travel
Staffing			
Staff salaries – Open Data Data Management	50000	60000	1 FTE Data Programmer
Data Quality/Curation	50000	60000	1 FTE Data Curator
<Other>			
Staff salaries – Open Access publications Information management			
Head, SBDM	31000	31000	0.2 Data Management Coordinator
DCL Atlas Team Leader	22000	22000	0.15 DCL Atlas Update and Maintenance
Staff salaries – IP/Legal (in support of OA-OD)			
Staff salaries – IT (in support of OA-OD)			
Membership Fees			
Altmetrics provider(s)			<indicate which companies/services>
ORCID (unique researcher IDs)			
Publisher-based institutional memberships			<indicate which – ex: PLOS Institutional Account, Springer OA Membership>
<Other>			<indicate which – ex: DataCite membership>
Other Expenses			
Marketing/promotion materials for OA/OD			
Professional development/ training to support OA/DM	40000	50000	Data management training for CRP
OA Fees for Articles			
<Other>			

Annex 3.7 Linkages with other CRPs and site integration

Submitting CRPs should fill in all templates in a manner specific to their CRP.

Template 1: *Overview of Inter-CRP Collaboration: Provide and Receive*

For template 1 the intent is to:

- Provide an easy-to-understand overview of all inter-CRP collaborations (other major non-CGIAR regional or applicable international programs should be entered in Annex table 3.2), visualizing commitment to "One System One Portfolio".
- Allow a particular CRP to report either per FP or clusters of FPs (to be chosen). Cluster titles (if used) to be provided by submitter – examples only shown here for a generic AFS CRP.
- Show in what manner the CRP is connected to others in the Portfolio (what the CRP provides and what the CRP receives from other CRP programs or platforms, as headlines – examples only shown here) and can be substantiated in Annex Template 2a (following) with more information (including geographical focus of activities and intended outcomes).

Collaborating CRPs	**CRP: DCL AgriFood System**				
	FP1	**FP2**	**FP3**	**FP4**	**FP5**
	Priority Setting & Impact Acceleration	**Pre-Breeding & Trait Discovery**	**Variety & Hybrid Development**	**Integrated Land-Water-Crop Management**	**Improved Rural Livelihood Systems**
AGRIFOOD SYSTEM PROGRAMS					
FISH		*DCL provides:* DCL grain for use as plant protein sources to support the movement towards reduce the reliance of aquaculture on marine ingredients. *DCL receives:* Knowledge and information related to the needs and priorities of the fish feed industry.			
FTA	*DCL provides and receives:* Next steps for the options-by-context approach co-developed by FTA and DS in phase 1.	*DCL provides:* DCL crop varieties or hybrids for tree-based systems.		*DCL provides and receives:* Tree-based options for land restoration and intensification in dryland regions.	*DCL provides and receives:* Modelling impacts of tree-based options on livelihood outcomes and implications for scaling across landscapes.
LIVESTOCK	*DCL receives:* Information on feed supply and demand scenarios	*DCL provides:* Varieties/hybrids of 'full-purpose' crops (food, feed, fodder) for testing of feed/fodder quality in animal feed trials. Data on genomics and genetics of traits. *DCL receives:* Data on nutritive value of crop residues of different varieties/cultivars. Access to seed distribution systems.		*DCL receives:* Mitigation options for livestock-related environmental impacts at the farm scale.	*DCL provides:* Access to research sites in dryland areas to assess integrated approaches to livelihood improvement *DCL receives:* Livestock options (technologies and institutional arrangements) for livelihood improvement.
MAIZE	*DCL provides and receives* insights on smallholder preferences to improve the match of technologies for various intercropping systems *DCL provides* socioeconomic data to	*DCL provides:* Bean and soy varieties, including those with drought and heat tolerance for testing in maize-based systems in the humid tropic regions of Latin America (bean) and Africa (soy).		*DCL receives:* Varietal testing and fertility management of bean and soy varieties in maize-based systems in humid tropics.	*DCL receives:* Inclusion of bean and soy in integrated approaches to maize-based livelihood systems in Latin America (bean) and Africa (soy).

	parameterize crop and socio-economic models including cereal-legume mixed systems *DCL receives*: foresight analysis on optimal combination of improved maize and legume (e.g.) soy technologies for maximum positive impact on food security and poverty under climate change			
RICE, RTB, WHEAT		*DCL provides and receives:* Varieties/Hybrids of rotation and inter/companion crops	*DCL provides and receives:* Management practices for crops in rotations or mixed cropping in DCL target and spillover countries.	*DCL provides and receives:* ▪ Innovation platforms and pilots for livelihood options ▪ Mixed flour and processing options
GLOBAL INTEGRATING PROGRAMS				
A4NH	*DCL provides:* Insights in utilization of nutritious crops in its portfolio *DCL receives:* Expertise in the analysis of nutritional impacts and appropriate measurement tools	*DCL provides:* High-yielding, adapted varieties or hybrids of common bean and pearl millet for screening for improved micronutrient content. *DCL receives:* Micronutrient information on DCL-provided high-yielding, adapted varieties and hybrids of common bean and pearl millet. Dissemination of biofortified varieties of common bean and pearl millet.		*DCL provides and receives:* Characterization of food systems as part of context for household typologies; nutrition perspective to interventions, particularly on diet diversification; assessment of nutritional implications of interventions at scale.
CCAFS	*DCL provides:* (From previous work) Farm household characterization work: collation of existing datasets; Rapid survey tools for characterization and M&E purposes (e.g RHoMIS); Modelling tools and analyses across scales (e.g. GLOBIOM); Articulated demands for specific climate-related analyses. *DCL receives:* Priority setting for CSA: downscaled climate projections, regional climate outlook, prioritisation frameworks; Support to breeding programs with relevant	*DCL provides:* Climate-smart crop varieties and hybrids in early development for evaluating benefits through a CSA lens. *DCL receives:* Metrics, methods and participatory platforms (e.g. Climate Smart Villages) to evaluate emerging technologies and practices; evidence and business cases for promoting scaling out.	*DCL provides:* Technologies and practices that enhance adaptation and/or reduce GHGs; Data on crop-livestock production practices, knowledge of development trends. *DCL receives:* Guidance on: sustainable intensification that reduces emissions; GHG estimates and LED priorities.	*DCL Provides*: Contributions to synthesis of knowledge and evidence; joint investments in weather-based insurance pilots and scaling *DCL Receives:* Global analyses of opportunities for climate services and associated safety nets; Insurance Learning Platform.

	climate information.				
PIM	*DCL provides*: Dryland-cereal and legume-related input for foresight modeling; DCL examples and specific needs in the area of adoption of technology and seed systems; suggested topics for political economy analysis. *DCL/PIM actively collaborates in the value chain analysis and provides specific insights for DCL regions/crops* *DCL receives*: Foresight modeling tools and results; analysis of technology adoption; policies for seed systems performance; country-level political economy analysis.	*DCL provides:* Information from past studies on seed-sector constraints for DCL crops and countries; testing of novel approaches to seed delivery. *DCL receives:* Address of cross-cutting regulatory issues inhibiting seed sector, identification of novel approaches to seed delivery with cross-commodity relevance.		*DCL provides and receives*: Tools, methods, and results of studies of governance of shared landscapes and maintenance of ecosystem services.	*DCL provides*: Case studies of value chain analysis; findings on post-harvest loss (PHL) measurements *DCL receives*: Tools and methods for value chain analysis, intervention testing and scaling up; methodology for measurement of PHL. *DCL provides and receives:* Results of work on insurance.
WLE	*DCL provides and receives:* Impact assessment to achieve sustainable intensification beyond the farm system; Socio-demographic drivers of change at scale *DCL receives:* Current status and prospects on water resources variability and accessibility for input to current and future scenario developments, decision analysis tools for trans-disciplinary impact assessment.			*DCL provides and receives:* Enhancing the role of agricultural water management incl. soil moisture and irrigation in DCL value chains alongside agronomy and mechanization change; Developing the means for sustainable intensification of DCL crops/crop – livestock systems in dryland environments subject to long-term reduction of water resources, including analysis of GW use and mgt; Understanding of water flows management through modelling and existing monitoring for access and support of DCL crops and value chains in dryland agro-ecological systems	DCL provides and receives: Water-smart agricultural and livelihood systems; the role of agriculture water management innovations to build resilient livelihoods, nutritious food supplies and to transform poverty affected farming systems in drylands.
PLATFORMS					
Genebank Platform		*DCL provides*: Collections of novel diversity of DCL crops; use of existing and	*DCL provides*: Phenotyping platforms and results; SOPs for		

		new DCL germplasm collections; phenotypic characterization *DCL receives*: Maintenance of germplasm reserves and high-quality seeds for use in pre-breeding.	nursery research and seed health maintenance. *DCL receives*: Maintenance of DCL germplasm reserves, and timely receipt of high-quality DCL seeds for use in breeding programs.		
Genetic Gains Platform		*DCL provides*: Genomics data for use in analyses pipelines such as Genomic Open Source Breeding Informatics Initiative (GOBII) *DCL provides and receives:* Customization of tools to support the sampling to data analysis pipeline, and SOP for effective use of genotypic /sequencing/marker information in DCL breeding programs; knowledge on breeding design simulation, cross prediction, use of high-density genomics data for genomic selection, gene-to-phenotype models etc.	*DCL provides:* Feed-back on phenotyping capacities/needs and current developments; HT phenotyping tools/ approaches (eg LeasyScan) from DCL to enrich the GG module. *DCL receives:* New phenotyping tools/technologies from the phenotyping Community of Practice through GG.		
Big Data platform	*DCL provides:* Regional characterization of DCL-based farming systems; current yields and yield trends, potential yield gaps to be closed; region-specific portfolio of genetic, environmental, and management constraints *DCL receives:* Regional data of environmental drivers of crop yield (e.g. varying climate, soil and water condition); socio-economic data (e.g. market's demands and accesses, technological availability, access to financial services for agriculture, agricultural extension services). This input includes the data and results generated by CRP-DS's global socio-ecological GISresearch.	*DCL provides*: Regionally explicit collections of DCL crops (incl. existing and new germplasms) and their phenotypic characterization (incl. potential and current phenotypic gains) *DCL receives*: Past, current and future environmental data regions which DCL reports data on pre-breeding and discovered traits. This input includes the data and results generated by CRP-DS's global socio-ecological geoinformatics research.	*DCL provides*: Regionally explicit DCL varieties and phenotyping platforms; regionally explicit characterization of DCL seed systems (different forms of seed production units, seed quality maintenance, distribution network). *DCL receives*: Data on factors affecting performance of DCL seed systems (e.g. research stations' and communities' technological facilities, market links). This input includes the data and results generated by CRP-DS's global socio-ecological geoinformatics research.	*DCL provides*: Regionally explicit options on land & water management for enhancing the performance of DCL-based systems. Options here are at farm- and village-level. *DCL receives*: Data on the contexts that influence the effectiveness and provide the system niches of sustainable LWM options, including portfolios of proximate and underlying drivers of land degradation and ks, and so on. This input includes the data and results generated by CRP-DS's global socio-ecological geoinformatics research.	*DCL provides*: Compelling use cases for so-called sustainable livelihood options by context across DCL-based systems in different dryland regions. *DCL receives*: Data on the multi-dimensional contexts that influence farmers' adoptions, ingenious decisions, and effectiveness of management options. These data are not only on where DCL operates, but also across global dryland as an extrapolation domain support the scaling out and up of DCL place-based-findings. This input includes the data and results generated by CRP-DS's global socio-ecological geoinformatics research.

Template 2a: *Partnerships with other CRPs (activities, mode, geographies and outcomes sought).*

Submitting CRP: DCL

Partner CRP	ACTIVITY [COUNTRY(IES) IN WHICH THIS TAKES PLACE]	DCL ROLE	COLLABORATING CRP ROLE	COLLABORATION MODE	OUTPUT; ADDED VALUE; TARGET COUNTRIES
AGRIFOOD SYSTEM PROGRAMS					
FISH	Options for DCL-based aquafeed.	Provide DCL grain for testing.	Testing of DCL grain in aquafeed.	Joint resource mobilization.	Increased market opportunities for DCL-based aquafeed; reduced dependence of aquaculture on marine ingredients.
FTA	Options-by-context approach co-developed by FTA and DS in phase 1 taken forward with a link to systems analysis, synthesis and scaling CoA in the FTA FP3 livelihood systems.	Collaborative use of results in DCL target sites	Collaborative use of results in DCL target sites	Co-invested bilateral projects, DryDev and BioDev.	Improved natural resource management.
	Co-development of tree options for land restoration and intensification.	Collaborative research and development of options	Collaborative research and development of options	Co-invested bilateral projects, IFAD/EU Dryland Restoration	Improved natural resource management.
	Modelling impacts of tree-based options on livelihood outcomes and implications for scaling across landscapes.	Collaborative research and development of options	Collaborative research and development of options	Co-invested bilateral projects, AfricaRising, Trees4FoodSecurity	Improved livelihood options from tree-based systems.
Livestock	Development of full-purpose (food, feed and fodder) varieties/hybrids of DCL crops (Ethiopia, India, Nigeria)	Delivery of varieties/ hybrids with increased fodder yield and quality	Phenotyping for fodder traits, and facilitating dissemination of seed of new cultivars	Complementary (Ongoing)	Leveraging Livestock expertise to add value and enhance benefits to farmers of improved cultivars developed by DCL
	Development of forage seed delivery systems in drier areas.	Access to existing and improved seed systems	Identification of suitable forage species	Joint resource mobilisation	New forage seed delivery mechanisms in dry areas
	Piloting of crop-livestock related livelihood options in dryland areas	Access to sites for joint pilot testing.	Identification of suitable technologies and institutional arrangements to improve livelihoods and resilience in dryland areas.	Joint resource mobilisation	A suite of crop-livestock related livelihood options tested and evaluated in dryland areas.
	Co-location and co-investment of research on environmental impacts and mitigation at farm scale (Ethiopia, India, Nigeria)	Research on environmental impacts and mitigation at farm scale.	Research in Livestock will underpin livestock-related impacts in support of research in DCL sites.	Joint resource mobilization	Agricultural systems diversified and intensified in ways that protect soils and water (Ethiopia, India, Nigeria)
MAIZE	Testing and agronomy of beans and soy within maize-based systems in humid tropic regions of Latin America and Africa.	Development and delivery of varieties of bean and soy.	Varietal testing in maize-based systems of humid tropics, and development of fertility management for bean/soy-containing maize-based cropping system.	Complementary.	Maize-based cropping system options that include bean or soy in the humid tropics of Latin America and Africa.
	Modeling optimal combination of improved maize and soy technologies in Africa under future climate change	Collaborative research and development of options	Collaborative research and development of options	Co-investment	Maize-based cropping system options that include soy in Africa under future climate change

Partner CRP	ACTIVITY [COUNTRY(IES) IN WHICH THIS TAKES PLACE]	DCL ROLE	COLLABORATING CRP ROLE	COLLABORATION MODE	OUTPUT; ADDED VALUE; TARGET COUNTRIES
RICE	Variety development, testing and agronomy for rice-legume rotations.	Legume varieties and their agronomy for rice-legume rotations.	Rice varieties and agronomy for rice-legume rotations.	Joint resource mobilization.	Diversification of agricultural systems for improved income, nutrition and soil health.
RTB	Variety development, testing and agronomy for RTB-DCL rotations and/or intercropping.	DCL varieties and agronomic practices adapted to intercropping with RTB crops in dryland regions; Guide selection of best RTB crops and varieties for rotation with DCL crops in dryland regions.	Adapt potato varieties and their management as rotation crop with grain legumes and dryland cereals. Sweet potato varieties for intercropping and for enhancing the quality of cereal residues as animal feed (FP2, FP4, FP5)	Complementary.	Diversification of agricultural systems for improved income, nutrition and soil health.
WHEAT	Variety development, testing and agronomy for barley-wheat and wheat-legume rotations in DCL target and spill-over countries.	Barley and legume varieties for barley-wheat and wheat-legume rotations.	Wheat varieties for barley-wheat and wheat-legume rotations. Bio-economic modeling of wheat-based systems with barley and legumes as options for rotation;	Complementary.	Diversification of agricultural systems for improved income, nutrition and soil health. Identification of crop and variety portfolios for enhancing system resilience;
GLOBAL INTEGRATIVE PROGRAMS					
A4NH	Increasing diet diversity, biofortification of DCL-based food.	Development of high-yielding adaptable DCL varieties and hybrids.	Identification and dissemination of micronutrient-rich pearl millet and common bean from DCL pool of high-yielding, adapted varieties/hybrids; Providing a nutritional perspective to diet diversification.	Complementary	Biofortified bean and pearl millet; diversification of smallholder diets.
CCAFS	- Incorporation of climate-smart varieties of millet, sorghum, cowpea, groundnuts and associated climate-smart technologies and practices, into CSVs in Burkina Faso, Ghana, Mali, Niger and India. - Scaling up of climate-smart technologies and practices through CSV approach in rain-fed systems of West Africa (WA) and South Asia (SA).	Development and delivery of improved varieties/hybrids and associated climate-smart practices.	- Incorporating DCL products into a broader climate-smart perspective (e.g. downscaling and climate outlook, climate information services, insurance, local adaptation planning, low emissions development, synergies and trade-offs). - Downscaling and climate outlook for input into DCL breeding program. - National to global engagement to inform climate-related policies and investment strategies. - Generation of evidence and development of portfolios of CSA interventions to integrate into the scaling up plans in WA and SA.	- Complementary (ongoing in Burkina Faso, Ghana, Niger, Mali). - Through Site Integration in Burkina Faso, Mali, India, - Jointly planning, implementing, and scaling-up CSV portfolios in WA and SA.	- Location-specific varieties with package of practices that are recognised as CSA and are incorporated into global, regional and national policies and investment packages, with a focus on WA (in particular Burkina Faso, Mali, Niger) and SA (India). - Prioritized portfolios of CSA interventions in dryland agriculture systems, and business and institutional models for scaling-out CSA.

Partner CRP	ACTIVITY [COUNTRY(IES) IN WHICH THIS TAKES PLACE]	DCL ROLE	COLLABORATING CRP ROLE	COLLABORATION MODE	OUTPUT; ADDED VALUE; TARGET COUNTRIES
PIM	Foresight modeling (global)	Participate in community of practice, provide biophysical and other attributes for general modeling suite, run scenarios of particular interest to DCL, share results.	Development and maintenance of core modeling suite, training, convening community of practice, coordination and synthesis of cross-cutting foresight studies.	Co-investment	• Scenarios with different assumptions about technologies • Value for decisions on investment in research, value for regional and national planning for climate-preparedness Global, regional, and national
	Strengthening value chains	Development of research tools and methods, convening community of practice, prioritization of value chains and enabling environment constraints, coordination and synthesis of cross-cutting value chain studies, maintaining online platform for dissemination (tools4valuechains.org). Provides estimates of the value of land and land degradation	Development of tools and methods, application to value chains of interest to DCL, sharing lessons with community of practice, dissemination of PIM and DCL results to stakeholders in relevant value chains.	Co-investment, complementary/ parallel investment	• More systematic understanding of bottlenecks in value chains and workable interventions • Value: cross-CRP learning DCL target and spillover countries.
	Measuring and reducing post-harvest losses	Co-development of methodology, application of methodology in value chains in DCL, sharing of findings to the research, development and policy communities.	Development of methods, coordination of joint studies, convening to discuss results, and dissemination.	Complementary/ Parallel investment	• More rigorous understanding of cost of PHL, design of cost-effective interventions • Value: cross-CRP learning, integrated view DCL target and spill-over countries.
	CGIAR Collaborative Platform for Gender Research	Participation in collaboration through the platform, application and dissemination of good gender research practices.	Management of Platform	PIM funds Platform; DCL funds gender research within the program.	• Better coordination of gender research, strategic prioritization • Value: strategic prioritization, cross-CRP learning DCL target and spill-over countries.
	Managing shared landscapes	Participation in workshops and collaboration, joint development of new methods, sharing findings.	Convening group for periodic workshops to share approaches and results, providing tenure and governance inputs into landscape-level interventions tested by DCL.	Complementary/ Parallel investment	• Shared body of work covering a range of resources within shared landscapes • Value: Cross-CRP learning, cross-resource learning DCL target and spill-over countries.
	Methods and approaches to assess diffusion, adoption, and impact of technology	Participation in group, development of methods, agreeing on agenda of shared work	Convening group to improve and share methodologies, coordinated studies, present findings	Complementary/ Parallel investment	• Greater coherence and strategic prioritization in work on adoption; higher quality research results • Value: strategic prioritization, cross-CRP learning DCL target and spill-over

Partner CRP	ACTIVITY [COUNTRY(IES) IN WHICH THIS TAKES PLACE]	DCL ROLE	COLLABORATING CRP ROLE	COLLABORATION MODE	OUTPUT; ADDED VALUE; TARGET COUNTRIES
					countries
	Seed system regulations and delivery	Addressing crop specific seed regulation and delivery constraints	Addressing cross-cutting regulatory issues inhibiting seed sector, testing novel approaches to seed delivery with cross-commodity relevance.	Joint resource mobilization	• Reduced systemic barriers to seed production and delivery systems that foster quality increases and are sustainable • Value: new approaches to chronic problem; cross-CRP learning Focus on Africa
WLE	Watershed basins in Ethiopia, Kenya, Nigeria, Nepal	Technologies for improved water use efficiency in cropping systems. Interactions of cropping systems and land and water management practices. Provides estimates of the value of land and land degradation/restoration	Watershed and irrigation system scale assessments of water use efficiency and management, land degradation & restoration	Joint resource mobilization	Improved decision making tools for the use of water and its allocation at various scales; restoration of degraded land
Platforms					
Genebanks	Increasing the use of *ex situ* crop genetic resources	Use of germplasm stored in DCL genebanks to increase the genetic diversity of its breeding programs; research into health and longevity of stored seeds; review progress, determine bottlenecks to faster advancement, and seek new diversity from the genebanks	Basic functions of maintenance and upgrading of genebanks and the therein stored germplasm collections	Complementary	Increased use of high-quality DCL germplasm from genebanks; enhanced genetic diversity in DCL breeding programs
Genetic Gain	Collaborative, fast-paced development and use of existing and new tools for high throughput genotyping, phenotyping and bioinformatics for accelerated genetic gain.	Genomics and bioinformatic data from DCL genome sequencing, resequencing and the GOBII platform; Phenotyping protocols (eg LeasyScan) and data for parameters related to drought tolerance and other traits.	Shared information, SOPs, data and databases for genomics and phenomics.	Complementary	Ease of availability and use of novel, need-of-the-hour, and cutting-edge tools and technologies for crop improvement and accelerated genetic gain.
Big Data	Effective management and leveraging of data to enable Big Data capability.	Maintenance of DCL Atlas for GIS and related data storage and analysis; development of user interfaces that connect DCL Atlas with other databases; co-development of commonly accepted tools for project management, and common source control repositories. Strengthen integrated	Develop and implement a unified approach among CGIAR entities (CRPs, centers)to the collection, management, and analysis of large amounts of biophysical and socio-economic data about the global food system	Joint	Effectively managed Big Data capability.

Partner CRP	ACTIVITY [COUNTRY(IES) IN WHICH THIS TAKES PLACE]	DCL ROLE	COLLABORATING CRP ROLE	COLLABORATION MODE	OUTPUT; ADDED VALUE; TARGET COUNTRIES
		systems analyses via modelling and training			

Template 2b: Plans for site integration in CGIAR target countries

In the countries you have identified as important to your CRP, please complete the template, identifying the steps taken so far - and with a schedule for completion - for site integration (for ++ and + countries) with other CRPs.

DCL directly targets 15 countries for development and considers 18 countries for spillover efforts. Between these two categories of countries, the program addresses six "site integration ++" countries, and twelve "site integration +" countries.

Target country (++ and + countries relevant to your CRP)	**Define steps taken so far (March 2016) to establish national level engagement with other CRPs towards site integration**	**Define plan and schedule through which your CRP will provide relevant elements for development of CGIAR site integration in this country**(Responses here should be guided by the outline steps provided in the site integration annex table of instructions to authors.)
Bangladesh Craig Meisner (WorldFish)	In Bangladesh, for over 3 years 7 CGIAR centers representing over 7 CRPs have established a CGIAR Advisory Committee. Through this venue all CGIAR centers plus AVRDC and IFDC meet with our NARS and Ministry officials twice a year. We have met twice in 2015 and will meet 2 times in 2016. All details for this integration as well as 4 CAC minutes are posted on the http://gcard3.cgiar.org/national-consultations/bangladesh/	DCL participated in the Bangladesh site integration meeting, and was represented by ICARDA. This is a spillover country for the program and very critical for pulses, and the rice fallow systems, for crop intensification. DCL is already planning work with RICE to address opportunities for sustainable intensification of the rice-based cropping systems in the country with the inclusion of a second or a third crop of pulses. This adds value both in terms of income and for nutrition.
Burkina Faso Mathurin Zida (CIFOR)	The starting point was the June 6-7 2013 meeting of WLE, FTA and CCAFS in Bonn which agreed to explore areas of cross-CRP synergy (both issue and place-based) in Burkina Faso. All three CRPs had indeed major new research programs in this country, and there was potential to link to CRP Drylands. On 24 August 2013, CIFOR organized a first internal meeting between ICRAF and CIFOR in Ouagadougou to review the expected outcomes of the CRPs' joint initiative in Burkina Faso. A committee was set up at this meeting and was tasked to establish a database of CGIAR projects in terms of targets, location, and partners that would be a basis for discussing improved coordination, but also for joint development of new projects. A 2nd meeting was convened in December 2013 in Ouagadougou with participation of a broader set of partners intervening in Burkina Faso (CRPs FTA, CCAFS, WLE, Drylands, national and other international research institutions, including universities, state and non-state development partners, international NGOs) to review the quality of previous partnerships with CGIAR initiatives in Burkina Faso and to work out a new partnership framework guided by the aim to contribute to the same development pathways in Burkina Faso in a synergetic manner. A 3rd meeting was held in February 2014 with the same set of partners to define a vision, mission and action plan for the partnership framework. It was also agreed to develop a common theory of change aligned to the strategy for accelerated growth and sustainable development of Burkina Faso (SCADD), particularly the national programme for the rural sector (PNSR). The outputs of this	Burkina Faso is a primary target country for DCL and is important from the point of crop yield gap narrowing, soil amelioration or prevention of further degradation and for intensification through mixed cropping of dryland cereals and legumes. DCL participated in the consultation in BF, and aims to build on previous efforts in partnership with other CRPs including CCAFS and WLE, where BF had a concentrated presence as a regional transect country to focus work.

	meeting were validated by CRPs Leaders. As part of the agreed roadmap, the CGIAR-led initiative for building a thematic and geographical database of all CGIAR projects and those of non-CGIAR actors working in the rural sector of Burkina has been merged with a similar initiative led by the SP/CPSA (Permanent Secretariat for Coordination of Agricultural Sectoral Policies) to setting up a map database of Government and development partners' interventions in the areas of rural development in Burkina Faso. The CRPs' joint initiative in Burkina Faso has also partnered with the CCAFS Scenarios program and the SP/CPSA in a specific process aimed at examining the ending PNSR in the context of multiple socio-economic and climatic scenarios, to improve its robustness, flexibility and feasibility in the face of possible diverse futures. This scenario-guided policy revision workshop, held in July 2015, offered a unique opportunity to CGIAR experts (FTA, CCAFS, Dryland, WLE) and national policy making experts and all other workshop participants to identify research areas through which CRPs and CG Centres can contribute to the expected outcomes of the upcoming revised PNSR. Overall, the CRPS' joint initiative in Burkina Faso has set up and followed until now a participatory approach involving CGIAR actors (CRPs and Centres), national actors of Burkina Faso, and other international actors intervening in Burkina Faso, to frame partnership, map research interventions and define development and research priorities to be considered for the rural development of Burkina Faso.	
Ethiopia Siboniso Moyo (ILRI)	The Ethiopia CGIAR country collaboration and site integration process is coordinated by a committee representing 11 CGIAR Centers (Bioversity, CIAT, CIFOR, CIMMYT, CIP, ICARDA, ICRAF, ICRISAT, IFPRI, ILRI and IWMI) that are based in Ethiopia plus 3 others (Africa Rice, IITA and IRRI) who have no offices in the country, 10 CRP focal points, (Climate Change, DCLAFS, Forest and Agro Forests, Livestock, Maize, Nutrition and Health, PIM, Rice, Roots Tubers & Bananas and WLS&E) and the Genebank platform. This is the larger group that receives all communications on this process and meets quarterly for those who are based here to coincide with the existing Heads of Institutes meetings. This committee also helps with data collection (eg. mapping of ongoing projects in Ethiopia and baselining on the 10 principles of site integration). Out of this we formed a smaller group of six (3 Centers and 3 CRPs) which meets more often to plan for meetings and the process in more detail with the help of ILRI Communications and Knowledge Management team which facilitates and helps capture the notes of meetings. We are in the process of activating a wiki for our communications. At strategic points of the planning process we have brought in the Agricultural Transformation Agency and the Ethiopian Institute of Agricultural Research to help us better prepare for the national consultation process. Some key activities to date include: • Creating a database of our major partners/collaborators • Mapping CGIAR Center and CRP work in Ethiopia (November 2015). Continuing to refine. • Engaging in partners' (ATA, RED&FS) national consultations	Ethiopia is a primary target country for DCL and is very much at the forefront of AR4D efforts for many of the Centers participating in the program including ICRISAT, ICARDA, ILRI, ICRAF and others. DCL participated in the country consultation and is also leveraging the country strategies for Ethiopia developed by the Lead Center. The country grows 7 of the twelve target crops of DCL, and had an important presence of DS activities from the Phase I and extension period. DCL will work with other CRPs active in the country including WHEAT and MAIZE, and the Global Integrative Programs.

	on alignment to GTP II (November 2015 – January 2016). • Conducting National Consultation Meeting (11 December 2015) • Different CRPs/Flagships are conducting focused group consultations (January-March 2016) • Conduct focused group discussion with a target group of stakeholders (women and youth groups, farmers associations and others as agreed in the December meeting) • Joining the Ethiopian Institute of Agricultural research in celebrating their golden jubilee through a series of seminars, technology exhibition and other high level ceremonies. • Creating a wiki for the coordinating committee On 11 December 2015 we held a national consultation whose main objectives were to: 1. Improve understanding of the national priorities and goals for agricultural and related nutrition and health research for development; 2. Present CGIAR work in Ethiopia (major thematic areas, partnerships and geographic location); and 3. Identify major opportunities to align activities across actors around specific themes, including reviewing modalities for country collaboration. Participants were drawn mainly from the Federal Government Departments, Development partners (Donors, NGOs) and very few private sector and farmer association groups. The meeting participants agreed that the follow on focused meetings by CRPs should aim to include the wider stakeholders groups including women and youth. The Roadmap for agricultural and economic growth in Ethiopia is spelt out in the Government's vision was launched in during the last quarter of 2015 through the Growth and Transformation Plan II. The CGIAR should continue to align its programs to that. In addition there are already big ongoing programs led by the Government like the Sustainable Land Management (SLM) to which the CGIAR is already a major player. Following the launch of GTP II there have been a lot of national consultation meetings organised by several of CGIAR partners working on the alignment to GTP II. A good example are the meetings organised by the Agricultural Transformation Agency (ATA) and the Rural Economic Development and Food Security Sector Working Group (RED&FS) to discuss different pillars under GTP II. A number of CGIAR Centers participated in these consultations based on subject matter. The months of October-December were a busy time in Ethiopia. The CGIAR national consultation focused on strengthening mechanisms of engagement and seeking ways to better align to national priorities. One of the key recommendations was the need to establish a joint CGIAR-national agriculture research system collaboration and communication mechanism. This mechanism, it was recommended, would establish a permanent secretariat for joint planning, sharing of findings, and monitoring and evaluation. The other areas of collaboration were: the development of joint research proposals, sharing of equipment and resources, streamlining	

	policy engagement, and improving opportunities and modalities of capacity development. The need to facilitate access to laboratory facilities was also highlighted as key. These goals could be achieved through enhanced joint research implementation and supervision. This meeting was fully supported by ILRI and the Livestock and Fish CRP. When contacted most Centers had no budgets to support this meeting. We risked not holding the meeting if the Lead Center had not taken action. This is a gap that the committee has raised in the previous meetings and asked every Center and CRP to seek further clarification from DDGs, CRP Directors and the CO on the way forward. More details on the Ethiopia national consultations can be found on the GCARD3 website. **Next steps:** In our last meeting on the 16th of February we reflected on the December meeting and the follow on focused group meetings by individual CRPs. We further tried to clarify amongst ourselves what we understood site integration to mean? We agreed that so far the CRPs' priorities were well aligned with those of the GTP II and ATA's priorities. This is very promising for upcoming collaboration. We plan to purposely use the GTP II language in our engagements with the national processes and/or document through a flyer how CGIAR is contributing to GTP II. Furthermore we are aiming to identify what each CRP is seeing as the current situation and then the future situation in terms of site integration in Ethiopia from the perspective of the 10 elements which were highlighted in the guidelines, and to turn all that information into a narrative that also looks at collaboration initiatives and at ideas for future integration based on pipeline plans and projects. We were planning for a day's meeting for a smaller group to synthesize this material and write the site integration plan. At the time we discussed this we were not sure what is the level of details the CO is expecting for these plans? We also plan to continue the process of refining the mapping of CGIAR work in Ethiopia.	
Mali Ramadjita Tabo (ICRISAT)	The Mali CGIAR country collaboration and site integration process is coordinated by a committee representing 7 centers and 1 CRP. Three Mali based CGIAR Centers (ICRISAT, ICRAF, and ILRI), AVRDC, AGRA, Africa Rice ,IITA and CCAFS CRP are members of the steering committee. The committee worked on mapping of on-going projects in Mali by the different centers and CRPS. The committee under the leadership of ICRISAT organized a CGIAR site integration workshop in Bamako from March 01 to 02, 2016. Nearly 70 participants attended the two-day workshop including representatives from the Ministry of Agriculture, Non-Governmental Organizations (NGOs), donor community, private sector, CGIAR centers and farmers group. At the end of the two-day consultation, the participants came up with a draft framework of the site integration, which includes CGIAR Mali current status, principles, gaps and opportunities for site integration, resourcing, communication within and outside the CG as well as	Mali is a primary target country for DCL, and the country consultation was attended by DCL's ICRISAT representative in WCA. It is an important country for all of DCL's Flagship Projects, which can build off from previous efforts in both DC and GL. It is an important location for cross-CRP activities with RICE, CCAFS and others, and the long-time presence of ICRISAT in Bamako enables the program to network with the partners of this Centre as well as others.

	mechanisms to monitor progress and assess activities and impact. The main outputs of the integration workshop are outlined below: • The workshop served as background information for participants to build on their individual experiences within their organizations. It also helped the CG partners to upgrade and improve the draft inventory of various research programs and project partnerships in Mali • For more efficiency and increased impact, stronger coordination and collaboration were highlighted. Participants agreed that there is a strategic advantage to integrate activities and programs for the benefit of the final beneficiaries in light of the challenges linked to research funding and human resources. • Participants had a clear understanding of what the gaps and opportunities are in Mali for ARD. In addition, they proposed concrete ideas to improve the collaboration among research partners, NGOs and producers. Another key lesson addressed was the need for research to go beyond the production stage and focus on empowering farmers and NGOs to develop value chains. Working groups were formed to reflect on the following five main issues of site integration: (i) key features of integration, (ii) principles for selecting sites, and integrating actions, and (iii) towards effective collaboration and cooperation, (iv) communication and (v) progress tracking and impact assessment. The group discussions were conducted very well and allowed all participants to share their views in a constructive and open way. The working groups demonstrated the presence of vast knowledge that participants have about integration, principles for site selection and collaboration. **Next Steps:** We are in the process of finalizing the brief report for submission to the CGIAR office by March 9th, 2016 and a full report on the national consultation for Mali by March 25th, 2016. The Site Integration plan will be submitted on or before April 29th, 2016. The Site integration process steering committee agreed to meet to discuss the modalities of preparing the CGIAR site integration plan for Mali based on the 10 elements which were highlighted in the guidelines.	
Nepal Arun Joshi (CIMMYT) Sugden Fraser (IWMI)	The process of site integration in Nepal was initiated on November 9, 2015 by organizing a meeting of all CG centres working in Nepal. The site integration steering committee was formed (with one member from each CG/CRP centre). This included CIMMYT, IWMI, Biodiversity Int, IFPRI, IRRI, CIFOR and ICARDA. CCAFS was included in the subsequent meeting. Two meetings were held on 4th and 30th December to share information on work being done by each centre in Nepal and to plan for a stakeholder consultation meeting which was organized at Kathmandu on 11 January 2016. The purpose of the stakeholder meeting was three-pronged: to design the integrated research agenda, to consolidate CGIAR centres, and to	Nepal is a spillover country for DCL and its importance arises from similar opportunities for crop intensification in rice fallows as with Bangladesh. DCL will work with RICE specifically for the crop rotations involving pulses, but will also join with other CRPs including WLE, PIM and A4NH for contributing to the SLO targets.

	coordinate with national actors and strengthen the coordination, collaboration and alignments with partners in line with national priorities and policies. More than 60 participants, representing 34 national institutions participated. The cost of this meeting was shared by all centres. A joint presentation on activities being undertaken by all CG centres on various CRPs in Nepal was presented and two discussion sessions were held. The first one focused on better alignment of current CGIAR research activities, whilst the second one on targeting stakeholders' needs. Opportunities for further alignment of CG programs and CRP integration were identified through shared goals, activities and increased partnerships. The minutes were prepared along with one pager blog and submitted to CGIAR. The next CG-national consultation meeting was proposed to be held in Nepal in January 2017. Highlights included how to better align CG work with national policy issues, demand for continued capacity building of local agricultural scientists, the development of stronger national databases, promoting local genetic resources and the need for research on both climatic and non-climatic stress on agriculture. Ideas for new research avenues were also raised. For more info, see https://library.cgiar.org/handle/10947/4148 The next steering committee meeting has been scheduled for 10th March to draft the site integration. This is being done based on the national consultation and experiences of each of the centers in Nepal. In doing all this, the central point will be the Agriculture Development Strategy (ADS 2015-2035) approved by Government of Nepal on 14th August, 2015.	
Nicaragua Maya Rajasekharan (CIAT)	To take the **Nicaragua** site integration forward, a steering committee was established with representatives from CIAT, Bioversity, CATIE, ICRAF and CCAFS. As the first priority, a national consultation was held in Managua, Nicaragua from 17-18 November, 2015. Participants included six CGIAR Centers (Bioversity, CIAT, CIMMYT, CIP, ICRAF, and IFPRI), as well as CATIE and CIRAD and 20+ national partners. Centers represented work of nine CRPs (from Phase 1) which are active in the region (A4NH, CCAFS, FTA, Humidtropics, L&F, Maize, PIM, RTB, and WLE). Opportunities for further CRP integration were identified, including shared goals, activities, partnerships that would benefit the work being carried out by each program in Nicaragua and a proposed theory of change and impact pathway to carry them out. CIAT covered expenses related to the venue and food, while each participant assumed the cost of their travel and other incidental expenses. https://library.cgiar.org/bitstream/handle/10947/4180/Informe-Reunion-Integracion-2015-English.pdf?sequence=1. With the guidance from the Consortium Office, the steering committee will draft the site integration plan building on the national consultation and past/current experiences of centers in Nicaragua. A clear understanding of what is being proposed in Phase 2 CRP proposals are important before we carry out any further stakeholder	Nicaragua is a spillover country for DCL, and its importance is primarily from the point of crop improvement opportunities and seed system modes for common bean. DCL will primarily partner with MAIZE here intending to deliver improved common bean varieties into the maize bean systems in the country. The presence of CIAT, an important partner for DCL in Central America, enables the program to effectively and easily leverage the crop improvement efforts at the Center and its regional locations.

	consultation. Potential sites of integrative work were identified based on previous and ongoing CGIAR efforts (such as CCAFS climate-smart village (CSV) and FTA sentinel sites) and on priorities of the government (such as the dry corridor). Some integrative work has been already done in Tuma La Dalia CSV between CCAFS and FTA regarding baseline surveys and implementation of agroforestry measures. Developing information and knowledge management systems are essential to sustain dialogue and communication. Unlike other countries, we don't anticipate Nicaragua being a physical hub leading to a single CGIAR office. Political situation in Nicaragua is challenging and therefore engagement with the national Government and collective process towards policy level process are not easy. To meet donor/CGIAR aspirations on site integration, dedicated funding to support coordination and collective efforts are required.	
Tanzania Regina Kapinga (IITA)	The Tanzania CGIAR country collaboration and site integration process is coordinated by a CG- Tanzania Site integration process group composed of representatives from: The Ministry of Agriculture , Livestock and Fisheries (3 persons), Private Sector (1) , 7 CGIAR Centres (CIAT, CIP, ICRAF, IITA, IRRI, Africa Rice, and ILRI) that are based in Tanzania plus 4 others (Africa Rice, ICRISAT, CIMMYT, Bioversity International) who have no offices in the country, 9 CRP focal points, (Climate Change, Livestock, Maize, Nutrition and Health, PIM, Rice, Roots Tubers & Bananas, WLS&E) and the Genebank platform. From the national stakeholders' consultation workshop which was held in December 2015, principles of success and major opportunities for integration between and amongst CG centers, CRPs and national partners were identified to be: mutual trust, shared vision, shared rules of engagement, joint planning and clearly defined roles, transparency and accountability, flexibility, equal voice in partnership, comparative advantage and collective responsibility. To ensure alignment with the national agricultural priorities, both CG centres and CRPs have to understand the national strategies as elaborated in the Tanzanian Agricultural Sector Development Program (ASDP) Phase II. This implies that both CG centres and/ CRPs, when preparing the proposals that include Tanzania, should ensure to access the ASDPII documents for references so that where possible align the activities with the identified national priorities. IITA therefore as a lead focal centre, in January this year, was invited to participate in a 5-days national ASDPII prioritization workshop whereby we worked closely with the Ministry officials and other key stakeholders to identify key areas of focus by the country. The documents from this exercise, have been shared with all the CG site-integration focal persons to share with their respective directors and teams for consideration when developing the draft proposals. It is expected that before final submissions, some of the NARS reps. will get an opportunity to provide input on the proposals which include Tanzania to ensure alignment. We are also currently striving to jointly develop and implement projects that have multiple commodities and disciplines. An example we plan to emulate is that of AFRICA RISING project which although is	Tanzania is a primary target country for DCL, and very significant as the country grows 8 of the 12 target crops of the program together or separately in its various ecologies. The dryland regions of the country have been of specific importance to DC previously and our efforts will be further strengthened by the site integration here. DCL was represented by ICRISAT at the Tanzania consultation.

	led by IITA, it has other implementing centres which include-ICRAF, CIAT, ICRISAT, IITA, ILRI, AVRDC, and CIMMYT respectively. These together with various national R4D partners in the country, are demonstrating a good example of collaboration and integration. AFRICA RISING project, is using a common set of research sites and staff from various centres are participating in the implementation the project. In the pipeline is the new CGIAR-FARA-African Development Bank's Africa-wide initiative on FEEDING AFRICA. This potential project known as Technologies for African Agricultural Transformation (TAAT), will implement the scaling up and out of the proven technologies from the CG-centres to about 20 African countries. Tanzania, is one of the focus countries for TAAT project which again will provide an opportunity for about 13 CG centres to work together and also partner with the governments and other agencies from the selected focus countries. On 11- 15 April, IITA in collaboration with AfDB, will convene in Nigeria, a TAAT awareness regional consultative workshop which will be attended by several CGIAR centres, development partners, sub-regional organizations and several national stakeholders from various countries. Regarding the sharing of the CGIAR facilities, IITA –Tanzania office, already is hosting three CG centres–CIP, IRRI, and ILRI. AGRA although not a CG centre is hosted by IITA. ICRAF and Africa Rice centres are located in the neighbouring areas which also makes it easy for consultation and effective use of the CG facilities. Our site-integration process group will regularly communicate via emails and where possible organize meetings at least once every six months. Co-funding of these meetings will be explored and explored. Plans are also under way, to discuss the possibility of organizing a CG- NARS national awareness workshop aimed at popularizing to the new government, our best-bet technologies for scaling-up and out using the internally-sourced resources. Therefore, the workshop will strategically target the policy & decision makers, private sector and other key players for resource mobilization. The selected technologies for popularization should have been tested and proven for potential to reach and impact millions of beneficiaries in Tanzania	
Uganda Eldad Karamura Bioversity	The site integration process in Uganda is jointly chaired by Bioversity and CIP on a 2-year rotational basis, with Bioversity starting in 2016. A steering committee involving all the 8 CGIAR centres present in Uganda (Bioversity, CIAT, CIP, ICRAF, IFPRI, IITA, ILRI, and IWMI), was formed and held its first meeting on January 27, 2016. At that meeting the 1st Consultation Stakeholder meeting was fixed for 9 March 2016. All centres agreed to share the costs of the stakeholder consultation workshop. A second Steering Committee meeting was held on 11 February 2016, following which the chair and co-chair visited some key NARS stakeholders such NARO-Uganda DG and Makerere University. CIAT member consulted with the Uganda National Farmers' Federation, while the IWMI member consulted with teams in the Ministry of Finance. These consultation helped to collect secondary data and afforded us opportunities to interact with key stakeholders. The steering committee resolved that the first stakeholder workshop be co-hosted with the National Agricultural	Uganda is another important DCL primary target country which had long-standing efforts from both DC and GL, and these will continue with collaborative efforts with other CRPs operating here. It is also a country where we expect some interactions with RTB for testing humid tropic systems including common bean.

	Research Organization (NARO) of Uganda in order to enhance ownership by national partners. The third Steering Committee meeting was held on February 29, 2016 and focused on the plans for the implementation of the Stakeholder Consultation workshop; drew up the program, agreed on the discussion issues and the details of workshop outputs. Other staff members from the CRP working in Uganda are email-looped into all communications regarding the CGIAR site integration process right from the start. We hold internal brief consultations to discuss issues on the structure and content of on meeting agendas and usually arrive at a common consensus. Minutes from these meetings are shared to all members of the steering committee through whom information is shared with respective centre teams. In addition we are collecting information from partners and stakeholders and we hope to build this information into sharable data about our site. Materials collected so far include: - CGIAR major partners/collaborators in Uganda. - documents that highlight national development priorities in Uganda. - CGIAR research work in Uganda. - Individual project activities The CGIAR site integration committee has so far not reached a stage of discussing potential bilateral project or W1/2-funded activities planned in Uganda for joint activities amongst CRPs. However, in our discussions, we noted that for several CRPs operational in Uganda, there are already several clusters of centres collaborating in one or more of the CRPs and sharing sites among themselves and with NARS. The Humidtropics Uganda action sites of Mukono-Wakiso and Kiboga-Kyankwanzi field sites seem to be common sites in which many CGIAR centres are currently working including ILRI, CIP, IITA, Bioversity, ICRAF and CIAT. Furthermore, it was noted that centres were already sharing laboratory facilities along with NARO-Uganda institutes. The workshop on March 9, 2016 will lay the foundation for a long term engagement between the CRPs and Ugandan partners and stakeholders. Our intention at this stage is not to come up with a complete work plan/site integration plan during the actual meeting but to really listen to and discuss with partners and stakeholders about the development priorities for Uganda; what the various stakeholders and partners are doing themselves to meet those priorities and goals; and exploring what the opportunities are for partnership, alignment and working together towards these goals. The outputs of the meeting will guide the development of our site integration plans while informing the CRP II process.	
Vietnam Dindo Campilan, CIAT (revised 8/03/16)	Nine CRPS and 10 Centers have participated in the Vietnam planning for CGIAR country coordination. A national stakeholders' consultation workshop was organized in December 2015, with over 70 participants representing: 1) research institutes and government agencies, 2) universities, 3) NGOs-private sector agencies and associations, 4)	Vietnam is a spillover country for DCL, and we expect our efforts there to be similar as in Bangladesh and Nepal, for intensification of rice-pulse systems and hence the collaborations will be mostly with RICE. We anticipate our efforts to be comparatively less in this country in relation to the others listed here.

	international organizations and donors, and 5) CGIAR staff. Stakeholders agreed on an eco-regional framework to facilitate in-country collaboration and site integration. The target regions are: 1) Northwest, 2) Northeast, 3) Red river delta, 4) North central coast, 5) Central highlands-south central coast and southeast, and 6) Mekong river delta. In addition, integrating CRPs with national and local development plans was considered a key dimension of country collaboration. For each region, the stakeholders identified: 1) development priorities as set by government policymakers/decision-makers, 2) key research gaps which are recommended for the CGIAR to address, and 3) potential partners for specific research and development initiatives. Between December 2015 and March 2016, CRPs/Centers also engaged in bilateral discussions on specific collaboration needs and opportunities. Several CRPs also organized their respective country/regional planning and consultation events. A follow-up meeting by the CGIAR Vietnam team was held on 7 March, with 8 CRPs and 7 Centers represented. The 8 participating CRPs re-confirmed that Vietnam is a target country for CRP2 proposals. As next step, it was also agreed that subnational targeting will be undertaken for higher-resolution site integration plans, i.e. within each agro-ecoregion. A draft agenda for the 10-element site integration report was prepared. The proposed action items are to be shared with CRPs, for them to indicate their suggested priorities as well as intent for co-financing/cost-sharing. The country collaboration/site integration efforts in Vietnam is coordinated through: 1) core team with representatives from CRPs/Centers having physical (office) presence in Vietnam, and 2) working group with representatives from all CRPs/Centers planning to undertake activities in Vietnam for CRP2. CIAT provides overall leadership, with ICRAF as co-lead Center. In each eco-region, a lead Center and supporting CRP/s have also been identified and agreed upon.	
Zambia Peter Setimela (CIMMYT)	The first step towards site integration was the establishment of a steering committee composed of representatives from CIMMYT, ILRI, WorldFish, HarvestPlus, CIAT, IITA, Bioversity, ICRAF, ICRISAT and CIP. The steering committee developed the agenda for the site integration consultation workshop which was held from the 9-10 February 2016 in Lusaka. The workshop brought together stakeholders from the CGIAR Research Programs (CRPs), Ministry of Agriculture and Livestock, research agencies, academic institutions, donors, NGOs and the private sector. The consultative meeting came against the background of the launch of the Second Phase of the CRPs, focusing on integrated research agendas to more effectively contribute to the objectives and targets set by the Strategic and Results Framework of CGIAR and also to align the CRPs research agenda with national agricultural priorities in Zambia. From the workshop, the participants identified key elements that would lead to successful site integration, the key elements are	Zambia is a primary target country for DCL, with only one of DCL crops growing here, namely , soybean. Its opportunities from the standpoint of soybean will be closely gauged before decisions on continuing investments here. To the extent that DCL work will be occurring here we anticipate partnering with MAIZE for the systems efforts that include soybean in maize-based systems.

	summarised under the headings of: core values, administration and management, technical, communication and resource mobilisation in the workshop report. Furthermore participants identified key activities that would be required to bring about site integration and which areas they would like to proceed in partnership with the CGIAR and CRPs. The Zambian National Agriculture Investment Plan (NAIP) provided a basis for the discussions and is key in ensuring the alignment of the research and development priorities in the Zambia agricultural sector goals. The key issues identified for site integration included the following: a) Resource mobilization to drive the site integration process b) Development of coordination structures to provide strategic direction for site integration c) Shared vision among CGIAR Centers and national partners d) Capacity development of national partners and research infrastructure e) Collaboration mechanisms f) Alignment of CGIAR research activities to national priorities g) Identification of research priorities, effective delivery and scaling-out h) Impactful development initiatives to ensure improved production, food and nutrition security for smallholder farmers in Zambia. i) Coordinated and harmonized communications strategy encompassing learning hubs to share lessons. The workshop also identified critical steps that will lead to the establishment and coordination structures to drive site integration in Zambia.	

3.2 Partnership Strategy

Overview:

The DCL Partnership Strategy is based on the established networks of partners involved in DC, DS and GL, and on a situational analysis of partnerships in DC and GL conducted in 2015 (report pending). It is supported by the CGIAR site integration plans in the six target or spillover countries of DCL where the CGIAR site integration plans are operating in the initial phase.

A. Who and what type of partners

DCL is a partnership of eight CGIAR Centers, with ICRISAT leading, and several non-CGIAR partners in the public and private sectors.

Research and Development Partners

CGIAR Tier 1 and Tier 2 Partners

ICRISAT: ICRISAT, the Lead Center for DCL, has crop improvement and systems research programs that operate across Asia and SSA. It undertakes and leads strategic research in crop improvement for three grain legumes (chickpea, pigeon pea and peanut) and three dryland cereal crops (sorghum, pearl millet and finger millet). In addition, integrated NRM in the drylands has been central to ICRISAT for over 40 years. ICRISAT has state-of-the art genomics, phenotyping, plant transformation and agribusiness innovation platforms and demonstrated experience in collaborating with other CGIAR centers including CIAT, IITA and ICARDA, and in being a part of bi- and multilateral partnerships.

Bioversity International: Bioversity delivers scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity for sustainable global food and nutrition security. It has a research portfolio closely aligned with the DCL research strategy.

CIAT: CIAT has global responsibility for the improvement of two staple foods, cassava and common bean, together with tropical forages for livestock. In its work on agrobiodiversity, the Center employs advanced biotechnology to accelerate crop improvement, and holds unique collections of about 65,000 crop samples. Alongside its research on agrobiodiversity, CIAT also works soils, and decision and policy analysis, which cut across all tropical crops and production environments.

ICARDA: ICARDA has a long history of natural resource management, farming systems and soil, water and nutrient management in dry areas with inherently low levels of productivity. In addition, it has a strong varietal development program on barley faba bean, kabuli chickpea, lentil and grass pea through conventional and marker-assisted approaches. The center has organized itself to ensure that the gains in genetic potential through plant and animal breeding are realized in farmer's fields by providing packages of technological, institutional and policy options in cooperation with national and others partners.

ICRAF: ICRAF has experience in working with multiple partners towards integrating crop, livestock and tree based options for agricultural development, and has particular expertise in integrating sustainability in these systems. It operates in six regions and has more than 30 country offices, enabling on-the- ground participation in DCL activities in most of the target and spillover countries. It has an excellent track record in managing the West African Sahel regional flagship of the Dryland Systems CRP, where it mobilized the expertise of various centers.

IITA: IITA has a very strong commitment to crop improvement, and has the global mandate for improving cowpea and a regional mandate for improving soybean. It has a long experience in Integrated Pest Management in both cowpea and soybean, collaborating with a network of R4D partners. IITA's Refreshed Strategy for 2012–2020 addresses cereals, cowpea, and livestock integration in the dry savannas of West Africa.

ILRI: ILRI has a long history of engagement with livestock and related issues in the drylands and its research teams are globally recognized for the quality of their research and publications. ILRI's expertise ranges from the specific (systems and component modeling studies, etc.) to the big picture (policy analysis, foresight and high level engagement). ILRI has specific experience that few centers can match in taking *systems* research to scale with development partners (LIVES, Africa RISING).

IWMI: IWMI has been a lead developer of small holder water and land management strategies, piloting and knowledge transfer in collaboration with farmers and in collaboration with national research and policy, and CGIAR institutes, ranging from the rainfed (green) water management towards full irrigation (blue water) managed systems. In recent and ongoing activities, IWMI leads smallholder water and land management in key DCL countries such as Ethiopia (IWMI office), Nigeria, and Tanzania with additional activities and experience in Ghana (IWMI office), Burkina Faso, Niger, Mali, India, Sudan, and Uzbekistan.

Leveraging Synergies with Other CGIAR Research Programs: DCL will work in close partnership with the Global Integrating Programs, PIM, A4NH, CCAFS, and WLE. It will also engage in coordinated research with other agrifood system programs, including MAIZE, RTB, Livestock, WHEAT, FTA and RICE. These synergies are described in Annex 3.7 and its associated tables.

NARS, Apex Bodies and Sub-Regional Organizations: DCL works hand in hand with the Indian Council of Agricultural Research (ICAR), particularly with the All India Coordinated Research Projects on barley, chickpea, groundnut, pearl millet, and sorghum, and State Agricultural Universities, to meet challenges in production of barley, millets, pulses and sorghum in South Asia. Such coordinated efforts are also in place in all of the other target countries of the program, as with EIAR in Ethiopia, KALRI in Kenya, INRAN in Morocco, and IET in Mali, to name a few. DCL has recently established stronger ties with the Forum for Agricultural Research in Africa (FARA), and continues its collaborations with the West African Council for Agricultural Research for Development (CORAF/WECARD) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). The Phase I program DC is also partnering with APAARI, RUFORUM and WACCI for the joint administration of the Dryland Cereals Scholarship program.

Advanced Public and Private Research Institutes: The Phase I programs, DC and GL, already engage in joint research with IRD/CIRAD, the University of Queensland, EMBRAPA, Cornell University, the University of Georgia and the University of Hohenheim. DCL is strengthening collaboration with the Agropolis Fondation, beyond the existing relationship of DC and GL with IRD/CIRAD. The recently initiated Genomics and Open Source Breeding Informatics Initiative (GOBII), involving CIMMTY, ICRISAT, IRRI and Cornell University will further strengthen the ties with Cornell, and foster cross-CG/CRP partnerships. A strong partnership is operating with the University of California, Davis targeting drought tolerance, high productivity, disease resistance and malting quality. Another important collaboration has been developed with the USDA-ARS, North Dakota on barley genomics research. In DC, links were also being established with a world-leading brewing industry and USAID on the development of malt barley to benefit small malt barley producers in Ethiopia, India and Morocco.

The USAID-supported Feed-the-Future Innovation Labs on (1) Grain Legumes, (2) Peanut and Mycotoxin and (3) Sorghum and Millets will continue to be close partners of DCL and will contribute their expertise in the genetic enhancement in dryland cereal and legume crops through genomics, bioinformatics, physiology, and breeding materials in Ethiopia and West African nations. These will also contribute to improvements in production-system management and the development of value-added products including new food products like flour blends or convenience products, poultry and ruminant-animal feeds, and nutritious forage/fodder products.

Private and Public Enterprises: The Pearl Millet, Pigeon Pea and Sorghum Hybrid Parents Consortia established by ICRISAT since 2000 provides effective dissemination of improved research products to the farmers and will be used as a model for establishing similar entities in Sub-Saharan Africa, once a sizeable private sector gets established. In finger millet, links with the key processing industries in the ESA region such as Nyirefarm in Tanzania and Unga Millers in Kenya are essential for supporting demands. Monitoring and communications activities of DCL will rely on collaboration with farmers' organizations, development actors, and rural radio networks for successful and wide coverage. Evaluation of communication efficiency will require collaboration with ARI communication research specialists initially, e.g., Wageningen University and other partners via the McKnight Foundation CCRP Community of Practice for West Africa. DCL will also continue its strong collaboration with Dupont Pioneer from the Phase I DC, and is in discussion to take this to the next level.

B. Role of partners

The GOBII project will develop and implement genomic data management systems to enhance the capacity of public sector breeding programs to deliver increased rates of genetic gain. The HPRC in India has helped to overcome adoption constraints through close collaborations with emerging seed companies and farmer-cooperative seed enterprises, increasing information flow and capacity of seed production and marketing. This is now being modelled in Kenya as an initial experiment in Africa. Alliance with FARA enables DCL to participate in coordinated efforts through its innovation platforms established in the DCL target countries in Africa, and to leverage its successful proof-of-concept studies on livelihood improvement in smallholder agriculture involving DCL crops in sub-Saharan Africa. In WCA, which has major cowpea, groundnut, pearl millet and sorghum systems, CORAF/WECARD is the key partner organization for research coordination. This has been a continuing collaboration in the region since Phase I of DC, and DC and IRD/CIRAD scientists in the region support the efforts of CORAF/WECARD in enhancing scientific exchange, information sharing and collaboration, especially in the newly started IAVAO platform. DC is also a partner in one of the nine recently formed National Centers of Specialization (NCoS) in West Africa, Dry Cereals (sorghum and millets), based in Senegal, coordinated by the Centre d'étude regional pour l'amélioration de l'adaptation à la sécheresse (CERAAS). In East and Southern Africa, DCL works in partnership with ASARECA.

Partner Engagement in Program Management and Oversight:

Beyond developing partnerships as part of the research and development activities, DCL directly involves partners in the management and oversight of the program. Partnership with FARA, the apex continental organization for Africa, has been strengthened through its representation in the Independent Steering Committee of the program. The Independent Steering Committee (ISC) of the program includes representatives from FARA and ASARECA, as well as those from NARS (ICAR, INRAN, EIAR), ARIs (Cornell University, Univ of Adelaide, Univ of Leeds, Agropolis International), and the private sector (DuPont Pioneer). The USAID-funded Feed the Future innovation Labs (Grain Legumes, Peanuts & Mycotoxin and SMIL) are represented by one

member as resource person in the Research Management Committee. A representative each of IRD/CIRAD and CSIRO will also participate in the same capacity on this committee. Such involvement in the oversight and direct research management of DCL is seen as vital to create momentum for the new partnerships designed for the program.

C. Partnership Modalities: Partnership modalities include an array of collaborative steering, governing, managing and implementing, and brings on board principles of joint networking, resource mobilization, in-kind partnerships, joint ventures etc. Partnerships with the other CRP programs operate either as complementary implementation towards the overarching SLOs, or joint resource mobilization and joint implementation. Multilateral innovation platforms such as the IAVAO (with CORAF, CERAAS, IRD/CIRAD and others), and the HPRC (with NARS and private sector partners) have the standard operation modes of innovation systems.

D. Strategic Partnership Activities:

***Ongoing engagement and dialogue* & Alignment with and support of regional initiatives:** Examples of important strategic partnership activities include creation of awareness of the economic case for sustainable land management, through the global Land Degradation Initiative; establishment of infrastructure, as with the identification of TPEs and establishment of representative testing sites across WCA in the IAVAO partnership; bilateral service arrangements and in-kind partnerships for upstream discovery research specifically, genotyping, with DuPont Pioneer; participatory demonstration trials using best available varieties in WCA, spearheaded by the Syngenta Foundation; downstream support of scaling of seed dissemination through the HPRC platforms. The strategic partnerships of DCL, inherited from DC, GL and DS span activities from discovery research > product development > product delivery > scaling. An example of the specificity of these collaborations is presented in page 19 of the Extension Proposal for DC. These are all ongoing strategic engagements, where emerging dialogue builds on current accomplishments and aspire for the next level.

E. Sustaining Partnerships: The two central elements of the partnership strategy for DCL are (1) establishment/gap-fill of all critical strategic partnerships required for successful achievement of program goals in the target regions, and (2) compatible terms for win-win implementation of collaborative R4D. DCL partnerships are sustained through the latter element, which includes mutual capacity building, joint implementation, in-kind contributions, diligent use of non-exclusive licensing opportunities, and others, all leading to the delivery of International Public Goods.

F. Partnering Capacity: The comparative strengths of DCL reflects the unique advantages of the CGIAR, and include: (1) rich genetic diversity for commodity crops, preserved in central germplasm collections for global use towards international public good, (2) strong global and regional networks of partners, (3) local implementation capacities and infrastructure in the developing world that allow translation of innovative academic modeling tools and systems research on the ground, and (4) local and regional socioeconomic data resources for most Low Income Food Deficit Countries, combined with sophisticated tools and technologies enabling analyses and forecasting.

G. Appropriate resourcing of partnerships: While the first and extension phases of DC, DS and GL allowed resourcing of partnerships through commissioned and competitive grants, such financial resourcing for Phase II will mostly be covered by those bilateral projects that support specific partnerships. In the uplift budget scenario, the existing strategic partnerships of DCL will be further strengthened for increased effectiveness.

Examples of Strategic Partnerships in DCL

Mode 1: Agricultural Research Partnerships (Flagships 2 and 3)	
Name	**Tropical Legumes III**
Convenor of the Partnership and their role	International Crops Research Institute for the Semi-Arid Tropics. To develop high yielding pest and disease resistant legume varieties and deliver these to smallholder farmers in Sub-Saharan Africa (SSA) and South Asia (SA).
Specific focus and objective	Develop improved cultivars of common bean, cowpea, chickpea and groundnut; Deliver seed at scale to small-holders in SSA and SA to reach 4 million smallholder farmers and fundamentally strengthen the NARS and CG breeding programs and seed platforms
Science Agenda	1) Support for the development and release of farmer-preferred varieties in the priority legume crop x geography. These include cowpea and groundnut in Burkina Faso, Ghana, Mali, Nigeria; common bean and chickpea in Ethiopia; common bean and groundnut in Uganda and Tanzania; and chickpea in Uttar Pradesh, India; 2) Strengthening of the legume breeding capacity of the partner CGIAR centers (ICRISAT, IITA and CIAT) African stations (Nigeria, Mali, Uganda, Malawi), and national partners through a formal and structured assessment and improvement process, to enhance their capacity to deliver improved cultivars beyond the timeframe of the project; and 3) Establishing of sustainable seed delivery systems that service the needs of small-holders, especially underserved women farmers in the African partner geographies. Seed delivery platforms, personnel and targets will be established for each priority legume crop and country.
Geographical focus / location	Seven countries in SSA (Burkina Faso, Ghana, Mali, Nigeria, Ethiopia, Tanzania and Uganda) and SA (India)
Role of the CRP/FP in the partnership	Although the Foundation has provided adequate funds for the project, the centers are prepared to call upon the CGIAR Research Program - Grain Legumes to supplement that investment as needed by drawing upon the scientific expertise and resources available in the CRP and the Centers. Breeding priorities for each crop have been aligned to address key regional biotic and abiotic production constraints identified by the CGIAR Research Program on Grain Legumes and national programs and following robust discussions with an array of crop scientists, gender specialists, farmer and trader representatives and socio-economists.
Key CGIAR partner(s) and their (its) role(s)	Internationals Crops Research Institute for the Semi-Arid Tropics – Adoption, Impacts and Gender, Groundnut and Chickpea Genetic Gain and Seed Systems; International Institute of Tropical Agriculture – Adoption, Impacts and Gender, Cowpea Genetic Gain and Seed Systems; International Centre for Tropical Agriculture – Adoption, Impacts and Gender, Common Bean Genetic Gain and Seed Systems.
Key 'external' partner(s) and their (its) role(s)	The Institut de l'Environnement et de Recherches Agricoles (INERA), groundnut and cowpea improvement in Burkina Faso. Savannah Agricultural Research Institute (SARI), Tamale, Ghana: cowpea and groundnut improvement in Ghana The Institute of Rural Economy (IER), Mali: cowpea and groundnut variety development, evaluation and release, Ethiopian Institute of Agricultural Research (EIAR): Common bean and Chickpea improvement in Ethiopia. Naliendele Agricultural Research Institute (NARI): groundnut improvement in Tanzania. Selian Agricultural Research Institute (SARI): Common bean improvement in Tanzania, National Agricultural Research Organization (NARO): Common bean and groundnut improvement in Uganda. Indian Institute of Pulses Research IIPR: Chickpea improvement in India.
Contribution to ToC and impact pathways	Developed country strategies and seed adoption roadmaps to replace 30% of area cover with improved legume varieties in focus geographies.

Mode 1: Research in Development – Flagship 4	
Name (project)	Enhancing Food and Water Security for Rural Economic Development - Drylands Development Programme (DRYDEV) http://www.worldagroforestry.org/content/drylands-development-programme
Convenor of the Partnership and their role	Funded by the Ministry of Foreign Affairs of the Netherlands via the General Directorate of International Cooperation (DGIS), with a substantial contribution from World Vision Australia (WVA)
Specific focus and objective	The process of embedding research in development in such a way as to speed up learning cycles within development and increase the probability of impact
Science Agenda	Developing the 'options by context' paradigm for research in development using robust and simple large n (many replicates) design to test interventions with farmers / local communities
Geographical focus / location	Sahel (Burkina Faso, Mali, Niger) and Horn of Africa (Kenya, Ethiopia)
Role of the CRP/FP in the partnership	Will contribute to FP1 ('science of scaling'), FP4 (soil and water management) and FP5 (food security and rural development)
Key CGIAR partner(s) and their (its) role(s)	ICRAF – leading the program, project design, MEL and impact assessment
Key 'external' partner(s) and their (its) role(s)	Development partners such as World Vision (Kenya, Ethiopia), Reseau Marp (Burkina Faso), Care International (Niger), Sahel Eco (Mali)
Contribution to ToC and impact pathways	Yes significantly in the 5 countries. Conceptually also across DCL

Mode 2: Research for Development – Flagship 2	
Name	African Orphan Crops Consortium (AOCC) (http://africanorphancrops.org/
Convenor of the Partnership and their role	World Agroforestry Centre (ICRAF) is hosting the AOCC at the HQ in Nairobi, Kenya. Providing laboratory facilities and training of 250 plant breeders in genomics and marker-assisted selection for crop improvement over a five-year period. The work will drive the creation of improved planting materials that will then be offered to smallholder farmers throughout Africa.
Specific focus and objective	The consortium's goal is to sequence, assemble and annotate the genomes of 100 traditional African food crops, which will enable higher nutritional content for society over the decades to come. The resulting information will be put in the public domain with the endorsement of the African Union.
Science Agenda	High end research that seeks to deliver new knowledge (and related tools) that can be used to improve or scale-up promising options and practices
Geographical focus / location	Africa but the crops are relevant across the global tropics
Role of the CRP/FP in the partnership	The AOCC will be sequencing four of the target crops: Finger millet, Lentils, Common beans and Faba beans, and it is providing capacity development for national partners
Key CGIAR partner(s) and their (its) role(s)	World Agroforestry Centre (ICRAF) (hosting the AOCC) International Livestock Research Institute (BecA – ILRI)
Key 'external'	The African Union- New Partnership for Africa's Development (AU-NEPAD Agency); Mars,

partner(s) and their (its) role(s)	Incorporated; BGI; Life Technologies; World Wildlife Fund; UC Davis; iPlant Collaborative and Biosciences eastern and central Africa –
Contribution to ToC and impact pathways	Yes through capacity development of national intuitions and facilitating improved planting materials to smallholder farmers throughout Africa.

Mode 2: Agricultural innovation delivery partnerships (Partnerships, platforms and alliances with the private and public sectors creating value for farmers and companies) – Flagship 3	
Name	**Hybrid Parent Research Consortium**
Convenor of the Partnership and their role	**ICRISAT:** Generation of hybrid parents, convening of regional NARS, private and public sector partners for consultation and setting traits and market priorities, selection of hybrid parent material every other year, distribution of selections to partners for hybrid development and upscaling.
Specific focus and objective	Improved genetic gain through the use of diverse germplasm resources, facilitation of upscaling via partners, rapid adoption of improved hybrids, and fast seed replacement rate
Science Agenda	Improved genetic gain, and faster seed replacement rate
Geographical focus / location	India, Africa (initiated)
Role of the CRP/FP in the partnership	Breeding for the development of improved parental material; distribution of the parental material to downstream partners who then upscale seed production and distribution.
Key CGIAR partner(s) and their (its) role(s)	None
Key 'external' partner(s) and their (its) role(s)	Bayer Crop Science, Dupont Pioneer India, JK Seeds, Hytech Seed India, and some 25 more medium and small seed enterprises, Indian Institute of Millet Research, India Institute of Pulses Research and the respective All India Coordinated Programs (sorghum, pearl millet and pigeonpea)
Contribution to ToC and impact pathways	Increased yields of targeted C&L and companion crops & reduced yield gaps, coupled with sustained increases in agricultural profits. Increased food & nutritional security via higher and more stable production and quality of food in mixed dryland systems

Mode 3. National Agri-food systems innovation partnerships (Inter-linked farm to policy multi-stakeholder processes and partnerships action changes in food systems that create social and economic value) – Flagship 5	
Name	**Agribusiness & Innovation Platform**
Convenor of the Partnership and their role	**ICRISAT**: Value-chain analysis for stakeholder strengthening, identify intervention points for increased incomes opportunities, support on market linkages to farmers & small entrepreneurs, technical support and handholding of youth and women for entrepreneurship development on agribusiness and food processing.
Specific focus and objective	Enhanced market opportunities for farmers and rural communities through market linkages and development of rural enterprises by providing technical and business support services.
Science Agenda	Socio-economic development, market linkages for increased income, improvement of health and nutrition of communities
Geographical focus / location	India (three states).
Role of the CRP/FP in the partnership	Technology support in crop production, post-harvest and market penetration through cross CRPs and FS linkages.
Key CGIAR partner(s) and	IITA, ILRI, ICARDA for Technology Support

their (its) role(s)	
Key 'external' partner(s) and their (its) role(s)	Private sector (HUL, Mathesis, Ind-Millet, Terra Green), ICAR-Agribusiness incubators, Community development organizations, Farmer Producer Companies, NABARD, EPTRI, Vennela Education Society, HKM, Bhavishya Bharat.
Contribution to ToC and impact pathways	By providing support to the value-chain stakeholders and strengthening the linkages, AIP-ICRISAT will enhance the income levels of the players especially farmers and rural communities resulting in improved health and nutrition.

Mode 3. National Agri-food systems innovation partnerships (Inter-linked farm to policy multi-stakeholder processes and partnerships action changes in food systems that create social and economic value) –Flagship 5	
Name	**Harmonising sectoral policy implementation for sustainable watershed management**
Convenor of the Partnership and their role	**ICRISAT**: Develop multiple methodologies to encourage discussion and coordination between stakeholders (especially government and civil society ones) towards harmonizing sectoral institutional (dis-)incentives related to watershed management.
Specific focus and objective	Identify positive and negative interactions between sectoral institutions and promote synergies enabling sustainable watershed management and its upscaling.
Science Agenda	Improve understanding of sectoral institutional interactions; develop tools for policy makers to support them in adapting the institutional framework across sectors to achieve sustainable multidimensional outcomes in watershed management.
Geographical focus / location	India (three states).
Role of the CRP/FP in the partnership	Providing scientific support in the collection and analysis of data, development of tools, facilitation of multi-stakeholder processes
Key CGIAR partner(s) and their (its) role(s)	IFPRI – coordination and standardization of governance research for improved comparability; IWMI – identification of ecosystem service related externalities
Key 'external' partner(s) and their (its) role(s)	e.g. Directorate of Watershed Development and Soil Conservation – adapting watershed intervention strategies; Department of Agriculture – adapting subsidy schemes (mechanization, seed, inputs), capacity development; Department of Animal husbandry - adapting subsidy schemes (fodder, veterinary, breeding), capacity development; Foundation for Ecological Security – implement and facilitate watershed projects, capacity development, upscaling of approaches; Bharatiya Agro Industries Development Research Foundation - capacity development, upscaling of approaches; GIZ – upscaling of tested approaches.
Contribution to ToC and impact pathways	Adjustments in the governance environment increase effectiveness, efficiency, and sustainability of agricultural and livelihood interventions.

Mode 3. Sustainable Intensification through better integration of crop and livestock production systems for improved Food Security and Environmental Benefits in Sahelian zone of Burkina Faso – Flagship 3	
Name	**Sustainable Intensification Innovation Lab – Burkina Faso**
Convenor of the Partnership and their role	**ILRI**: Baseline characterization of intensification options and practices; participatory testing and evaluation of sustainable intensification innovations; gender analysis; tradeoffs analysis and nutritional benefits of intensification options; capacity building.
Specific focus and objective	- Increasing crop and livestock integration through improved crop production, soil fertility, water harvesting and livestock feed enhancing interventions, all combined leading to improved nutrition through increased consumption of animal sourced food -Assessing the economic, social, nutritional and environmental benefits and tradeoffs of the productivity enhancing interventions, and their potential for cost-efficient out-scaling -Building capacity of smallholder farmers and researchers on sustainable intensification and improved nutrition through multi-stakeholders' platforms and providing platforms for co-learning.

Science Agenda	Crop-livestock productivity enhancement, socio-economic development, improvement of food security and nutrition diversity.
Geographical focus / location	Burkina Faso (two regions).
Role of the CRP/FP in the partnership	Technology support in crop-livestock production, trade-offs analysis of intensification options.
Key CGIAR partner(s) and their (its) role(s)	None
Key 'external' partner(s) and their (its) role(s)	The Institut de l'Environnement et de Recherches Agricoles (INERA) – testing and evaluation of crop-livestock intensification options, capacity building; University of Wisconsin, Madison – analysis of socio-economic aspects behind variation in natural resource management; The International Union for Conservation of Nature (IUCN), Central and West Africa Program – cost-benefit analysis of productivity enhancing interventions; Fédération Nationale des Groupements Naam (FNGN), Burkina Faso – capacity building of farmers, dissemination of intensification technologies; Association pour la Promotion de l'Elevage en Savane et au Sahel (APESS) Burkina Faso- – capacity building of farmers, dissemination of intensification technologies.
Contribution to ToC and impact pathways	By promoting sustainable intensification options of smallholder farmers, household food and nutrition security is improved, and opportunities for additional household income are enhanced.

Annex 3.3: Capacity Development strategy

BACKGROUND

The participating Centers of DCL have a long history of CD interventions that enhanced capacities of partners and national agricultural research systems, extension and farmers. The program will build on this experience, integrated through the support of the CD Taskforce and key stakeholders involved within the agricultural sector.

By uniting and coordinating the efforts of the Centers involved, DCL will allow **to focus CD interventions into a comprehensive, holistic, integrated and all-inclusive systems approach which ensures that interventions are demand-driven and at the same time support the achievement of the program's IDOs**.

DCL adopts a comprehensive definition of capacity development that includes **all efforts, interventions, activities, and interactions aiming at developing the capacity of female and male individuals, institutions, organizations and systems to enable them to perform certain tasks leading to the achievement of research and development goals**.

Vision for DCL capacity development

Main stakeholders, partners and teams will have in place human resources, institutions and systems capable of effectively working collaboratively as integrated systems while successfully carrying out their defined roles in DCL, leading to the achievement of IDOs in the target regions.

Mission for DCL capacity development

Our mission is to ensure the development and successful implementation of a strategic, holistic, inclusive, results-oriented, internationally competitive and sustainable approach to CD that is fully integrated into the impact pathways and that leads to the development of capacities of participating actors and innovation systems as a means to support them in effectively achieving the targeted development outcomes. DCL CD will ensure a greater emphasis on the uptake of research as part of a broader innovation system and follow an integrated approach to capacity development. This involves a move towards multi-stakeholder, interdisciplinary and client-driven strategies which ensure that all critical actors will be involved since the beginning and will endorse the decision taken.

CD is one of the **key pathways** that drive impact for DCL and one of the **key performance indicators** for the program's success, especially within the framework of ensuring that agricultural research outputs will be transferred to the other stakeholders involved in the value chain thus enabling development outcomes.

DCL will support capacity development to improve performance within a wider system, rather than as an end in itself. Therefore, there is generally an underlying **theory of change** (stated or implicit) that presumes that capacity development components will strengthen certain actors and modify attitudes and practices, in turn changing the performance of a wider system. Consequently, **appropriate data should be monitored** to track each of the steps in this theory of change – capacity gaps, capability gains, behavior changes, and performance improvements – with the emphasis placed on improved performance to higher-order results.

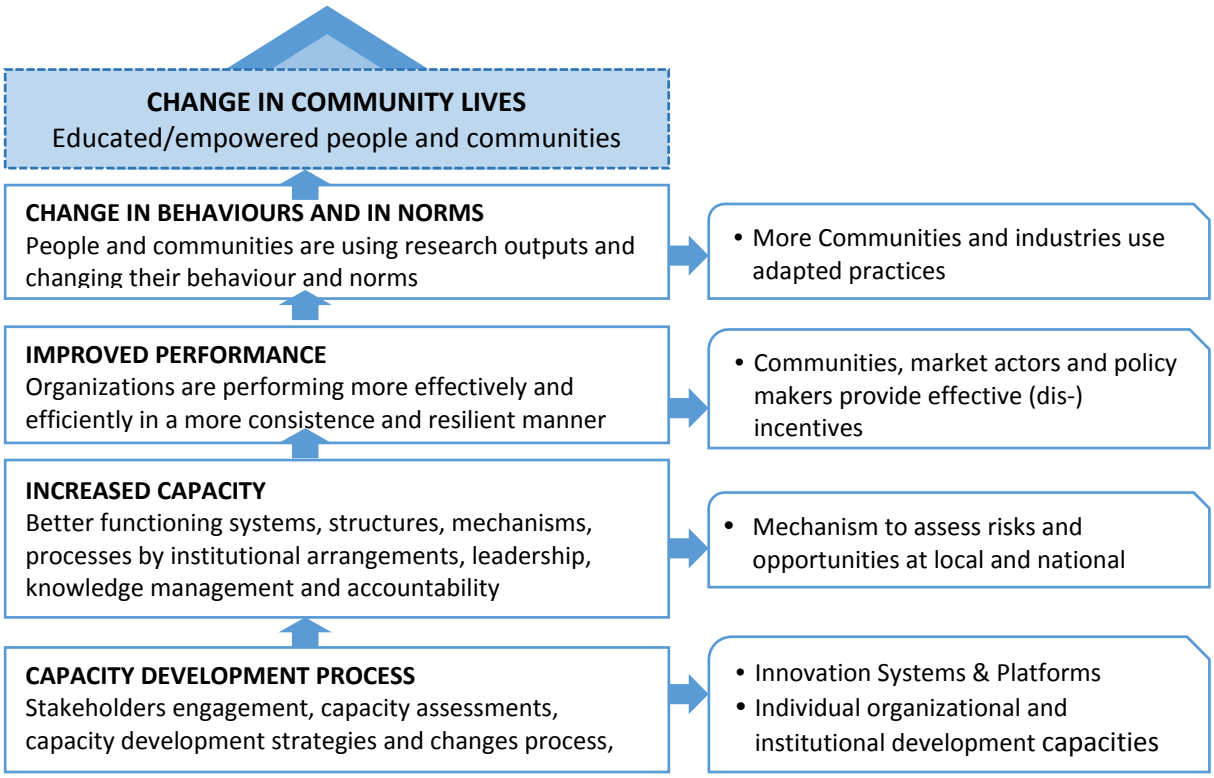
Capacity Development is a complex interplay between individual, organizational and institutional levels. The focus of CD therefore is on the **process rather than just on the acquisition of skills and knowledge** to perform a defined task.

Lessons learned from previous CRPs and bilateral projects will be addressed in order to capitalize on the best practices implemented, the networks of partnerships developed, key individual actors

involved. The CD for DCL will learn from failures and will adopt new process that will avoid those failures.

Five main goals of DCL capacity development

A. Developing the capacities of core **individuals**, **organizations** and **systems**;
B. Maximizing impact and reach through **partnering** with international, regional and local organizations, private sector and civil society;
C. Increasing **communication skills** : Getting to be known by our actions and results;
D. **Ensuring sustainability** of CD efforts through innovative resource mobilization;
E. A **continued assessment of processes** using Performance Gaps Analysis, Needs Assessment, Implementation assessment, and Impact assessment.



FRAMEWORK FOR CAPACITY DEVELOPMENT INTERVENTIONS AT VARIOUS LEVELS:

Contributions of DCL Flagships to Capacity Development

The CRP's starting point for capacity development is a careful priority setting based on a **Needs Assessment** of critical capacity gaps. Especially CoA *Foresight, Climate Change Analysis and Priority Setting* of flagship *Priority Setting and Impact Acceleration* will contribute to this task in collaboration with the DCL Capacity Development Taskforce. The latter will conduct a comprehensive stakeholder analysis and facilitate, in particular, the inclusion of a wide variety of stakeholders in this process as well as the identification of the stakeholders who are most critical for achieving the CRP's goals. Related is FS1's work on *Impact Assessment, Enabling Environments and Scaling*. For developing efficient **Intervention Strategies,** it is not only important to know what is demanded but also what works.

DCL will, as an Agri-Food-System CRP, invest intensively in the **Organizational Capacity** of NARS and government and non-government development partners. In particular the flagships *Integrated Land,*

Water and Crop Management and *Improved Rural Livelihood Systems* as well as the Cluster *Nursery Research and Seed Production* of FS3 will contribute to this task. As a tool in this process the same DCL components will apply Action **Research** approaches. The CD Taskforce will - with backstopping from the CGIAR CD Community of Practice - support these activities by introducing new approaches and sharing lessons learned. More specifically, there will be a CD sharing and joint fundraising mechanism in particular between the CRPs FTA, WLE and DCL, providing opportunities for learning and using synergies across CRPs. These programs have a history of CD collaboration during CRP phase 1. **Learning Materials and Approaches** will be developed and adopted to the CRP's and – most importantly – the partners' needs. Critical contributions in this field will be enabling technology platforms.

During the first phase of the CRPs it was identified that critical capacity gaps for achieving ambitious impact objectives are related to **Institutional Strengthening**. In particular, the CoAs *Value Chains, Markets and Drivers of Adoption* and *Impact Assessment, Enabling Environments and Scaling* of FP1 as well as the CoAs *Markets, Institutions and Policies* and *Testing, Adaptation and Validation of Options* of FP5 will develop this capacity amongst various actors with special emphasis on policy makers. Also, falling into the institutional sphere, **Gender-Sensitive Approaches** will be especially developed in CoA *Empowering Women and Youth* of FP1. The DCL CD Taskforce will support these activities by facilitating multi-stakeholder platforms and feeding results into larger scale policy processes (e.g. international conventions).

Contribution of the DCL Capacity Development Taskforce

The Capacity Development Taskforce of DCL understands its role within the CRP as a service provider to all partners. It will set its priorities based on the assessment of most critical capacity gaps within the CRP's Impact Pathway. This will happen in close collaboration with FP1 and key stakeholders. Based on this assessment, the Taskforce will support the program in identifying stakeholders which are most critical in the impact pathway. The Taskforce will develop strategies by which gaps can most efficiently be filled. The CD Taskforce will further support various activities by facilitating multi-stakeholder forums. This will contribute to the **CRP's and Center's Partnering Capacities**. In addition, the Taskforce will coordinate more traditional Capacity Development such as Scholarship programs across all involved disciplines which have the objective to **Develop Future Research Leaders** especially within the target countries. Lastly, it will partner with the program's MEL process for common **Monitoring and Evaluation** processes that follow critical principles: no activities without identifying the needs, no activities without records, no records without analysis, no analysis without learning, no learning without action.

Multi-stakeholder Platforms (MSP) as critical approach

Research outputs within an innovation system are broader than purely technical and encompass methodological, policy, process and institutional outputs. The innovation system brings the users and the suppliers of knowledge together from the outset which is the only way to ensure that innovation takes place. Research therefore remains important but is one element within the system.

In this context MSPs are a rationale tool for mapping the national system, identifying stakeholders and their institutional relationships, assessing their capacities and identifying gaps and weaknesses for creating, adapting, packaging, trading, disseminating and using knowledge. The MSPs should be the place to define and agree on the challenges, and the modalities of interventions, ensuring the communication flow amongst all stakeholders, developing strategies. MSPs within DCL will be implemented as a joint effort in particular between the flagships 1 and 5 as well as the CD Taskforce.

Operational Multi-Stakeholder Platforms:

Definition: Platforms that are set up at the grassroots level to respond to target commodity or system of production need for specific market.
Objective: Ensuring that local human resources will have the necessary skills/competencies to apply research on the ground and get results that will be communicated to other stakeholders via the Development channel.
Modalities of interventions: Mentoring programs, Scholarships, on the job trainings, train the trainers trainings, study tours and modalities will have to be defined through need assessment with targeted stakeholders.
Main partners: CG Scientists/NARS/Extension staff/ Hosting Farmers/Universities/ARIs.
Role of Cap Dev Team: Ensuring the smooth implementation of the activities by the concerned colleagues and quality insurance (e.g. evaluating the activities conducted, ensuring quality reporting, communicating on the activities implemented and scaling out).

Strategic Multi-Stakeholders Platforms:

Definition: DCL sets up platforms at higher level of governance and management hierarchies with a broader geographic coverage.
Objectives: 1) Ensuring that the key research questions addressed within the flagships are responding to the needs of different actors. 2) The main role of the platform will be to ensure that research results/outputs will be transferred to all the stakeholders. 3) Enabling environments are adapted to permit/facilitate impact.
Modalities of interventions: Based on the assessment of performance gaps, CD activities of the whole DCL program will ensure the transfer of science knowledge (e.g. through mentoring programs, policy analysis, fundraising, project management cycle, MEL, needs and impact assessments).
Main partners: NARS, Extension staff, Farmers community, Private sector, NGO's, Donors agency, Policy makers, Universities, and Media at the local/regional and national level. All activities will be conducted in cooperation between the CG Centers and the other CRPs.
Role of Cap Dev team: Identifying the keys actors along the impact pathway (with FP5); setting up and facilitating MSPs (with FP1 & 5); identify gaps and specific needs, mentoring, contribution to implementing joint MSP activities.

Links between Capacity Development and Site Integration strategy

DCL acknowledges that coordinated efforts increase cost efficiency and effectiveness in achieving impact, reduce transaction costs, enable synergies and avoid duplications. Based on the CGIAR site integration strategy, the CD Taskforce will facilitate CD investments to be coordinated at the sites where different CRP's and CG Centers plan their interventions. Site selection priorities will be decided based on a consultation process with the other CRPs and their respective Capacity Development taskforces, in coordination with the CGIAR Capacity Development Community of Practice. Cross-Center and Cross-CRP Centers of Excellence for capacity development activities at the site level are proposed under the uplift budget scenario.

Template for Online Submission Tool for: 3.5 Capacity Development Strategy

3.5.1 CapDev role in impact pathway

Main stakeholders, partners and teams will have in place human resources, institutions and systems capable of effectively working collaboratively as integrated systems while successfully carrying out their defined roles in CRP DCL AFS, leading to the achievement of IDOs in the targeted regions.

3.5.2 Strategic CapDev actions (see CapDev Framework)			**3.5.3 Please indicate any Indicators- from CapDev Indicators document or other - that could be used to track progress and contribution to CapDev Sub-IDOs**
Intensity of implementation of chosen elements (Please indicate High, Medium, Low) Note- it is expected that no more than 3-4 elements would be implemented at High intensity		**Give an indication of how chosen elements will be implemented (Note: more space available for full plan in Annex)**	
1. Capacity needs assessment and intervention strategy design	**Medium**	Participatory prioritization process, including identification of capacity gaps; Identification of co-investments to fill the gap;	Proportion of participants targeted in Needs Assessment involved in stipulated CapDev interventions (disaggregated by organization, CRP, Flagship, gender, and role/position).
2. Design and delivery of innovative learning materials and approaches	**Medium**	e.g. developing enabling technology platforms with innovative approaches and infrastructure;	Number of partner organizations who use materials and approaches; Number of people trained (disaggregated by sex, job/role, location, literacy).
3. Develop CRPs and Centers' partnering capacities	**Medium**	Partnership with different AFS CRPs and global platforms related e.g. to technology development;	No. of collaborations (e.g. joint research, training/workshops conducted jointly, shared funding arrangements, common membership of multi stakeholder platforms) with partner organizations; Number of technologies/tools adopted across partnering organizations.
4. Developing future research leaders through fellowships	**High**	Students and researchers especially from target countries will be trained; Fellow- and internship programs;	Number and type of training opportunities provided to early career scientists Number of scientific publications accepted.
5. Gender-sensitive approaches throughout capacity development.	**Medium**	Throughout all activities gender specific needs are identified and outputs accordingly adjusted;	Number of CapDev activities in gender approaches/toolkits initiated (disaggregated by type).
6. Institutional strengthening	**High**	Multi-stakeholder processes facilitate institutional change directly linked to needs assessment; focus on policy makers and CBOs;	Number of policy-oriented knowledge sharing/training activities targeting human resources in NARS (disaggregated by focus – policy, technical); Number of policy papers issued using research evidence generated by CRP/Flagships.

7. Monitoring and evaluation (M&E) of capacity development	**Low**	CD M&E will be embedded in the overall CRP M&E;	Number of Flagships / clusters that conduct M&E of capacity development activities.
8. Organizational development	**High**	All field activities are carried out with NARS or other partners. Their capacity is developed using diverse approaches (formal trainings, multi-stakeholder processes, learning by doing).	Increase in engagement activities between NARS and brokers and end users of research (identifying research needs and subjects; sharing research results); Increase skills of NARS in valorization of research outputs.
9. Research on capacity development	**Medium**	Embedded in impact assessments; Analysis of CD data across CRPs;	Number of research papers on CapDev processes and learning published.
10. Capacity to innovate	**High**	Multi-stakeholder processes improve change process capacity of local, national and regional key stakeholders (esp. CBO, NARS, NGO and private sector) as identified in stakeholder analysis;	Adaptation, adoption and spread of innovation associated with participating groups, platforms, households, etc; Degree of adoption of approaches that support experimentation, learning and reflection.

3.5.4 Budget and resource allocation (The CRP should demonstrate that budgets allocated for CapDev have a credible share of the total CRP budget (e.g. totaling around 10% although amounts may vary in individual Flagship budgets). IMPORTANT: Please indicate in Table 3 of the PIM the investments of each FP on the Capacity Development sub-IDOs

Budget for CRP:	We strive to set apart 10% budget for capacity development at the CRP level. If we base this budget on only W1-W2, which is a total of $11.5MM for the CRP, this would indicate that a 10% budget would be $1.15MM. However, if we follow a process of allocating a minimum of 10% towards each cross-cutting activity, this would exhaust the available W1-W2. Considering this, and the fact that DCL is supported by almost 90% W3/Bilateral funding, we aim to assess the components of each bilateral project mapped to the CRP (and its different FPs) and thus determine how much budget is available for allocation to CapDev. This will be a changing scenario throughout the year as existing W3/bilaterals come to the end of their project lifetime and new projects get mapped.						
Budget for Flagships/other:	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**CD Taskforce**

3.4 DCL Gender Annex: Empowering women and young people in the drylands

DCL Gender M&E strategy

The plan for M&E of the Gender Strategy will be nested within the overall DCL M&E strategy, and will also draw on and be consistent with the CGIAR's indicators listed in the reporting requirements for the CRPs' Annual Reports. A participatory gender-explicit monitoring and evaluation framework will be implemented as result of phase I CRPs. The framework integrates local and gender-specific indicators for monitoring of outcomes. Monitoring focuses not only on equality of treatment for women and men, but also ensuring that the intervention outcomes provide benefits for both women and men in an equal way. To ensure this, all data from intervention activities, and M&E processes are disaggregated by gender and analyzed, provide feedback lessons for better mainstreaming of gender into the activities, programming and implementation process of the CRP as well as inform policy makers.

M&E framework

The CRP will work with gender experts to adapt a performance-measurement framework that identifies and integrates gender-specific, measurable indicators relevant for research and development interventions. Specifically DCL will work closely with WLE, CCAFS, Livestock and FTA having established a gender group with joint staff with those CRPs. In this regard, the common gender-sensitive indicators developed by the M&E committee of the CG Gender Network, the ones for the Gender Performance Fund prepared by the Consortium office and the latest indicators[1] proposed by the CapDev COP will be used wherever relevant.

Annual reviews by stakeholders and gender-specific audits will be organized periodically to assess the progress towards gender mainstreaming and to evaluate gender-specific social impact on smallholder well-being. The 2016 IEA CGIAR Gender review[2] will inform this process and stimulate specific review that DCL will conduct in partnership with other CRPs and Partners. Annual reports on gender M&E will be provided to the Research Management Committee. Feedback sessions, specifically for and with women, in which results of experimentation are discussed, will be part of the program. The program will aim for a balanced staff structure where the participation of women researchers and students will be encouraged. It is also proposed that the participatory M&E system in each center be guided by a performance measurement framework that integrates local and gender-specific indicators for monitoring project outcomes. This will ensure that these are measured both with technical indicators as well as with indicators generated by local women and men. Outcomes and outputs will be monitored for the extent to which they have affected both women and men.

Implementation arrangements

This M&E framework will be implemented through the CRP's existing organizational structures and processes. The results will be shared at annual CRP scientists meetings and also in annual CGIAR meetings. The findings will also be fed back to the participating CGIAR and non-CGIAR scientists and other partners (governments, CSOs, NGOs, producer organizations, UN, etc.). The collaborating organizations/networks of GAP, YPARD, and

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1 https://library.cgiar.org/bitstream/handle/10947/4080/CapDevIndicators_18%20Nov2015.pdf?sequence=1

2 http://iea.cgiar.org/evaluation/evaluation-gender-research-and-cgiar-workplace-0

Africa Harvest, will play special roles in disseminating the findings, to influence policy-makers, development practitioners and researchers in a wide range of organizations.

Indicators

Some of the indicators used in phase I will be monitored in phase II. The increased interaction in the last year of phase I will also generate new type of indicators from our organization and create opportunities for synergies and joint data collection.

Process indicators: Indicate the extent of integration of gender into R4D and extent of use of gender analysis results in determining priorities, technology design and recommendations.

1. Identification of target population (men and women, other social groups, vulnerable and marginalized groups), and establishment of targets for reduction in gender equality pertinent to adoption and use of innovations
2. Representation of women beneficiaries in participatory technology evaluations and related activities, in proportion to their representation in the population
3. Consideration of gender differences in defining and prioritizing research problem (e.g. grant proposals)
4. Mechanisms and protocols in place for consultation and participation of women and men in the design and implementation of the program, and in the dissemination of findings and lessons learned
5. A gender-responsive monitoring and evaluation system is in place, including measurable indicators (to monitor change processes, outputs, and outcomes)
6. Mechanisms in place, and used, to draw on country- and program-level gender expertise; gender integration becomes more demand than supply led
7. Budget and staffing levels appropriately reflect the strategy's activities and outputs; representation of women in program staff, especially where gender segregation requires women staff to work with women
8. Capacity needs of staff and partners assessed to integrate gender in the R&D program

Output indicators:

1. Sex-disaggregated and gender-relevant data collected
2. Gender and social analysis conducted and, used to inform program and intervention design
3. Gender-sensitive and women-targeted technologies identified / developed and disseminated
4. Paper, reports, policy briefs and other science products that are gender sensitive and gender focused are produced and disseminated
5. Capacity-building strategy on gender developed and implemented for program staff and partners

Outcome indicators (Intermediate Development Outcomes)

1. Improved understanding of how to respond to gender differences in resources, technology adoption rates and value-chain positions
2. Improved capacity and skills of women farmers
3. Improved nutrition and health of women and children
4. Improved market opportunities and benefits for women from use of resources, skills and technologies

More opportunities for women's meaningful

Gender research questions in the impact pathway. In March 2015, a gender integration workshop for product line leaders in the CRP GL initiated a conversation of how to design gender research questions, well aligned within the impact pathway outlined for achieving of intermediate development outcomes. Investigation of assumptions made in 'who' would change and the 'behavior' they would change for the delivery of the IDOs lead to 'unique gender research questions' for 3 product lines. Leaders of two product lines increased their support to gender research[3] in their portfolio of activities since the workshop. We learnt that it is not enough to have the gender capacities and money allocated, but having a well outlined 'gender research question' in the program is key. When the research question is clear, the biophysical scientists become allies in supporting gender research. **Action 1:** In DCL we have matched the gender research focus in each of the flagships to a unique area of research interest. Flagship 1 hosts the gender cluster of activities [COA1.3] that will focus on strategic and crosscutting research questions of intersection of culture and norms and innovations in legumes and cereals; how best to engage the youth in agriculture; women's participation in agricultural capacity building in unique cultures and gainful engagement of women in value chains. **Action 2**: DCL proposes to develop a gender competency framework, a mechanism for supporting research teams in understanding basic concepts in gender research, skills and attitudes that facilitate a team in identifying clear and distinct gender research questions while developing proposals and research activities.

Prioritizing gender preferred traits. The CRP on GL and DC is heavy on trait discovery, developing of varieties and hybrids; highly specialized areas of biology and science. Integrating gender research into these very specialized areas of biology has not been easy. The bean program has provided a unique example. The social economics team investigated farmers ranking of production and post-harvest bean traits under varying production conditions of Kenya. The study identified a very strong correlation between the weight attached to cooking time of a bean and a variety's acceptability [Katungi et al., 2015][4], information that was looped back to the program scientist. Cooking time[5], is a women preferred trait. It relates to the labour [time] and firewood [cost] resources needed in household food preparations; and having a significant reduction in these resources made the reduced cooking time emerge as a key driver of selection of varieties by both women and men. The bean program has initiated a gender responsive breeding program to identify the markers for 'cooking time trait' with the possibility that the cooking time trait could be transferred to various bean varieties, taking advantage of the accelerated breeding tools and genomics. **Action 3:** We have identified a postdoc fellow to go back into the PVS/breeding history in GL and DC data and document the traits that have been prioritized in breeding programs, the consideration that has been given to gender preferred traits in the varieties/hybrids that have been released over time; the challenges and opportunities, in both in GL and DC and update the literature on gender differentiated traits. This information, the methodologies that are used will be carried forward into DCL. **Action 4:** Flagship 2 on trait discovery has been designed to prioritize advancement of this conversation, offering a space for interaction between the gender scientists and breeders giving room for methodology development and outcomes that lead to more focus on gender responsive breeding programs. The gender and breeding-working group of the CGIAR will be a key stakeholder in this process.

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[3] Product line 1 [beans program] hired a postdoc with a fellowship from the CO Gender Action Plan and product line 5 [bio-pesticides in cowpeas] allocated funding for gender research activities in cowpeas value chain.

[4] Enid Katungi1, Enoch Kikulwe and Rosemary Emongor (2015). Analysis of farmers: Valuation of common bean attributes and preference heterogeneity under environmental stresses of Kenya. African Journal of Agriculture Research. Vol 10(30): 2889-2901. DOI: 10.5897/AJAR2014.8979

[5] Other traits that have been mentioned in PVS include the snapping trait [in finger millet, that saves labour in harvesting], the wood thickness in pigeon pea plants [for use as firewood]

Gender Yield Gap assessments: The FAO and the Worldbank have documented the importance of being aware of the gender yield gap in agriculture. In CRP GL, we prioritized to assess the state of gender yield gaps in legume production, in CRP DS optimizing dairy value chains through gendered systems research (Najjar, 2014; Rischkovsky, 2015, El-Dine Hilali, 2015, 2013). We have a postdoc fellowship that is targeted in generating evidence on this area in legume farming systems, starting in 2016. The TLIII project has full time gender position with the objective of assessing gender gaps in their target geographies. **Action 6**: DCL will take evidence from the findings of the gender gap assessment activities to design interventions that give resources to women farmers in improvement of their livelihoods.

Sex disaggregation of data: Household level data has been collected in a number of household surveys in different agricultural livelihood systems by DS, and in both HOPE and TLI/TLII, bilateral projects mapped to CRP DC and GL respectively. CCAFS also has household level datasets. Using these datasets for analysis of gender gaps in legume/cereals productivity or modeling of gender scenarios in climate change has not been satisfactory. The main challenge has been in the way data collection was designed in those surveys; where gender analysis was not among the key determinants of the process followed. **Action 7**: We propose to develop a standard recommendation on how to best collect household data that can be used for gender responsive analysis. This will be especially critical for FP1 where adoption, impact assessment and foresight modeling activities are implemented.

Youth in Dryland Agriculture: The future of dryland agriculture and the role that the young people play, how the future generation will be fed, are questions that are rising among the global priority. Almost 200million people in SSA are aged between 15 – 24; Africa currently has the youngest population in the world. This demographic dividend presents both a opportunities and challenges [AGRA, 2015] There are rapid changes taking place in today's globalized world that is typified by migration, urbanization, technological innovations, increasing educational levels and aspirations, and the IT and social media revolution linking the young people to global information and change movements. On one hand, these changes are leading to new opportunities for better- paid and higher-status work outside agriculture that cream off some of the best talent among the rural young people. On the other hand, these changes also create unrealistic aspirations of a better life in the cities that entice other young people to escape their grueling and often unrewarding agricultural work, especially in the marginal drylands, only to find their dreams dashed. With the exit of these young people, the agricultural labor force is ageing in many countries, raising serious questions as to how future populations will be fed. These topics are currently studied by CRP DS in cooperation with YPARD in North Africa. **Action 8**: Based on DS youth strategy, effective youth oriented policies and innovative development strategies are needed to tap the potential of this young labour force and channel it productively, especially in the agriculture sector [AGRA 2015]. DCL has prioritized research on 'how best to engage with the youth in dryland agriculture' as an important component of the gender strategy.

Women and dryland cereals and legume seed systems. Most of the cereals and legume crops that are produced in the drylands are designated as 'women crops'. These crops are oriented to household food provision; they are labour intensive in their production and processing processes. Informal systems of seed management and distribution that are mainly handled by women are therefore important avenues for new legume and cereals seed injection into the drylands. CRP DS has several successful projects (ICRAF,2015, ICARDA, 2015), where farmers learnt to supplement their income through seed production and sale for local varieties. Tanzania has a policy supporting the quality declared seed processes. **Action 9:** FP3 will prioritize testing of different models of working with women

[as farmers, women groups, entrepreneurs] in the distribution of dryland legume and cereals seeds.

Women participation: from women farmers to women scientists. Researchers working in the TLII under chickpea research and development programme in Ethiopia highlight that there is very low participation of women in training events organized by the program compared to men. This is despite the program instituting a policy that every male farmer would be required to attend training with the wife. Even then, a training of about 70 participants would have only 5-6 women; and yet the scientists would 'see' the women working on the chickpea fields [Ojiewo, 2015: Personal communication][6]. Women's attendance in scientific meetings, even in the CRP, is always low. There is a possibility that the pool of women in the CRPs is small. As shown in DS research, this could also be related to social norms in the farming communities as well as in the scientific communities. Once social norms are addressed, women can be integrated in research in very gender-differentiated societies (CIP, 2016). Social norms are difficult topics for even well designed household surveys to explore effectively. Social norms of gender are in constant dialogue with women's agency and may determine women's capacity to act, participate and get involved in the agricultural continuum from farmers to scientists. **Action 10:** DCL will prioritize supporting women's gainful engagement as well as capacity development along the cereals and legumes value chains – from farmers to scientists continuum.

There are examples of change in women participation in the American Society for Microbiology (ASM) General Meeting[7]. In 2015, they achieved gender equity, with 48.5% of the oral presentations being given by women. The mechanisms associated with increased female participation were (i) making the Program Committee aware of gender statistics, (ii) increasing female representation among session convener teams, and (iii) direct instruction to try to avoid 'all-male' sessions. The DS Gender Working Group carried out a series of norms studies regarding gender relations, women and youth in agriculture in 2015. The GL gender research team designed a qualitative study to investigate the culture, the norms and practices that lead to low participation of Ethiopian Women farmers in field based extension and capacity building trainings. **Action 10:** DCL will prioritize supporting women's gainful engagement as well as capacity development along the cereals and legumes value chains – from farmers to scientists continuum.

The **policy to integrate and support gender research** in the CGIAR programs culminated in hiring of gender researchers into the CRPs in the 1st phase and in the extension phase was a hallmark in changing the scientist constitution in the CGIAR since 2012. There was an allocation of an annual budget that was ring-fenced to support gender research in the CRP financing plan. **Action 11:** DCL will continue in supporting this policy [staff and budget] capacities for gender research are much better, there are now scientist/senior scientists as well as postdocs in most of the centres that are contributing to the DCL implementation, raising the bar for gender research higher in DCL than in the phase 1 CRPs.

Building on earlier work of CRP DS, DCL gender research prioritizes a **socio-ecological systems approach** to understand the social power web and its interaction with ecological elements of the system as well as the impact of agricultural development interventions in shaping rural food security and agricultural livelihoods. The systems approach is used to

[6] Njuguna, EM., Liani, M., Beyenne, M., 2016: Cultural norms and practices influencing the Ethiopian women's participation in agricultural training and capacity development.

[7] Casadevall A. 2015. Achieving speaker gender equity at the American Society for Microbiology General Meeting. mBio 6(4):e01146-15. doi:10.1128/mBio.01146-15

identify agriculture-related socio-economic factors and mechanisms needed to be managed for improving food and livelihood outcomes. This socio-ecological systems approach acknowledges the coherent interrelationships between biophysical and socio-economic systems that controls the functions and performance of agricultural livelihood systems in terms of total productivity, profitability, ecosystem services integrity and social equity. Change to ensure that women, men and youth in farming communities can benefit from research will happen through an understanding of what impact up-scaling of research products (technologies) have on the ground, on the socio-economic fabric and ecological situation of the targeted agricultural livelihood system on all stakeholders. The understanding of these effects and of the dynamics and feedback loops triggered by research interventions will allow stakeholders to see opportunities and adapt their behaviour. **Action 12:** FP5 will jointly with FP1 and other FPs research on social power web and its interaction with ecological elements of the system, on gender interests in systems trade off analysis and on gendered impacts on household income, nutrition, ecological environment and general wellbeing.

DCL Gender in the M&E strategy

The plan for M&E of the Gender Strategy will be nested within the overall DCL M&E strategy, and will also draw on and be consistent with the CGIAR's indicators listed in the reporting requirements for the CRPs' Annual Reports. A participatory gender-explicit monitoring and evaluation framework will be implemented as result of phase I CRPs. There is a marked increase in appreciation of the existing M&E teams to embrace Gender indicators in the M&E frameworks. The framework integrates local and gender-specific indicators for monitoring of outcomes. Monitoring focuses not only on equality of treatment for women and men, but also ensuring that the intervention outcomes provide benefits for both women and men in an equitable way. To ensure this, all data from intervention activities, and M&E processes are disaggregated by gender and analyzed, provide feedback lessons for better mainstreaming of gender into the activities, programming and implementation process of the CRP as well as inform policy makers.

M&E framework

The DCL M&E team will work with gender experts to adapt a performance-measurement framework that identifies and integrates gender-specific, measurable indicators relevant for research and development interventions. Specifically DCL will work closely with the Gender Working Group established by DS, and WLE, CCAFS, Livestock and FTA having established a gender group with joint staff with those CRPs. In this regard, the common gender-sensitive indicators developed by the M&E committee of the CG Gender Network, the ones for the Gender Performance Fund prepared by the Consortium office and the latest indicators[8] proposed by the CapDev COP will be used wherever relevant.

8 https://library.cgiar.org/bitstream/handle/10947/4080/CapDevIndicators_18%20Nov2015.pdf?sequence=1

Annex 3.5 Youth strategy:

Youth Strategy of Dryland Cereals and Legumes AgriFood System (DCL):

"Youth seizing opportunities in agriculture"

Challenges of Youth to seize opportunities: Inclusion of female and male youth in agricultural value chains from producer to consumer is not only important from the perspective of an individual's aspirations to build a livelihood, but also for the economies they live in. Some 87% of the world's youth live in developing countries and make up a third of the population in these countries[1]. The majority lives in rural areas where 70 % of the world's poor live, relying on agriculture as a principle source of income and employment[2]. Youth, however, is largely excluded from contributing to the economies of their countries and to overcoming poverty. In 2013, youth made up 40% of the world's unemployed; 536 million of employed youth in developing countries were underemployed (estimated 42% of youth in developing countries). In 2010, a staggering 341 million youth in developing countries (estimated 27% of youth in developing countries) were not in education, employment, or training and their number is increasing. Statistics for developing countries show young women being less unemployed than young men, as they are not recorded as such. The reasons are girls' teenage marriage and pregnancies, and traditional expectations of girl's work as unpaid and un-accounted family workers. The future of agriculture is in the hands of the young. The challenges of youth are therefore agriculture's challenge.

What are these challenges of youth in agriculture?

1. From research[3] we know that young people in many of our target countries still lack knowledge (education), which is one of the main requisites for making informed choices and to contribute to innovation. The adoption of new agricultural technologies, the ability to sustainably operate within a context of climate change and/or land degradation, and the modernization and professionalization of smallholder agriculture through the application of communication and information technology needs (i) a broad basis of rural youth with good basic education, and (ii) institutionalized possibilities for young people to get further education in themes related to agriculture.

Currently, young males and in some target countries females, leave farms as the available education and local values fail to inspire innovative agriculture and drives urban migration. Although youth often have better education than their parents, this education does not sharpen their skills in agriculture and is also not the appropriate education for off-farm employment.

Female youth in some countries remain unmarried because of out-migrating young males, while in other countries poor rural girls marry and give birth very early as teenagers. The education of both types of young women does not prepare them for non-traditional livelihoods and roles in agriculture, and does not prepare them for pro-active participation in agricultural value chains.

2. Land is often not enough for the growing rural population and so farm-sizes are shrinking or land as a resource is difficult to access for male youth because of the lack of finance, and 'trust capital', as they have not proven their abilities yet to others. This is even more so for female youth because in addition to the discouragement of independent female activities in agriculture and agri-business, in some societies, young women face unfavorable inheritance laws.

3. Many female and male youth in smallholder farms in developing countries view agriculture as drudgery, where there is a lot of work and hardly any empowerment to make decisions, while work in the urban area seems to promise a better lifestyle. Youth often sees agriculture as the default option, when you are not able to carve out any other livelihood.

[1] Population Reference Bureau, data from 2013

[2] World Economic Forum, 2013

[3] A. Giuliani, email on first research results, CRP Dryland Systems, 22. December 2015

4. Youth in the various rural livelihood and food systems throughout the target countries of DCL is a heterogeneous category with varied cultural and educational backgrounds in varied ecological and economical environments. Youth therefore needs different types of support to be able to realize its potential in agriculture.

With youth unprepared for these challenges, agriculture is losing out on their innovative drive and positive energy for development. Agricultural value chains are less quickly professionalized for effective and efficient food and agricultural production, and most of the young resign themselves to competing for precarious jobs with low economic productivity in over-crowed urban areas, or as underemployed rural (family) laborers.

Objectives of the Youth Strategy

1. More rapid adoption of innovations and technologies with additional benefits for youth by incorporating their preferences.
2. More options for youth to earn income from agriculture, especially crops and livestock related production, processing, and services.
3. Improved access of youth to resources such as skills, agri-technologies, assets, services, and markets through policy reforms.
4. Empowerment of youth within smallholder households, agro-enterprises and communities.
5. Enabling of youth to build an ecologically sustainable, viable and resilient agricultural livelihood.

With this research we aim to achieve three system level **OUTCOMES**: (1) Reducing rural poverty by changing system dynamics and the elements causing it; (2) Improving food security, nutrition and health; (3) Building the future with sustainable management of agro-eco systems.

A set of **METHODOLOGIES** will be used to research the above issues, but a special focus will be put on

1. impact assessments to research for evidence on 'what works' (this includes randomized control trial studies and literature studies on evaluations related to youth in agriculture and agricultural value chains) for giving evidence-based advice to policy makers
2. systemic social action research to combine the compilation of research results with the practical application of new practices and knowledge by youth, and
3. research on "youth typologies" to deal with the above mentioned heterogeneity of youth, to characterize different categories of youth and allow for a more targeted research.

What does Dryland Cereals and Legumes AgriFood System (DCL) plan to do?

1. **Collect evidence** (e.g. impact analyses, RCTs) **on which developmental approaches work** to support youth to seize opportunities in agriculture. The focus is the professionalization of agricultural value chains from production to consumption ensuring high agricultural productivity and good nutrition for all, and at the same time encouraging youth to build agriculture-related livelihoods. This will also facilitate the development of off-farm opportunities or alternatives for rural youth, which do not necessarily need scarce land and water as major inputs. Specific research activities include:

a. Systems analysis with a focus on options of youth in different contexts such as different rural and agricultural livelihood systems[4];
b. Collection of evidence for policy building to render agriculture 'smart' for youth, researching on approaches to support youth to seize opportunities in agricultural value chains (e.g. demand-driven ICT applications for agriculture and agri-business, one-stop shops for agri-entrepreneurs, demand-driven agriculture/agri-business entry packages for youth including skills and finance);

[4] This research is currently done by some CRP Dryland System researchers;

c. under Flagship 5, a youth-sensitive research on combinations of crops, trees and livestock produced by smallholder farmers that will improve their productivity, resilience and diversification, and on enabling their response to emerging market opportunities. Innovation systems research of Flagship 5 brings the key stakeholders such as female and male youth in farming together to identify, implement and test innovations that address the behavioural, social, institutional, governance, economic and ecological opportunities for and barriers to upscaling;
d. Youth preferences for crop (and livestock) varieties and traits incorporated in technology development from breeding to processing products (largely realized in youth-sensitive research of Flagship 2 and 3).

2. Research on how to provide **sufficient resources** such as skills, knowledge, information, startup capital, inputs, support networks and other resources to young women and men to build an agricultural or agriculture-related livelihood. This will include research on

a. Curricula in schools regarding agriculture, for agricultural vocational training and colleges, and development of approaches – especially also within DCL - for the effective inclusion of youth regarding capacity development in relation with agricultural innovations. For example, "varieties and hybrids that meet requirements for local adaptation, end-use orientation, and tolerance/resistance to prevailing abiotic and biotic stresses" developed by Flagship 2 will involve youth; as well as "high-quality farmer-preferred products for efficient seed-replacement rates in the target production environments" addressed in Flagship 3, and new combinations of crop components for better land and water management and livelihoods in FPs 4 and 5.
b. Best approaches for the inclusion of female and male youth into the agriculture-related labor market in African and Asian target countries of DCL. This includes the required skills set to place youth in agriculture related production and services, and incentives to attract youth into production and services related to the whole agricultural and livestock value chain;
c. Youth's access and control of assets, intergenerational resource transfer (assets, land, knowledge), and participation of youth in decision making, in the context of the targeted rural and agricultural livelihood systems;
d. Agricultural incubators (possibly with production which brings quick returns such as horticulture or poultry) for female and male youth, especially from disadvantaged backgrounds, as well as agri-business incubators including mentoring programs for young entrepreneurs and agri-entrepreneurs;
e. approaches, especially with the private sector, insurers and banks regarding access to working capital finance and possibly investment (venture) capital for agriculture and agri-business by young female and male farmers and agri-entrepreneurs
f. Youth-focused agricultural extension services

3. Research on **aspirations, values** of female and male youth, and of those, who influence them such as parents and teachers, and of society represented by religion, public role models etc. This aims to pinpoint the factors that can lead to a reputation of agriculture as being 'smart', and thus ensure the sustainable production of nutritious food and agricultural products - beneficial to all in the value chain – in the future. This research will particularly emphasize understanding possible differences between the aspirations of female and male youth, role-related values and options. The resulting evidence will not only inform policy makers, but also community-based organizations in rural areas (especially those for natural resource management and agricultural innovation).

4. Research on **risks** perceived by youth, on how innovative agriculture changes traditional risk coping strategies and on how environmentally, economically and culturally more sustainable and viable risk management can be promoted through innovative agricultural technologies and practices. This includes the development of improved youth-sensitive methods for the sustainable use and conservation of natural resources and biodiversity. A large part of this work happens in Flagship 4, with

its focus on developing an integrated approach to promote efficient use of the natural resource base for sustained and enhanced crop and livestock productivity and smallholder livelihoods.

As promoted through Flagship 1, DCL research on youth will be demand-driven, outcome-focused, with high impact, inclusive (gender, youth, poor and disadvantaged), development-relevant and scalable. Furthermore, youth-specific indicators will be developed to monitor the progress in achieving youth related objectives as formulated in this strategy. The indicators will become part of the RBM system of DCL, and thus monitored and evaluated regularly.

Capacity development

To promote best practices in youth research, the following capacity development activities are envisioned:

a. Youth integrated across DCL research cycle

b. Researchers with expertise in social, cultural and economic research will carry out youth-strategic research (researchers from CRP Dryland Systems' Gender Working Group started multi-disciplinary youth research)

c. Biophysical researchers' and NARS researchers' and managers' awareness of methods and benefits of integrating youth in Agricultural Research for Development will be enhanced through practical trainings and manuals (mostly on-line formats)

d. Young researchers within and without the CGIAR network will be harnessed as drivers of innovative research by creating a network of young researchers. To promote innovation, space for innovation (which is space for trial and error; for testing the untested) will be created;

e. Youth networks, which collect and disseminate information for and on youth in agriculture, will be strengthened by involving them in DCL research.

f. Youth will be mobilized through associations, but also outside of these[5] to increase youth's awareness of their opportunities and what they need to realize them;

g. Youth's capacity will be strengthened by involving them in deciding on the kind of research being done about and with them;

h. Special funds for involving young men and women in agriculture in field tests, experiments and technical workshops, innovation fairs and exchange visits; for mutual learning, events with both younger and older farmers[6].

Partner strategy

DCL will achieve demand driven research on youth by defining research subjects and hypotheses jointly with national research partners, national policy makers, national representatives of stakeholders (farmers, youth, women, and private sector organizations), CGIAR researchers on youth, and carrying out research in cooperation with these.

Partners along the impact pathways:

- ✓ Development agencies
- ✓ Policy makers
- ✓ Line departments
- ✓ Producer and marketing associations
- ✓ NGOs/civil society organizations
- ✓ Youth platforms for the mobilization and information of youth

[5] Research of Dryland Systems (A. Giuliani, 2015) showed this as important;

[6] Idea from Ingrid Flink, KIT

- ✓ Extension systems
- ✓ Agribusiness and private sector service providers (e.g. mobile phone companies)
- ✓ Farmers of different age groups
- ✓ NARS
- ✓ Advanced research centers
- ✓ CGIAR Centers
- ✓ Other CGIAR research programs, particularly PIM (impact analyses) and WLE (agricultural education)

1. Introduction

1.1 Why Monitoring, Evaluation, Impact Assessment and Learning is important for the CRP DCLAFS

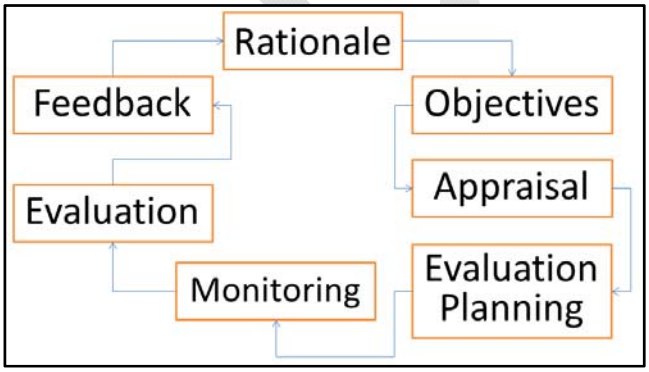
DCL is the 2nd biggest proposed CGIAR research program for Phase II, including 8 CGIAR Centers as PPA signatories and interacting with all others through a clear CRP-CRP interaction mechanism. The CGIAR Strategic Results Framework with its aspirational targets or SLOs represents the Results-Based Management (RBM) Framework adopted by all CRPs. Our CRP management structure is tailored to the RBM framework and contextualized with the Performance Indicator Matrix (PIM). People's livelihoods in dryland countries depend on our capacity to effectively optimize scarce resources and deliver solutions. We ensure that donor-disbursed taxpayers' money is wisely invested in order to get maximum value and build on evidence of "what works".

Quality evidence stemming from Monitoring, Evaluation, Impact Assessment and Learning (MEIAL) processes is important to: (1) make decisions about how and where best to target public spending, (2) demonstrate accountability, benefits and value for money of investment in research, (3) communicate the impact of research in helping solve development challenges, and (4) agile learning about effective ways to design and deliver research impact.

DCL will allocate a budget of approx. 5 M USD/Year for RBM. The budget is funded by W1/W2 and W3/Bilateral and may be modified over time in relation to: changes in W3/Bilateral donors' portfolio, which constitute 90% of DCL and optimized synergies with other CRPs, implementing partners and SDGs local and international partners. The average budget share in the bilateral portfolio is 3% for Monitoring, 2% for Evaluation and 1.5% for impact Assessments. W1/W2 will be strategically allocated to: 1) key evaluations (up to 300,000 per year); 2) Impact Assessment studies not covered by Bilateral funding (e.g. SPIA, BMGF, 3iE) in partnership with other CRPs such as WHEAT, WLE, PIM, RTB and FTA 3) Further development and implementation of the MEL Platform in collaboration with RTB; 4) Define common monitoring and evaluation standards through reflection and learning CapDev interventions with non-CG Partners (i.e. CORAF). This document is prepared within the framework of the CGIAR MEL COP Companion Document and in consultation with CG and non-CG Partners using face to face interaction and online survey.

2. How MEIAL processes fit into the CRP cycle

MEIAL processes are an integral part of the broad conceptual, implementation and delivery cycle of the CRP, as shown in Figure 1.



The evidence generated from MEIAL processes can be used to build on and strengthen analyses undertaken at the appraisal stage by testing and refining earlier assumptions, and improving the overall theory of change and implementation. This will enable real-time feedback throughout the whole cycle to track progress and identify potential barriers that can impede successful delivery. Investment in the generation and collection of quality MEIAL evidence is critical to assessing the real world validation, efficiency and cost effectiveness of the research intervention.

Our MEIAL Strategy is a living document and was developed on CGIAR RBM concepts and operational structures and informed by our active participation in the CGIAR Community of Practices for Evaluation (ECOP / IEA), the Monitoring, Evaluation and Learning (MELCOP / CO) and co-chairing of key working groups for improving Consortium-level RBM processes (e.g. Sub-IDOs indicators development, MEL strategic initiative, online collaboration tools). The integrative experience of DCL will be a knowledge asset for the new portfolio and will be useful in locations where other CRPs lead the work. The process for developing the DCL proposal and MEIAL was based on existing Phase I/Extension Phase approaches founded on a country/region perspective with strong RBM input from Partners. This approach is also now reflected in the CGIAR site integration plans.

3. The MEIAL Strategy

3.1 Ambition

The overarching goal of the MEIAL strategy is to ensure a robust CRP governance framework by generating high quality evidence on the effectiveness and quality of research interventions, which will inform critical CRP decision-making and be integrated throughout the conceptual, implementation and delivery cycle of the CRP. The following factors will be critical to the success of the strategy:

1. Adoption of a needs-driven and cost-effective approach to establishing MEIAL priorities.
2. An outward-looking approach that recognizes delivery of required outcomes requires successful collaboration and coordination with other organizations.
3. Promotion of a strong culture that incentivizes CRP staff and partners to proactively engage in the process of generating high quality evidence.

3.2 Objectives

In alignment with the CGIAR MEL COP Companion document[1], this strategy sets out three objectives:

1.Ensure a robust governance framework for all CRP activities through clear MEIAL processes and activities in order to generate learning and feeding into management decision-making to enhance the DCL-s effectiveness;
2.Establish a cost-effective MEIAL approach, and processes to inform conceptualization and successful delivery of all CRP activities at the level of SRF and within the broader framework of the SDGs;
3.Foster and promote a strong MEIAL culture with CRP staff and partners.

3.3 Scope

This initial strategy is focused on the CRP goals rather than those of its partners. Partners have their own practices and governance structures for MEIAL processes. Over time, a phased process for rolling out our MEIAL strategy across partner institutions, or synchronously merging DCL and partner MEIAL strategies, may be considered, if necessary. We will continue to refine and update the Strategy in light of the experience that comes with time and engagement with partners at regular intervals starting in January 2017. In delivering the MEIAL Strategy, DCL will take opportunities for standardizing approaches - as appropriate - to prevent duplication and inefficiencies within existing processes.

3.4 Adaptive structure

Our PIM operationalize DCL RBM at level of flagship project (FP)/cluster of activities (CoA), country and cross-cutting theme. However, we analyze our results using other levels or combination to effectively discover entry points in the agri-food systems. These dimensions generate nested Theories of Change (ToCs) where all actors

[1] 1) Outcomes-focuses culture; 2) RBM leadership to model results orientation; 3) Strong Participatory approaches at all levels; 4) Learning and adaptation through performance information; 5) Accountability and transparency; 6) Utilization-focused and flexible operational system.

find their position in terms of accountability, learning and contribution to adaptive management. ToCs outline how the research effort and supporting processes will lead to key developmental changes that contribute to SRF outcomes. The outcomes are measured with specific indicators at the crop, country and global level. While outputs are measured by quantified numerical targets the outcomes have a dual way of measurement. They have numerical targets and narrative analysis to support adapting management since they describe pathways and results against expected changes. This will provide a unique context-specific knowledge repository as the basis of the rigorous impact assessment design (ref. FP1/CoA1.6) in order to understand what works, what doesn't and why. Risks and assumptions are defined at each TOC step. Risks are treated according to the Risk Management Plan.

The Phase I/Extension Phase clearly defines the risks associated to CRPs resources and their translation into CGIAR basic and uplift scenarios. Based on lessons learned previously, DCL will elaborate a more adaptive management structure where research activities are reported every 6 months in order to adjust budget allocations. A second RBM aspect is related to the accountability of CG Partners' mapped projects. It is clear that the CGIAR reform is promoting better and more coordinated Bilateral projects for the CRP framework. However, CRP Governance bodies have to be empowered to decide which Bilateral projects should be mapped in accordance with a value for money analysis noted in the Guidelines for Mapping Bilateral Projects. Phase I/Extension Proposal bring the experience of CRP Performance Evaluations by the CO based on comparison of indicators and budget spent. DCL will work with international institutions and donors to define how these comparisons are reflecting value for money and when these are arbitrary or not feasible[2].

3.5 Building blocks

The strategy and the upcoming implementation plan are defined along 4 building blocks: 1) Monitoring; 2) Evaluation; 3) Impact Assessment; and 4) Adaptive Learning.

Monitoring is the responsibility of managers at different levels in the DCL governance and management structure. It implies regular observation of program implementation, data collection and analyses for informing management decision, evaluations and impact assessments. Adaptive/Agile management is one of the first key results of the strategy allowing smart learning, resulting in program adjustment, efficient supervision and feedback loops. DCL will also utilize the unique Monitoring, Evaluation, and Learning (MEL) platform developed in Phase I by CRP Dryland Systems and currently used by 4 CRPs[3]. The monitoring process will ensure Program Level reporting (Annual-CO; Semi-Annual-Steering Committee; Quarterly-Flagship Leaders/RMC) with quantitative and qualitative indicators at outcomes/impact level.

Evaluation is the responsibility of the CRP Governing bodies and Partners. Evaluation is the in-depth, formative/summative assessment of on-going program/institution/function and addresses explicit criteria (systematic). It is informed by triangulating multiple sources of evidence, commissioned externally and reported to oversight committees free of conflict of interest. DCL will adapt the DS Conflict of Interest Guidelines and Policy. Results are fed back into the program cycle and learning. As advised by IEA, DCL consulted with other CRPs and prepared a list of possible reviews and evaluations to be conducted over a reasonable period. In addition, DCL indicators will serve IEA evaluations both for DCL and CGIAR. The proposed evaluations are presented in table 1.

[2] Elsevier, Research Performance of CGIAR Research Programs, 29, 2015.

[3] The MEL Platform marks a key achievement compared to previous attempts from other older CRPs with systems already in place, partially contributes to fill the current gap identified by IEA (ECOP, Oct 2015) for the CRPs who stated that "monitoring systems are variable and lacking; not necessarily compatible for systematic generation of program data".

Type / Description	Dates From-To	Evaluation Focus	Main Evaluation Topic/Issue	Geographic Focus	Budget (Source)	Centers	Comments
Review	F: 05/2017 T: 010/2017	Capacity Development	Is our CapDev strategy sufficient to help us reach our scaling objectives?	Global	$40,000 (W1+2)	All Partner Centers	This CRP is the result of three different phase I CRPs. The review will analyze across all Partner Centers the CapDev previous, ongoing and planned interventions vis a vis the CapDev CO Indicators in order to assess the CapDev IDO Evaluability
Review	F: 03/2017 T: 08/2017	Open Access and Big Data	Is our OA and Data process sufficient to maximize our impact ensuring timely knowledge sharing with non CG Partners?	Global	$60,000 (W1+2)	All Partner Centers	The CRP Partners Centers have their own OA and Data Protocols. At Program Level we aim to ensure interoperability and enhanced knowledge sharing. The review will help in this process.
Evaluation: Formative process evaluation to test CRP approach	F: 02/2018 T: 09/2018	Cross-cutting IDOs: Gender, CapDev, Climate Change and Policies and Institutions	Have issues on cross-cutting IDOs been adequately addressed in the design of the FP and proper synergies set during the first year of the new CRP?	Global	$50,000 (W1+2) $30,000 (W3+Bil)	All Partner Centers	Our theory of change suggests that those IDOs are critical for success. The evaluation will help validate one of our key ToC assumptions.
Evaluation: Formative process evaluation to test CRP approach	F: 03/2018 T: 10/2018	FP 1	Refer to FP Impact Pathway and the narrative	Global	$200,000 (W1+2)	All Partner Centers	The FPs will be evaluated in terms of efficiency and effectiveness of FP-FP, CRP-CRP and Partnership interactions.
Evaluation: Formative process evaluation to test CRP approach	F: 04/2019 T: 10/2019	FP 2 and 3	Refer to FP Impact Pathway and the narrative	Africa, Asia	$300,000 (W1+2)	All Partner Centers	The FPs will be evaluated in terms of efficiency and effectiveness of FP-FP, CRP-CRP and Partnership interactions.
Evaluation: Formative process evaluation to test CRP approach	F: 04/2020 T: 10/2020	FP 4 and 5	Refer to FP Impact Pathway and the narrative	Africa, Asia	$300,000 (W1+2)	All Partner Centers	The FPs will be evaluated in terms of efficiency and effectiveness of FP-FP, CRP-CRP and Partnership interactions.
Evaluation Managers: Enrico Bonaiuti, Research Program Coordinator, e.bonaiuti@cgiar.org; Karl Hughes, Head of Monitoring and Evaluation, Partnerships & Impact, K.Hughes@cgiar.org.							

Impact Assessment, managed within FP1/CoA1.6 mandate, will facilitate the option development process through designing and carrying out rigorous impact studies of various promising research innovations in partnership with other CRPs. These studies will require high internal validity for the research process, as well as lower external (development) validity due to their localized nature. To address this challenge in the scaling process, the performance of devised options (from FPs across DCL) will be tested at larger scales and across heterogeneous conditions. Supporting impact assessment processes within such programs will have the benefit of enhancing program learning and effectiveness through robust evidence being fed back into the option development process (across DCL flagships) and/or scaled up and out. DCL will pursue more conventional impact assessment and cost effectiveness/benefit studies, as part of a concerted effort to rigorously identify what works, where, for whom, how, and at what cost. Theory-based evaluation approaches and mixed methods will be used to maximize learning. DCL will consult with ISPC and SPIA and prepare a list of possible IA to be conducted during the first three years.

Adaptive Learning is the process that DCL will use to achieve its ambitious strategy using the elements produced by the other elements (M/E/IA) and pursue behavioral change internally and externally to the

system. Both the research-in-development and impact assessments will generate important evidence relevant to improving conditions in such systems, which will be used to support the learning and scaling agenda of DCL. Here, work will take place with partners to influence key decision-makers to both uptake and promote options developed and tested under DCL, and create policy and institutional conditions conducive for facilitating such uptake. The final focus will then be to estimate the overall impact of DCL by critically assessing how it has influenced wider policy and practice and by monitoring the wider uptake of proven options and extrapolating the corresponding impact (see section 6 for more details).

4. Establishing a proportionate and cost-effective approach for implementing the MEIAL Strategy

As with all other aspects of our work and within a context of constrained resources, we have to balance the need for high quality MEIAL against other priorities to ensure that effectiveness and value for money is delivered for donor investments. It would not be cost effective to apply a blanket requirement for MEIAL across all activities undertaken within the CRP. The returns on the investment will diminish if the quality of the evidence generated becomes compromised, the evidence fails to add value to the existing evidence base within a timely manner, or the cost of the MEIAL is disproportionate to the size of the initiative. DCL has identified the following principles in order to establish a systematic but proportionate cost- effective MEIAL approach to identify priorities:

1. The scale of investment / potential impact;
2. Strategic imperative;
3. Delivering legal obligations;
4. Degree of risk; and,
5. Contribution to the evidence base[4].

Priorities will be set out in a MEIAL Strategy which will be made publicly available in the CRP Website. The initial MEIAL Strategy and activities will be launched in the first quarter of 2017 in accordance with funding confirmation and it will be developed with a participatory approach and updated annually. Whilst the CRP is responsible for driving forward the MEIAL Strategy, it recognizes that the delivery of many MEIAL activities will be done in collaboration with, or led by, other organizations such as Local Authorities, other delivery partners and expert practitioners. So opening up the proposed MEIAL priorities in a transparent and outward-facing way will help to underpin proactive collaboration amongst all CRP partners. The CRP Performance evaluation including the definition of indicators will be discussed within the MELCOP and with other collaborating CRPs such as RTB. Apart from being the two biggest CRPs we also share the same MEIAL tools to effectively implement RBM. During the period 2016-2017 DCL will actively support the development of consistency indicators across the different CGIAR units (IAU, IEA, ISPC/SPIA) as part of MELCOP objectives as discussed in Rome (October, 2015). In addition to this internal role, DCL will interact with relevant Organizations (incl. FAO, WB, SDGs working groups) committed at country level to ensure effective and efficient data collection to be used in the impact assessment design. Table 2 details the IDO indicators identified in partnership with stakeholders.

[4] This includes an assessment of how MEIAL will add value to the existing evidence base by: filling key evidence gaps; influencing future decision making; testing out innovative initiatives; the likely quality of the resulting evidence; and, generating generalizable evidence.

IDOs	Proposed Indicators	Proposed Monitoring Approach	Crops	Geographical Focus*
1.1 Increased resilience of the poor to climate change and other shocks	Increased resilience of the poor to climate change and other shocks**	The indicator measures the reduction in price volatility (measured by CV in price) influenced by stable supply of crop at country level	Pearl Millet, Sorghum	India, Malawi, Mozambique, Tanzania, Uganda, Nigeria, Mali, Senegal, Niger, Egypt, Ethiopia, Morocco, Syria, Turkey and Iran
	Households adopting options to improve resilience****	The indicator Measures the number of Households adopting proposed CRPs option through primary data collection at DCL-FTA research sites	All crops in Agro-Forestry systems	Nigeria, Mali, Niger, Uzbekistan
1.3 Increased incomes and employment	Increased export	The indicator measures the increased export due to reduced aflatoxin contamination	Groundnut	India, Vietnam, Malawi, Mozambique, Tanzania, Uganda, Burkina Faso, Ghana, Nigeria, Mali, Senegal and Niger
	More efficient use of inputs****	The indicator measures the water-and nutrient-use efficiency in common DCL-RICE key sites	Legumes-Rice	India, Vietnam
	Increased livelihood opportunities	The indicator measures the adoption of improved varieties, breeds or trees, and/or management practices at FTA/RICE/DCL key sites	All crops in Agro-Forestry systems and Rice-Legumes Systems	India, Vietnam, Nigeria, Mali, Niger, Uzbekistan
	Diversified enterprise opportunities****	The indicator measures the number of diversified farm activities (crop types, livestock and fish breeds, and tree species) per household in DCL-RICE action sites in key countries.	Legumes-Rice	India, Vietnam
	Increased income** & ****	The indicator measures the increased income from growing crops at household level at DCL-RICE key site	Bean, Cowpea, Chickpea, Faba bean, Lentil, Groundnut	India, Vietnam, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Increased premium quality marketable grain**	The indicator measures the increase in number of farmers producing grain of improved market quality	Finger millet	Ethiopia, Tanzania, Uganda, Kenya
	Increased profitability of grain for industrial use	The indicator measures the increase in profitability from improved grain quality for industrial use at country level	Sorghum, Barley	Nigeria, Kenya, Tanzania, Ethiopia, India, Iran, Morocco
1.4 Increased productivity	Cropping system productivity increased	The indicator measures the increase in cropping system productivity	Chickpea, Lentil	India
	Yield Quality****	The indicator measures the yield quality as: Micronutrient content of "biofortified variety; % meeting minimum target level Aflatoxin contamination level; % meeting standards In collaboration with A4NH	Legumes	India
	Decreased price	The indicator measures the decline in real price of target crop in target regions	Pigeonpea	India
	Increase in storage/stock	The indicator measures the increase in the stock of grains prior to harvest period for rural poor households producers	Finger millet	Ethiopia, Tanzania and Uganda
	Increased grain production	The indicator measures the increased production resulting in higher supply of grains to the market and ultimately consumers	Cowpea	India
	Increased grain yield** & ****	The indicator measures the number of farmers who have achieve increased grain yield (productivity) in collaboration with A4NH and WHEAT	Sorghum, Pearl millet, Barley, Finger millet, Cowpea, Chickpea, Faba bean, Lentil, Bean, Soybean, Pigeonpea	Ethiopia, India, Iran, Kazakhstan, Morocco, Turkey, Tanzania, Uganda, Kenya, Vietnam, Burkina Faso, Ghana, Nigeria, Mali, Niger, Senegal, Malawi, Mozambique, Zambia
	Increased stover digestibility	The indicator measures the increase in area (hectares) with increased stover digestibility	Sorghum, Pearl millet	India
	Increased stover/biomass yield	The indicator measures the increase in area (hectares) with increased stover/biomass yield (productivity)	Sorghum, Pearl millet	India
	New niches brought under cultivation	The indicator measures the new area in new niches brought under cultivation by growing heat tolerant varieties	Chickpea, Faba bean, Lentil, Bean	India
	Reduced yield losses	The indicator measures the reduction of yield losses due to the adoption of IPM innovations based on host plant resistance (including Bt-transgenics), biological control and bio-pesticides	Cowpea	India
2.1 Improved diets for poor and vulnerable people	Decrease in the length of hunger period	The indicator measures the decrease in the length of the hunger period for rural poor households producing grains	Sorghum, Pearl millet	Mali, Niger, Nigeria and Burkina Faso
	Increase in availability	The indicator measures the national level increase in the availability of food/feed grain/straw and industrial use at more stable market prices in CRP focal countries.	Barley	Nigeria, Kenya, Tanzania, Ethiopia, India, Iran, Morocco
	Increased availability of diverse nutrient-rich foods****	The indicator measures the increase in common beans production derived in part from an additional hectares in heat prone areas, and of climbing beans in collaboration with A4NH, RICE, RTB, FTA and WHEAT (Cereal-Legume systems) using Dietary Diversity and SDSN12: percentage of women, 15-49 years, who consume at least 5 of 10 defined food groups (FAO, WHO as potential lead monitoring agency)	Legumes-Cereals Systems	Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda, India
	Increased consumption**	The indicator measures the increase in consumption of crop products especially by women and children	Finger millet, Pearl millet, Sorghum, Chickpea, Faba bean, Bean, Lentil, Groundnut, Pigeonpea	Ethiopia, Kenya, Sudan, Tanzania, Uganda, India, Bangladesh, Nepal, Vietnam, Malawi, Mozambique, Tanzania, Uganda, Burkina Faso, Ghana, Nigeria, Mali, Senegal and Niger
	Increased intake levels**	The indicator measures the increase in iron and zinc intake levels from nutrient-dense grain by women and children in areas where high iron varieties/hybrids were adopted	Pearl millet, Sorghum, Finger millet	India, Ethiopia, Kenya, Tanzania, Uganda
	Increased supply at household level	The increased measures the increased supply at household level in target areas	Groundnut	Malawi, Mozambique, Tanzania, Uganda, Nigeria, Mali, Senegal and Niger
	increased use of biofortified food** & ****	The indicator measures the increase in the use of iron and zinc fortified grain as food by nutritionally vulnerable women and children in rural and urban areas and for individuals with special dietary requirements in collaboration with A4NH	Barley	India, Iran, Ethiopia and Morocco
3.2 Enhanced benefit from ecosystem goods and services.	Nitrogen fixation generated	The indicator measures the additional nitrogen fixed by adopted varieties	Bean	India
	Pesticide use reduced	The indicator measures the reduction of pesticides due to adoption of short-duration foliar diseases resistant varieties	Groundnut, Chickpea, Pigeonpea, Cowpea	India
	Soil fertility and organic matter increased	The indicator measures the increased in soil fertility and organic matter	Groundnut, Pigeonpea	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
3.3 More sustainably managed agro-ecosystems	Climate risks adaptive capacity****	The indicator measures the adoption rate of improved crop and natural resource management technologies (including adaptive to climate change, and mitigating GHG emissions), gender disaggregated where possible in collaboration with RICE.	Legumes-Rice Systems	India
	reduced environmental footprint	The indicator measures the acreage increase using enhanced water productivity technologies in rotation with legumes and with conservation agriculture practices	Barley, Sorghum	India, Ethiopia, Iran, India, Morocco.
	Climate risks adaptive capacity (Governance) ****	The indicator measures the national action plans using ecosystem-based adaptation principles in collaboration with FTA.	All crops in Agro-Forestry systems	Nigeria, Mali, Niger, Uzbekistan
	Net GHG emissions ****	The indicator measures the Net GHG emissions in the agriculture, forest and other land use (AFOLU) sector (SDSN Indicator, Draft Statement Report); Emissions of greenhouse gases in agriculture (per hectare of land and per unit of output, separately for rop and livestock sectors) (UNSC indicator, Draft Statement Report); Ammonia emissions from agriculture (FAO-STAT, Draft Statement Report) in collaboration with WLE, RTB and FTA.	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
A.1 Mitigation and adaption achieved	Decrease of failed acreage	The indicator measures the decrease in acreage requiring re-sowing due to improved crop tolerance to adverse weather conditions	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Crop Water Productivity****	The indicator refers to SDSN 16: Crop water productivity (tons of harvested product per unit irrigation water, FAO lead monitor. DCL will work in collaboration with WLE and WHEAT in key common countries.	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Increase in climate-adaptable cultivars	The indicator measures the increase by at least one the number of cultivars grown by farmers	Pearl millet, Sorghum, Finger millet, Chickpea, Lentil, Cowpea	Ethiopia, Sudan, Tanzania, Uganda, India, Burkina Faso, Mali, Mozambique, Niger, Nigeria, Senegal
	Increased biomass yield	The indicator measures the increase in biomass yield among adopters of varieties	Soybean	India
B.1 Equity and inclusion achieved***	Increased and gender-equitable income**	The indicator measures the increase in income for crop growers and processors (local food and industrial uses) in target areas	Ginger millet, Pearl millet, Sorghum, Barley	Burkina Faso, Mali, Nigeria, Ethiopia, Kenya, Tanzania, Uganda, India, Iran, Morocco
	Women's empowerment in agriculture index (WEAI)	The indicator is the Women's empowerment in agriculture index (WEAI) and component indicators (e.g., assets, decisionmaking, leadership, time use); WEAI score as compared to empowerment threshold. DCL will work with A4NH and RICE in common key countries.	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Reduced labor requirement** & ****	The indicator measures the reduced labor requirement for women cultivating short duration improved crop. DCL will work with RICE in key common countries.	Groundnut and Legumes-Rice Systems.	India, Vietnam, Malawi, Mozambique, Tanzania and Uganda, Burkina Faso, Ghana, Mali, Senegal, Nigeria and Niger
D.1 National partner and beneficiaries enabled***	Increased Knowledge ****	The indicator measures the # of people trained, improvement in knowledge (as measured by pre-post tests), and change in practice reflecting improve capacity, subjective assessments by beneficiaries of enhanced capacity. DCL will work in collaboration with WLE and A4NH in common key countries	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Institutional capacity ****	The indicator refers to SDG2: 14. Number of agricultural extension workers per 1000 farmers [or share of farmers covered by agricultural extension programs and services]. DCL will work with RTB in common key countries.	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda
	Innovation Platform****	The indicator measures the number of innovation platforms, learning alliances, and other multistakeholder platforms. DCL will work with RICE in common key countries.	All Crops	India, Burkina Faso, Ghana, Nigeria, Senegal, Mali, Malawi, Mozambique, Tanzania, Uganda

* Indicators are collected in target countries (site integration plan) and in non-target countries as results of bilateral projects/non-CG partners Interventions
** Gender dis-aggregated
*** Additional specific indicators included in the respective strategy as results of Community of Practices efforts
**** In collaboration with other CRPs

4.1 ICT Online Platform

DCL is the only CRP using a customizable open access platform that enables the transparent documentation of implementation processes and results, and where information is easily available to stakeholders. This platform was successfully piloted and rolled out in 2015 according to the request of more than 350 national and international partners. DCL together with RTB will test in 2016 an improved MEL platform developed by the CRP Dryland Systems. The web-based MEL platform enables better RBM, including planning, reporting, coordination, risk management, performance evaluation, and management of legal mechanisms in place among partners, as well as knowledge sharing and learning amongst different groups of stakeholders (donors, partners, CG center scientists) and within and across CRPs, CG center and Bilateral projects. The MEL platform is designed for Project/Program Managers within the organization to facilitate and automate technical/program implementation and financial processes, thereby enabling timely and informed decision-making, transparent reporting to donors and reduction in administrative/transaction time and costs. The MEL platform enables research staff and managers to input, archive, extract, and share all kinds of research data and knowledge products, including budget and financial information. It basically captures all the information required to ensure effective RBM and implementation of research projects from start to finish, including but not limited to: Research Outputs, Outcomes, Expected Deliverables, Indicators, Impact Pathway and Theory of Change, scientists' staff time allocation, budget expenditures, partners, risk register and management, gender results, outcome/communications stories, etc. It provides aggregated data per site (country) allowing synchronization of interventions with national and international partners. Different users have different levels of access and utilization of information captured through the MEL platform. Reporting in the MEL platform is currently customized by Activity, Cluster of Activities, Flagship (W1/W2) and Project (W3/Bilateral). These can be easily customized differently and further. The MEL platform offers a number of features and modules that enable timely and easy planning, reporting, and sharing. The MEL Platform is hosted on CGNET and AMAZON. It is compatible with Open Access requirements, using Dublin Core Metadata. It can be linked with any Open Access Repository and by using any Creative Commons license. The MEL platform provides two-way connectivity. It can harvest data from available systems like OCS, and it can provide the data to other systems via standard API. The MEL platform uses full stack open source environment. Its backend is developed using Zend Framework on top of PHP, its frontend uses Javascript, CSS and HTML and the platform database engine is MySQL. Learning and Knowledge sharing is enabled in a number of ways via: 1) Open repository (linkage with D-Space), 2) Internal smart keyword dashboard that notifies users about new/similar knowledge/data produced by other scientists with similar keywords. This functionality will be extended to non-registered partners (i.e. NARS, NGO) who will register in the platform and will have a customized dashboard, 3) Discussion Forum to enhance collaboration amongst stakeholders across different geographies, CRPs, CG centers, and partners, 4) Research planning and proposal writing tool.

5. Ensuring a robust CRP governance and management framework through the MEIAL Strategy

An important aspect of ensuring a robust and results-oriented governance and management framework for DCL is to establish an enabling environment, which incentivizes the collection and use of high quality MEIAL evidence to inform decision-making during the entire cycle of research planning and implementation. In part, this is a question of creating the right culture by making MEIAL activities – in line with current best practices - a required element and an integral part of the governance and management processes in DCL, from research

planning to implementation. This will also help provide greater oversight of planned MEIAL activities at senior level. DCL frames its management for results cycle within the CGIAR MEL COP Companion document 7 steps[5]. Additionally, DCL will ensure the MEIAL Strategy will appropriately contribute to a robust CRP governance and management framework, in the following three ways:

1. The CRP Steering Committee will have overall responsibility for ensuring the MEIAL Strategy and activities meet CRP needs at all governance and management levels.
2. The CRP Steering Committee will regularly monitor implementation of the MEIAL Strategy and activities in order to track overall CRP progress and ensure that knowledge, insights and lessons generated from MEIAL evidence are shared, fed back and appropriately incorporated into improved decision-making and policy across the CRP and amongst partners. This level of oversight is important given that the MEIAL of research initiatives can span long periods and their impacts can take a number of years to be observed and fully realized.
3. The third aspect is enhancing the quality assurance of MEIAL plans and deliverables. This will be led by the MEIAL officer/specialist and will be integrated with wider analytical assurance processes undertaken across the CRP partners.

4. Embedding a MEIAL culture across the CRP and amongst partners

At the heart of the MEIAL Strategy is the need to enhance the overall CRP organizational culture to proactively embrace, share and apply learning about what works and why - or why not - and use this knowledge to advance understanding, improve decision making, and increase efficiency and value for money during implementation. The MEIAL Strategy provides a clearer commitment to establishing and fostering such an organizational culture that will encourage CRP actors and stakeholders to plan more effectively for delivery of results and to target resources more efficiently. Establishing and fostering a sustained MEIAL culture in the long run will require close collaboration with partner organizations and appropriate resources. The IEA identified that CRPs needed to increase their efforts in evaluation in order to improve their capabilities for basing choices on evidence. DCL has accepted this conclusion, and the senior management team is strongly committed both to this Strategy and to ensuring that the MEIAL evidence generated through the life of the CRP is effectively utilized and lessons are shared for the benefit of future decision making. Priority will therefore be also given to increasing awareness and building internal capacities with regards to the value and importance of MEIAL. CapDev will be focused on providing people with appropriate knowledge and skills required to design and deliver new and quality MEIAL approaches, but also to draw lessons and insights from the existing evidence base more effectively.

A good support system will be essential to building these capacities. By reinforcing the connections between MEIAL, good governance and project management, DCL will continually seek ways to develop appropriate tools, guidance and support in a cost effective fashion. Technical support and advice will be provided by the MEIAL officer/specialist and this will be augmented by the development of a network of MEIAL champions identified across the CRP. We will also seek to draw on best practices and insights from external experts and our partner organizations.

[5] 1) Impact Pathway and ToC definition and review based on lessons; 2) performances-based budget allocation; 3) Planning for M&E; 4) Establishing responsibilities and accountabilities; 5) Monitoring and analysing performance and risks information; 6) Using performance and risk information; Reporting performance results.

Digital Agriculture + ICT in DCL Agrifood System

The ever increasing human populations, subsequent increased demands for food, fiber and energy have put tremendous pressure on land and water resources. Dryland agro-ecosystems of the developing world facing sever demand-driven challenges with serious environmental constraints that are likely to worsen as a result of ever changing climate, natural resource base and demography. There is a definite need for an integrated-digital-agriculture platform for efficient performance of DCL throughout the project cycle from the inception phase to implementation, intervention, acceleration to scaling.

Precise, timely and an interactive information is one of the key factors in understanding current trends and status that determine the matrix of intervention from local to global scales. The digital agricultural technology has progressed rapidly in the last few years (a decade) which is further enriched with ever increasing open-access protocols and analytical-powerhouse has kept expanding its horizon and become an integral part of solving food security equation in the developing countries. Recent advances in earth observation systems, spatial big-data and geo-cyber-infrastructure is transforming integrated agro-ecological and livelihood systems research and outreach by providing most powerful overarching-tool to help "**farming-stakeholders**" (scientists, farmers, decision makers, extension agents, system modelers, think-tanks, etc. who contributes to better farming-livelihoods) at various scales/levels (farms/household to landscapes/population). It became an indispensable mechanism for making various decisions from smallest sampling frame at agricultural research trails to on-farm operations to market and the plates. With increased availability and application of very high resolution (at space-time) remote sensing imagery (drones to satellites) on a real-time basis can help making 'precision-decision' on developing new crop varieties, planting, growing, harvesting and marketing leading to increased net return while decreased environmental as well economic impacts. It will act as one of the key-catalyst in integrating 5-FPs, CRPs, cross cutting research domains (package of practices), integrated systems analysis and modeling, and community of practices (Citizen Science) to contribute anticipating futures of agri-food systems research and outreach towards improved food, environmental security and social fairness.

Enormous efforts are underway throughout the world agro-ecosystem community to gather data and information on crops, livestock and related disciplines and their production mechanisms. However, in many instances, these

What this platform brings

- *Enriching the geo-spatial integration within an overall integration of agro-ecological and livelihood systems research and outreach.*
- *Conjugate extensive expertise across research programs and the specific thematic areas from farm trails, to farmscape to population and landscape levels.*
- *Increased timely access to agro-socio-ecological information, statistics for various sectors of the agro-ecosystem research and farming stakeholders*
- *Bring 'innovation for integration' for developing better options (package of practices) and prioritization (hotspots) for investment to intervention.*
- *Involve citizen-science and community of practices to build a co-learning capacities in integrated systems research across the domains toward co-producing both research and development outcomes.*

are collected at very course resolution, ranging from several hundred meters to tens of kilometers and often lack of consistency and wall-to-wall coverage. Such information or data are often used in many global and regional scale models to assess status or trends at the landscape level or even larger units. However, at these scales, such data may fail to reflect ground realities that are often very different from information or data collected at larger scales, and therefore fail to capture the complex nature of agro-ecosystems. This is especially so in the drylands of the developing world, where smallholders' landholdings are small (on average < 1 ha), and production systems are highly diverse and complex. Complexity has many dimensions, ranging from goods and services that are produced, soils, land scape position, water availability, elevation, aspect, localized weather events, poverty distribution, land degradation, infrastructure, migration, local policies on land tenure, market access, conflict, etc.

Overarching objective is to advance the development of digital agricultural platform needed for efficient, economic and ecological (sustainable) transitions of dryland cereals and legume agri-food system research from discovery to delivery at local to national, regional and global scales.

Digital agriculture platform enriched with smart ICT enables 'farming stakeholders' to effectively incorporate the constellation of biophysical, climatic, ecological, socio-economic, and institutional factors controlling the adoption of 'proven' innovations, technologies and optimal approaches to achieve resilient and sustainable intensification of drylands agro-ecosystems

An integrated agro-ecosystem systems approach is increasingly used to manage more productive, stable, and ecologically sound production system because it provides an interactive digital-platform for addressing complex and interactive sets of issues that are increasingly 'information-driven'. Implementation and intervention of new management paradigms to ensure food security and improved livelihoods requires access to better information in space and time. Figure 1 explains the role of the digital agricultural in DCL AFS and its interactions in addressing issues at interdisciplinary integration (e.g. big data, system analytics) to identify best scenarios and top priorities for developmental introversion and scaling. These integrations occur either across the commodities, overarching to enabling environment such as high throughout phenotyping (bio-spectral screening), integrated breeding, germplasm stratification(FIGS), adoption of technology (out/up scaling), soil and water management (water and land productivity), integrated systems analysis and modelling (iSAM/GCISR), land productivity (PEMs), ecosystem services. This platform itself yield as unique IPG, plus several interactive IPGs linked with CGIAR impact pathway of "science of discovery to science of delivery" through spatial data and knowledge gateways, improved algorithms, apps, web tools, precision farming, SDSS, etc. It will produce number of cross-cutting and mutual products within given common sampling frame (e.g. ALS) which could help in stitching together FPs and interact with CRPs and farming-stakeholders. It will also strengthen co-learning mechanism and CG-wise network of spatial commons (CGIAR-CSI), CGIAR BigData Platform and center's nodes as active member towards developing common portfolio for better integration and intervention.

Figure 1 (DRFT). Role of digitail agriculture platform in the DCL AFS and its intretctive domains and thematic areas.

----------Additional text / support materials ----------

Thematic focus

Thematic focus of the digital agriculture is multi-sensor-multi-scale observations of productivity (biomass, yield, and cardoon sequestration), water use (efficiency, allocation), and energy interaction (mechanization, shift) of the agro-ecosystems and associated socio-economic drivers for the adoption of the agricultural innovations for better livelihoods in the drylands.

Recent advances : a) recent advances in satellite sensor technology, b) guaranteed availability of quality time-series data, c) open (free) access to high quality digital images, d) advances in processing and handling of big data analytics, e) rapid increase in computational power, processing chain and archiving mechanisms, f) decreases in cost of proprietary software/algorithms, g) ease and increasing expertise in handling these complex datasets, and h) most importantly wider use of handheld gadgets (cell phone) across the end-user segment. Over the last 3 years, there has also been increased release of high quality datasets into the public domain, resulting in greater use of spatial data and the development of machine learning algorithms for thematic research. This trend is likely to increase in coming years and has ushered in a new era of ‘open access.’

The recent development of advanced sensor technology (e.g., specific bands), platforms (e.g., spaceborne, airborne, UAVs), satellite constellation (e.g., increased orbital speed (WorldView2,3), multiple-clone satellites (RapidEye, Micro-satellites (Google)), onboard capacity and grounding stations, etc. has opened new era of remote sensing applications across production systems (Figure 2). Just 3 years ago, it was a dream to get very high resolution images

on a daily basis. Today, one can get satellite imagery on a near-real time basis at sub-meter (up to 30cm) each day for any given location. The quality and details of the imagery and therefore of the inherent information has increased dramatically. Simultaneously, software packages and open-access platforms are developing necessary calibration and processing tools to make such information easily available to a range of end-users.

Armed with increased computational power, faster image processing algorithms, better geo-cyber infrastructure, and a host of tools including improved modeling framework, the GeSTA can be used to study and characterize (quantifiable terms) agricultural production systems at scales ranging from the field to the globe. These databases will allow farming stakeholders to plan, implement and track the progress and assess impact of various program interventions and help realize a near real time Monitoring, Evaluation & Learning (MEL). For example, the capability to identifying different land management units or production systems through their associated spectral properties is a major step forward in our ability to map and monitor crops-health, nutrient status, stress, etc. Ameliorated computational storage, processing power, and automated machine learning algorithms have been playing a greater role in enhancing pixel-based image analysis of high resolution data acquired over complex and highly variable agro-ecosystems. To be sure, there are still certain limitations associated with time-variant identical spectral characteristics among different land use and land cover types. However, the combined use of higher spatial, spectral and temporal resolution images has enabled us to produce better thematic maps with higher classification accuracy.

In the past, operational cost of digital agriculture was one of the major bottle necks in adopting the technology to a wide array of applications. A major portion of the cost used to be associated with high resolution satellite imageries, followed by the cyber infrastructure for processing and handling the satellite data, and high prices of major software packages and expertise. However, such overhead costs have been declining in the last two years due to increased open access to data, open source program and algorithms, decreased cost of the mass storage and increased computational efficiency and cloud based amalgamation which opens new era of digital agriculture.

Example case studies

- Mapping agro-climate-based adaptation domains for known/proven crop varieties
- Agricultural intensification and crop diversification: exploring untapped potential crop fallows http://geoagro.icarda.org/india/ (beta v0.1)
- Forecasting yield and production probability of commodities with theirs extent and spatial distribution pattern and market access for better integration into value chain

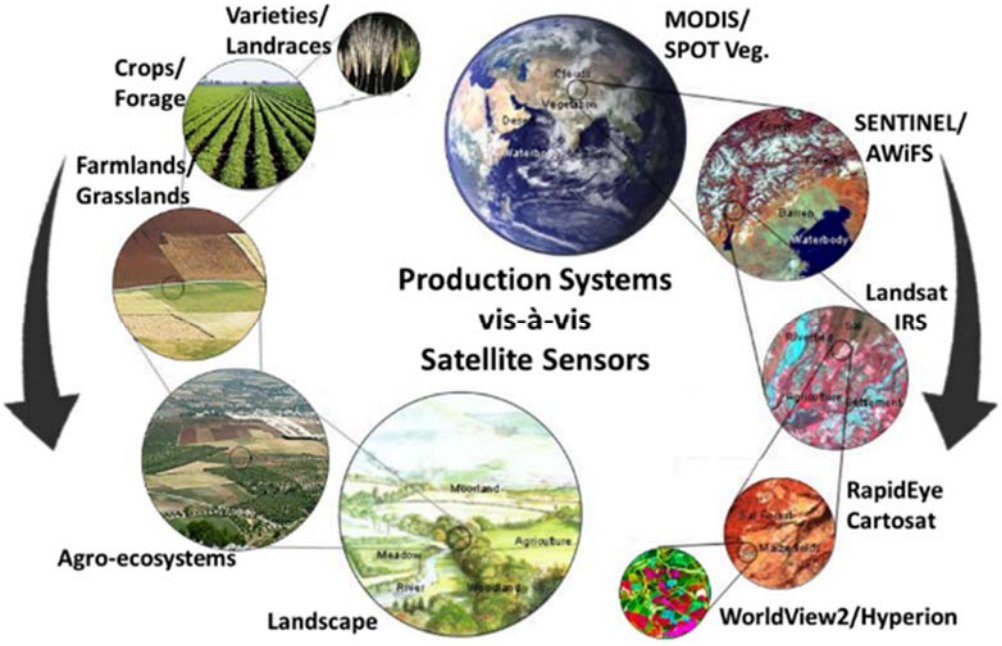


Figure 2. Remote sensing of agro-ecosystems and its scaling trade-off

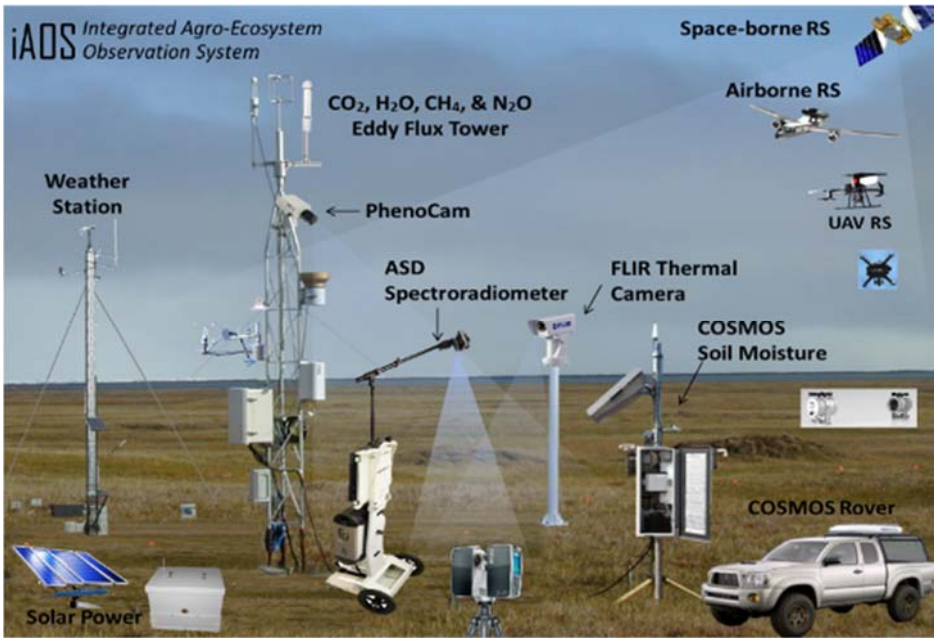


Figure 3. Framework of an integrated observation system for agro-ecosystem research

PRIORITY REGIONS FOR RESEARCH ON DRYLAND CEREALS AND LEGUMES

AUTHORS AND AFFILIATIONS

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ABSTRACT

KEYWORDS

Grain legumes, dryland cereals, farming systems, priority setting, geographic priorities

INTRODUCTION

International agricultural research and development programs usually consider the geographic dimensions of crop improvement and farming systems in their efforts to prioritize their activities. Where is the crop grown globally and what are the key obstacles to crop production? Does the program work in places where benefits of the research can reach a large number of people? How can resources be allocated to achieve efficiencies? But answering these questions requires integration of socioeconomic and biophysical data and the development of wide-ranging data and information resources. Often data exists for national jurisdictions, but it needs to be evaluated by agroecology. The task is even more difficult for crops like dryland cereals and grain legumes because – when compared to the major staple crops – these crops receive less attention and less information is available. The Dryland Cereals and Legumes Agri-Food System (DCL) research program of the CGIAR requested the development of an analysis of the 12 principal commodities of their proposed program and the farming systems in which they are found. The 12 priority crops of these dryland systems are groundnut, common bean, cowpea, faba bean, soybean, lentils, chickpea, pigeon pea, barley, sorghum, pearl millet and small millet (DCL, 2015). The research presented in this paper shows the development of spatial and statistical data intended to support geographic priority setting for the global DCL research program. In order to develop the analysis, this research builds on a global classification of farming systems, on maps of all 12 DCL crop commodities, on socioeconomic data on conditions of the population, and on biophysical constraints to crop production. It asks where these crops occur in the context of constraints and opportunities for their development. How could we target DCL technologies to best meet the objective of reducing poverty and malnutrition in dryland systems? The present analysis is based on a diverse array of geographic information, and includes new assessments of poverty, drought, heat and other information related to crop improvement. The study examines constraints to DCL crop production and uses the

most recent spatial data available. The analysis and resulting database provides the first global farming systems information resource for specifically evaluating priorities for DCL crop improvement. Tabular data from this analysis is open access and has been published in a data repository (Barona and Hyman, 2016). The geospatial data used this study can be accessed through a new online digital atlas for dryland cereals and grain legumes (see http://www.eatlasdcl.cgiar.org/).

METHODOLOGY

The study builds on previous work, but with a focus on the 12 principal commodities and farming systems of DCL. The main framework for the study is John Dixon's farming systems, a global delineation and resulting map of the major farming systems of the world (Dixon et al., 2001). Dixon's schema is built on consultations with hundreds of regional and global agricultural experts. In a participatory process, they geographically delineated 63 global farming systems and described their characteristics. The present study uses those farming systems together with spatial data on biophysical and socioeconomic conditions to characterize where DCL commodities are found. Using spatial overlay, biophysical and socioeconomic information ~~is~~ are organized according to the 63 Dixon farming systems.

A key advantage of this research was that instead of analyzing crop information by country, we use subnational data sets with estimates of crop distribution at pixel level (Hyman et al., 2008). Then, using spatial overlay, we organize that data by country, by farming system (63 types) and by combinations of countries and farming systems (544 combinations). Other data is also organized according to farming system and country – including information on drought, temperature dynamics with climate change, soil conditions, population and poverty. Readers should consult the supplemental material and our previous publication for a complete description of the methodology (Hyman et al., 2008).

DATA SOURCES

Spatial information on biophysical and socioeconomic conditions was acquired by availability, and with the objective of obtaining the most recent and spatially detailed information. The present study upgrades our previous work because we are using data that was not available before, especially the 2005 spatial distribution of crop area, production and yield (You et al., 2006; You et al., 2014). The previous study used crop distribution data from the year 2000, while the work we describe here uses 2005 data. Our previous data set only included 7 DCL commodities, in contrast to all 12 of the DCL commodities used here. These new data also benefited from improved spatial resolution and modeling procedures. This study used the most recent available data on global livestock and human population. The source of human population data was the gridded population of the world project (CIESIN, 2014). Livestock population from the Gridded Livestock of the World (GLW) database at 5 km spatial resolution and with the year 2005 as the reference year (Robinson et al., 2014).

Several data sets gave us information on abiotic constraints to crop production that are important for the DCL commodities. The data set includes indicators of drought based on maps of drought probability and the "failed seasons" concept. By simulating rainfall and by knowing crop requirements, the probability of a growing season failing to produce a successful harvest indicates drought conditions for a given pixel across the world (Hyman et al., 2008; Jones and Thornton 2000, Jones et al 2002). The drought probability is multiplied by total crop area to derive the potential drought impact index (PDII). The need for DCL crops to tolerate increased heat was indicated by estimates of expected temperature change between the current temperature and 2050 temperatures (Hijmans et al 2005, Ramirez et al 2008). The study used maps of soil constraints based on the fertility capability classification

(Sanchez et al 2003). These constraints included indicators such as soil acidity, length of the dry season, waterlogging, low nutrient availability and salinity – all constraints identified by DCL crop experts as important obstacle to overcome (DCL, 2015). Finally, the length of the growing period indicates seasonal constraints on crops that may be relevant for the breeding objectives of DCL crops (Fischer, 2009).

Detailed geographic information on population is not usually available until at least ~~5~~ five years after the dates of censuses and surveys. Our analysis includes estimates of the total population for the year 2010, as well as total, rural and urban population for 2005 (CIESIN et al., 2005; ~~CIESIN~~ CIESIN, 201~~0~~). The analysis draws on estimates of the number of people living on less than $1 and $2 per day for 10 km pixel areas, based on a project that combined poverty maps and survey data for the entire world (Wood et al., 2010).[1] Nutrition indicators include the absolute number and proportional numbers of children under ~~5~~ five years old that are two~~2~~ standard deviations below the median of weight for age (underweight) and height for age (stunting), according to international standards (CIESIN 2005, FAO,2007).

SPATIAL ANALYSIS

Spatial overlay was used to organize the data into spatial units according to farming system and combinations of farming systems and country. All data was converted to the Robinson equal area projection at 10 km spatial resolution before processing commenced. We used the zonal statistics tools in ArcGIS ~~10.1.~~ 10.1. The analysis counts pixels and descriptive statistics for each spatial unit, creating database files (dbase) for each overlay. These files were then converted to X spreadsheet files in Excel format (Barona and Hyman, 2016). An additional analysis was made of the pixels where more than one DCL crop occurred within the pixel. For each crop, if the area value in the pixel was higher than the mean for all pixels of that crop, it was considered to be of a sufficient density to map these crop combinations. By selecting only those pixels above the mean, we excluded those areas that may have a small concentration of the crop. The creation of the tables was facilitated using scripts written in arc macro language (AML) to facilitate updates as more recent or better data becomes available. This process is documented in the supplementary material.

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RESULTS

The DCL crops are concentrated in 18 farming systems where more than 160 million ha of these crops are cultivated, where more than 60% of the world's poor live and where the DCL commodity programs have selected target countries based on their fit with dryland systems (Figure 1; Table 1 & 7; DCL, 2015; DESA, 2010). We selected these farming systems if the farming system had at least six million ha of combined DCL crops. However, we excluded three Latin American and Caribbean (LAC) farming systems that met this threshold because these systems were overly dominated by soybean production in regions with typically large farms. These excluded systems were *temperate mixed* (Pampas), *cereal-livestock* (Campos) and *extensive mixed* (Cerrados_Llanos).

Priority DCL farming systems were included from Latin America and the Middle East and North Africa (MENA) regions that did not meet the six million hectare threshold described above. The *maize-beans* farming system in Mesoamerica was added because it is very similar to *maize mixed* system in sub-Saharan Africa. The *rainfed mixed*

[1] This global poverty data set is not available in the public domain. Interested users of poverty data should consult the harvest choice website at http://harvestchoice.org/topics/income-and-poverty.

and *pastoral* farming systems in the MENA region were added because they are the same farming systemss in sub-Saharan Africa (*pastoral*) and in South Asia (*rainfed mixed*). Two other farming systems – *dry rainfed* and *highland mixed* – are included on the basis of traditional importance in the dryland MENA region.

Another criteria was whether these farming systems overlapped with program target countries, as established in the DCL pre-proposal (DCL, 2015). One criteria for the target countries is that they fell within regions that are considered to have at least some dryland characteristics. Therefore, these 18 systems could be considered priority systems for the DCL program. This in no way excludes any areas of the globe as areas where DCL will should conduct and target research and development. It simply narrows down the DCL focus area to areas with substantial production of DCL commodities, with drylands and with substantial poverty and development problems.

PRODUCTION, AREA AND YIELD

Three farming systems in South Asia – *rainfed mixed, rice-wheat* and *dry rainfed* – make up about one third of the 162 million ha of DCL crops in the 18 priority farming systems (Table 1). The *rainfed mixed* system makes up 20% of the DCL crop area in these priority farming systems, accounting for more than 30 million ha of DCL crops. A second important region is Sub-Saharan Africa, where the *cereal-root crop mixed* system accounts for 21.3 million ha, the *agro-pastoral millet sorghum* system accounts for 18.6 million ha, the *pastoral* system accounts for 10.8 million ha and the *maize mixed* system has 7.6 million ha. In Eastern Europe and Central Asia more than 15 million ha are cultivated, with barley figuring prominently. In East Asia over 22 million ha are cultivated, with groundnut and soybean as the predominant crops. The overall DCL crop area in the Middle East and North Africa is the lowest, reflecting lower population density in this region.

In some cases DCL crops make up a large proportion of the total cultivated area in these farming systems, but their overall area may be relatively small when they are found in systems with large areas in maize, wheat and rice (Table 2). Three cereals (barley, pearl millet and sorghum) and two legumes (soybeans and cowpea) are present in several systems where they make up more than 10% of all cultivated crop area within the system. Seven farming systems have more than 13 percent of their crop area in barley – four of which are in the Middle East and North Africa and three in Eastern Europe and Central Asia region. Pearl millet is an important component in the *pastoral*, *agro-pastoral millet-sorghum* and *cereal-root crop mixed farming* systems, making up 35%, 32% and 11% of the total cultivated area respectively. In three African systems and one South Asian system, sorghum makes up more than 20% of the total cultivated area. In five of these 18 farming systems groundnuts make up between 5 five and 8%eight percent of the total cultivated area. The remaining crops – beans, chickpea, lentils, small millet and pigeon pea – have a smaller overall agricultural footprint.

Yields vary across the 18 farming systems and by DCL commodity (Table 3). A very general pattern is that yields are lowest in sub-Saharan Africa. They are somewhat higher in South Asia and even more so in Eastern Europe and Central Asia. Finally they are highest in the East Asian countries. Presumably these differences are related to many different factors, including population density, overall levels of development, market access, biotic and abiotic constraints, technology levels, management practices and many others.

LIVESTOCK AND DCL FARMING SYSTEMS

Livestock is an important component of the DCL research program and the farming systems where DCL crops are concentrated. The DCL crops are considered full purpose crops because they are used in many different

configurations of food, feed and fodder. All of the DCL crops can be used as feed and fodder crops. Soybean and barley are perhaps the most important, with the vast majority of their production going towards animal fodder. Sorghum and millet is also very important as feed and fodder in sub-Saharan Africa. There is also an important synergy because dryland systems since they have a greater focus on livestock as a unique characteristic of these drylands. For example the *agro-pastoral millet sorghum* system in sub-Saharan Africa exemplifies the synergy between key DCL crops and the importance of livestock in the system. Table 4 shows the estimated 2005 and 2000 cattle population in each of the DCL priority farming systems. The table and other tables described above show how cattle population generally follows the size of human population, the number of poor and the area of crops. Two farming systems stand out for their high population of cattle – *rainfed mixed* and *rice-wheat*, both in South Asia. However, high population and crop area in East Asia do not translate into these very high cattle populations that we see in South Asia. For example, the three East Asia ~~and Pacific~~ priority farming systems – *lowland rice*, *upland intensive mixed* and *temperate mixed* – have cattle populations in the middle of the range of the priority systems. Other priority systems in the middle of the range include *cereal-root crop mixed*, *agro-pastoral millet sorghum*, *pastoral*, *extensive cereal-livestock* and *maize mixed*. While the *small-scale cereal livestock* system in Eastern Europe and Central Asia and the *dry rainfed* system in South Asia have relatively low cattle population among the priority systems, livestock is clearly important in these systems.

ABIOTIC CONSTRAINTS

The farming systems where dryland cereals and grain legumes are concentrated are particularly prone to drought and high temperatures ~~and drought~~ (Table 5). Farming systems in areas with relatively low annual precipitation are more susceptible to ~~drought~~ failed growing season~~conditions~~s, as shown in Figure 2. These dryland systems, especially those with less than 1000 mm of annual precipitation, tend to have a higher probability of drought or a failed season, when precipitation does not meet crop requirements. Areas that have high probabilities of being affected by drought as shown by the potential drought impact index (PDII) include the *rainfed mixed* system in South Asia and the *agro-pastoral millet sorghum* and *pastoral* systems in sub-Saharan Africa (Table 5). The *rice-wheat* system in South Asia also has a high PDII number where drought may particularly affect pearl millet and chickpeas. Other systems that are particularly prone to drought include *cereal-root crop mixed* and *maize mixed* in sub-Saharan Africa and *dry rainfed* in South Asia.

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The DCL crops are also expected to be constrained by the rising temperatures that come with climate change. There is a general tendency and expectation towards the driest farming systems having higher expected temperature changes between now and 2050 (Figure 3). Average temperature changes are expected to be between 2.4 and 3.4°C. The DCL priority farming systems in Eastern Europe and Central Asia could be particularly hard hit, with expected temperature ~~changes~~ rises of 3.3°C for *extensive cereal livestock* and 2.8°C for both *large-scale cereal vegetable* and *small-scale cereal livestock*. The estimated temperature change by 2050 in the *temperate mixed* system in East Asia is 2.9°C. For the *rice-wheat* system in South Asia and the *agro-pastoral millet sorghum* system in sub-Saharan Africa the expected change is 2.8°C, important expected changes because of their large area of DCL crop cultivation. The *rice-wheat* system has more than 11.2 million ha of DCL crops, while the *agro-pastoral millet sorghum* system has more than 18.6 million ha. ~~Farming systems on the edge of the tropics or in the subtropics, as one moves away from the equator, are more likely to face rising temperatures with climate change.~~

The soils of DCL priority farming systems present a number of abiotic constraints to DCL crop production. Table 6 shows some of the principal constraints identified by the DCL commodity programs as they affect priority farming systems (DCL, 2015). The proportional area of farming systems with acid soil ranges from 9% in the *small-scale cereal livestock* system to 39% in the *rainfed mixed* system. The *cereal-root crop mixed* system is another one with

a very large proportion – 37 percent – of its area exhibiting acid soils. Another system with a large area of acid soils is the *maize mixed* system in sub-Saharan Africa, with 27 percent of its area under this constraint. *Lowland rice* and *upland intensive mixed* in East Asia have nearly a quarter of their areas with acid soil constraints. These latter two systems also suffer from large areas with soils of low nutrient availability, with over one third of the area under this condition. Low nutrient availability is also an important constraint in the *cereal-root crop mixed*, *maize beans* and *rainfed mixed* systems, with proportional areas of 19, 14 and 10 percent of their total areas under this constraint, respectively. Salinity constraints are less problematic, with 13 of the 15 priority farming systems having less than 6% of their areas with this condition. The exceptions for soils with salinity constraints are the *rice-wheat* system in South Asia with 23 percent and the *temperate mixed* system in East Asia with 18 percent of their areas subject to salinity constraints. A group of farming systems has between 20 and 40 percent of their areas on soils with low moisture holding capacity – an important constraint in dryland systems due to the need for soils to store water for as long as possible. These systems include the *agro-pastoral millet sorghum* (38%), *pastoral* (30%) and *cereal-root crop mixed* (22%) farming systems in sub-Saharan Africa.

SOCIOECONOMICS

The key DCL farming system regions are home to about half of the global population, including a massive number of people living in poverty (Table 7). About 3.5 billion people live in these areas, 2.3 billion of them living in rural areas and 1.3 billion in towns and cities. The highest populations are in South Asia and East Asia. The *lowland rice* and *upland intensive mixed* systems in East Asia are two of the largest systems in terms of population, with roughly 851 and 501 million people in each respective system. Important South Asian farming systems include large numbers of urban and rural people – with over 400 million people in the *rainfed mixed* system and over 600 million people in the *rice-wheat* system. The remaining 14 DCL priority farming systems have a total of more than 960 million people. Clearly the population found in the DCL farming systems show the importance of these systems for research and development aimed at improving conditions in these areas.

The DCL priority farming systems are home to a large proportion of the world's poor (Table 7). According to year 2005 childhood stunting and $1 and $2 a day poverty indicators, about 60% of the world's poor live within these 18 systems (Table 7; FAO, 2007; Wood et al., 2010). This large proportion is due to the importance of these systems in high-population countries like China and India, as well as farming systems spanning West and East Africa. Of the 63 global farming systems, the DCL priority systems include eight of the top 10 systems in terms of numbers of poor people. These eight DCL systems are *rice-wheat* and *rainfed mixed* in South Asia, *lowland rice*, *upland intensive mixed* and *temperate mixed* in East Asia and *cereal-root crop mixed*, *maize mixed* and *agro-pastoral millet sorghum* in sub-Saharan Africa.

Using the population of stunted children as a nutrition and poverty indicator, more than 60 percent of the 2005 global population of stunted children live within the DCL priority farming systems (Table 7; FAO, 2007; De Onis, 2012). Because height-for-age (stunting) indicates longer term nutrition deficiency, much of this poverty is concentrated in South Asia, East Asia and sub-Saharan Africa, regions with historically high rates of malnutrition. According to the stunting indicator, two farming systems stand out, both in South Asia. The *rice-wheat* and *rainfed mixed* systems have 28 and 24 million stunted children, respectively, figures exemplifying the high population density and well-known nutrition problems of these regions. In the *lowland rice* and *upland intensive mixed* systems of East Asia, the number of stunted children is about half of the South Asian systems mentioned previously, with 13 and 15 million stunted children respectively. In sub-Saharan Africa, the *maize mixed* and *agro-pastoral millet sorghum* systems have about 6 million stunted children each, half again as much as the East Asia

systems mentioned above. Another seven farming systems across five world regions have between one and four million stunted children. The remaining five farming systems regions – two in the Middle East and North Africa region and three in the Eastern Europe and Central Asia region – have less than one million stunted children, mostly reflecting the lower overall populations of these regions.

WHERE DO DCL CROPS COINCIDE?

The DCL crops present a number of opportunities for bringing multiple technology options among different crops to the same geographic area (Figure 4). The map shows several core areas where ~~3~~three to five~~5~~ or more DCL crops are grown together. These core areas include (1) a large area spanning the Sahel region of West Africa, (2) a discontinuous cluster of areas in East Africa, (3) a large part of South Asia extending from India north to Pakistan and then east to Bangladesh and Myanmar, and (4) a large swath of area in the Middle East extending from Iran to Turkey. But there are also concentrations of multiple crops in Mexico and Central America, China and other regions. Figure 5 shows some of the crop combinations with the largest area. In the Sahel region, a huge area where groundnut, pearl millet and sorghum are grown together is found. The eastern part of this region contains systems that include these crops plus common bean, while the Western part of the region includes the same crops and much more cowpea cultivation. In the Middle East, the combination of barley, chickpea, lentils and faba bean, make up large cultivated areas within the region. ~~These areas where the DCL crops occur together present opportunities for efficiencies in testing on experiment stations and in farms and in the location of CGIAR facilities in these regions.~~

DISCUSSION AND CONCLUSIONS

- ~~DISCUSS IN LIGHT OF TARGET COUNTRY MAP~~
- ~~DISCUSS IN RELATION TO 2008 PAPER (WHAT ARE THE DIFFERENT FARMING SYSTEMS?)~~
- ~~COMPARE WITH CHANDRA'S MAP~~
- ~~SA and SSA are the most important in terms of area~~
- ~~Proportional area shows how these crops coexist with other important crops. Rotatation, N-fixation~~
- ~~The substantial ranges between yields in different regions of the world suggest some scope for improving these crops in order to bring the farming systems with lower yields closer to the levels of those farming systems with the highest yields.~~
- ~~Previous research showed that farmers in these DCL farming systems face potential drought conditions that have much higher risk compared to most other farming systems (Hyman et al., 2008).~~

~~Rising temperatures in DCL farming systems will place a growing demand on farmers to cultivate heat tolerant crops and develop practices to protect these crops.~~This study identified 18 farming systems globally that are important for dryland cereals and grain legumes agri-food systems. The most important of these systems are found in South Asia and sub-Saharan Africa. The results discussed above suggests that these two regions deserve primary focus based on their relatively large cultivated area of DCL crops, large populations and high poverty. The farming systems in Latin America, the Middle East and North Africa, Central Asia and East Asia are also very important. Research in any one region can have spillover effects in the others.

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This result can be compared against two existing maps – one showing dryland ecologies and another showing the countries prioritized by the DCL research program (DCL, 2015).[2] The dryland ecologies map is solely based on dryness, as indicated by temperature, precipitation and evapotranspiration. Effectively, the map includes large areas where there are very few people and almost no cultivated land. The 18 farming systems identified in this research fall within the dryland ecologies map. Two exceptions to this pattern are the *maize-beans* system in Mesoamerica and the *rainfed mixed* system in India, where the boundaries of the farming system extend beyond the dryland ecology boundaries.

DCL's target countries map was developed using a combination of factors, namely, target crop area, agricultural population, population under poverty, prevalence of child malnutrition, and to the extent that data was available, land degradation based on NDVI. The emphasis was on countries in dryland ecologies. In an effort to prioritize the large number of countries (51+), the focus was defined to be on sub-Saharan Africa and South Asia, where the area under the combined dryland cereals and legumes was the highest among an assembled list of Low-Income Food-Deficit Countries. The target countries map also agrees well with the map of 18 farming systems. However, one drawback of the target countries approach is that it cannot distinguish between data representing the crop distribution and agroecology of DCL crops on the one hand, and country level data that was used for priority setting on the other. The results of this study overcomes that obstacle by combining farming systems and countries, and by taking a more detailed spatial approach at subnational pixel level, as opposed to country level.

The results of this study can also be compared against a previous study that used the same approach, but with 23 crops, including the major staples rice, wheat, cassava and maize (Hyman et al., 2008). That study focused on developing-country agriculture and prioritized 15 farming systems, with an emphasis on regions with large cultivated crop areas and large numbers of people. Seven of this study's farming systems were not included in that previous study – *pastoral*, *dry rainfed (SA)*, *highland mixed* (MENA), *dryland mixed*, *large-scale cereal vegetable*, *small-scale cereal livestock* and *extensive cereal-livestock*. These seven systems are mostly focused on DCL crops, have generally lower populations and cultivated areas, have a greater tendency towards livestock and cereal production and are found in areas with much less rainfall. Five of the 15 systems in the previous study do not appear in this study on dryland cereals and legumes. Two of these systems are lowland and very wet – *rice* in South Asia and *root crop* in sub-Saharan Africa. The other three systems in the previous study but not found in this one are highland systems in South Asia, sub-Saharan Africa and East Asia. The eight systems found in both studies show the importance of DCL crops to the global agricultural research and development effort. Six of the most important farming systems globally are also systems important for dryland cereals and legumes. They are *rice-wheat* and *rainfed mixed* in South Asia, *cereal-root crop* and *maize mixed* in sub-Saharan Africa and *upland intensive mixed* and *lowland rice* in East Asia. While the latter two systems have proportionally small areas of DCL crops, the absolute areas are large in highly populated Southeast and East Asia.

Dryland cereal and legume crop distribution data show that South Asia and sub-Saharan Africa are the most important regions for crop improvement. However, the proportional area of many DCL crops is often relatively low in regions where rice, wheat and maize are important staples. Nevertheless, the DCL crops are important in these regions. Grain legumes in particular may be important as a rotation crop to support soil nitrogen fixation. Because livestock are important in many of the 18 farming system regions prioritized in this research, taking advantage of crop-livestock system synergies is an opportunity that should be explored. For example, the benefits of pasture and crop rotations for soil improvement can be considerable. The substantial ranges between yields in different regions of the world suggest some scope for improving these crops in order to bring the farming systems with lower yields closer to the levels of those farming systems with the highest yields. These differences suggest that sub-Saharan Africa and South Asian yields could potentially be brought up to the level of those found in other regions.

[2] both of these maps can be viewed on the website of the DCL Atlas: http://www.eatlasdcl.cgiar.org/

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Abiotic constraints are significant obstacles to improving dryland cereal and legume production. Previous research showed that farmers in these DCL priority farming systems face potential drought conditions that have much higher risk compared to most other farming systems (Hyman et al., 2008). Rising temperatures in DCL farming systems will place a growing demand on farmers to cultivate heat tolerant crops, and to develop practices to protect these crops. Farming systems on the edge of the tropics or in the subtropics, as one moves away from the equator, are more likely to face rising temperatures with climate change. The combined effects of drought and heat in these farming systems pose a substantial challenge. The areas in the 18 priority farming systems show considerable soil limitations. One of the most important is infertility, as indicated by soil acidity and low nutrient reserves. Other important soil limitations are related to water. Long dry seasons limit the water availability in the soil, which is compounded in coarse-textured soils with low water holding capacity. The dryness of these systems also make them susceptible to salinity, another important soil constrain in the DCL priority systems.

Socioeconomic conditions in the DCL priority systems identified in this study indicate high levels of population and high poverty. There are both large rural and urban populations, suggesting positive supply and demand dynamics, especially so in sub-Saharan Africa and South Asia. These conditions suggest opportunities for developing market oriented production. Clearly much of the DCL crop production will remain for subsistence agriculture, as a component in larger agricultural systems. The high levels of malnutrition as indicated by childhood stunting, especially in South Asia and sub-Saharan Africa, shows the potential of DCL crops, which which are often important sources of protein and micronutrients. Biofortification of DCL crops could be an important consideration in these areas.

These areas where the DCL crops occur together present opportunities for efficiencies in ~~t~~research and development. ~~esting on experiment stations and in farms and in the location of CGIAR facilities in these regions.~~ Sites for testing the performance of crop varieties are typically carried out by national agricultural research institutes in collaboration with CGIAR centers. An integrated program to develop joint research could take advantage of these opportunities and efficiencies. Three regions stand out where DCL crops occur together – the Sahel region in West Africa, a large area and India and the Middle East and North Africa (Figure 4). Millet, sorghum, groundnut and cowpea systems should be a focus in the Sahel region.

This study points out several areas for further research on the geographic dimensions of dryland cereals and legumes improvement. First, an effort can be made to update this analysis using more recent data with higher temporal resolution. Using recent data is particularly important for crop distribution and socioeconomic data. This type of analysis will surely benefit from higher spatial resolution of geospatial data in the future, a trend increasingly common with improving capacities to collect, store and process geographic information. Perhaps the most substantial gap in this study has been the lack of information on biotic constraints to crop production. Pests and diseases are often the most important threats facing farmers. But there are few consistent and standardized geographic assessments of the major pests and diseases to dryland cereals and legumes. Overcoming this obstacle would require a systematic effort to collect information on the occurrence of biotic constraints. A recent paper showed the potential of improving our knowledge of the geographic dimensions of agricultural biodiversity (Casteneda et al., 2016). Interestingly, that research showed that the dryland systems area of the Middle East and North Africa is a priority for collecting wild relatives of food crops. Our research suggested the importance of temperature and precipitation under climate change for the future of DCL crops. Research is needed on understanding the sensitivity of each crop to increases in temperature and to the duration of drought conditions. Research is also needed on understanding genotype by environment interactions for the DCL crops. Other staple crops such as maize, wheat and rice have a better track record in these types of studies, suggesting a higher potential return on investment for this type of research on DCL crops in the future

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DECLARATIONS

DATA AVAILABILITY

This research initiative developed two general types of data – digital spatial data of the world related to DCL crops and tabular data that summarizes the geographic information by farming system and country. All the spatial data used in the analysis can be accessed from the DCL Atlas at http://www.eatlasdcl.cgiar.org/. This online Atlas includes data on the distribution of the 12 DCL crops, maps of predicted suitability of each crop, maps of abiotic constraints to crop production, maps of the biodiversity of relatives of each crop species, maps of socioeconomic conditions important for understanding the environment where these crops are grown and reference maps for putting all this information in the context.

AUTHOR CONTRIBUTIONS

GH, EB and SB conceived the study. GH, EB, SB and SS designed the research. EB, CB, SC, HE, EG and OR prepared the data sets for processing and analysis. GH wrote the manuscript. All authors interpreted and discussed the results and commented on the manuscript.

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COMPETING INTERESTS

GRANT INFORMATION

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Table 1: DCL crop area in '000's of hectares in 18 farming systems.

FARMING SYSTEMS	REGION	BARL	BEAN	CHKP	COWP	GRDN	LENT	PMIL	PSML	PPEA	SORG	SOYB	FABAB	TOTAL
Cereal-root crop mixed	SSA	26	573	32	2,983	2,949	1	4,649	128	78	9,594	295	19	**21,328**
Maize mixed	SSA	81	2,175	107	387	977	7	655	432	431	1,976	309	70	**7,607**
Agro-pastoral millet/sorghum	SSA	2	169	1	3,489	1,751	0	7,551	0	8	5,596	108	15	**18,691**
Pastoral	SSA	65	77	21	2,070	725	7	4,798	9	0	2,955	14	66	**10,808**
Rice-wheat	SA	461	1,575	1,966	0	277	977	4,012	144	543	966	362	0	**11,283**
Rainfed mixed	SA	161	3,951	4,062	4	4,014	595	2,628	1,697	2,149	4,226	7,276	0	**30,763**
Dry rainfed	SA	0	496	1,030	0	1,168	0	1,148	68	735	3,829	210	0	**8,685**
Highland mixed	MENA	1,704	83	524	0	1	189	1	67	0	291	75	28	**2,961**
Rainfed mixed	MENA	1,197	22	94	0	26	69	5	2	0	17	1	156	**1,589**
Dryland mixed	MENA	3,486	6	126	0	7	125	0	11	0	10	7	62	**3,841**
Pastoral	MENA	737	18	40	0	13	37	0	19	0	120	4	11	**1,001**
Maize-beans (Mesoamerica)	LAC	277	783	30	0	23	8	0	0	1	597	15	17	**1,750**
Large scale cereal-vegetable	EECA	5,927	44	2	0	0	1	0	309	0	30	634	1	**6,948**
Small scale cereal-livestock	EECA	2,057	59	235	0	6	181	0	2	0	0	0	9	**2,550**
Extensive cereal-livestock	EECA	8,322	5	12	0	0	6	0	535	0	22	250	6	**9,161**
Lowland rice	EAP	408	2,436	1	39	2,805	16	53	28	18	91	2,696	187	**8,778**
Upland intensive mixed	EAP	154	1,167	86	65	1,629	20	522	25	436	170	3,336	258	**7,869**
Temperate mixed	EAP	75	259	1	0	1,202	16	209	3	0	264	4,178	333	**6,539**
TOTAL		**25,141**	**13,899**	**8,371**	**9,039**	**17,576**	**2,257**	**26,233**	**3,477**	**4,399**	**30,754**	**19,770**	**1,236**	**162,152**

Table 2: Proportion of the total cultivated area by farming system. In some cases DCL crops make up a large proportion of the total cultivated area in these farming systems, but their overall area may be relatively low when they are found in systems with large areas in maize, wheat and rice

FARMING SYSTEMS	REGION	BARL	BEAN	CHKP	COWP	GRDN	LENT	PMIL	PSML	PPEA	SORG	SOYB	FABAB
Cereal-root crop mixed	SSA	0.00064	0.01421	0.00080	0.07398	0.07316	0.00004	0.11533	0.00317	0.00193	0.23797	0.00733	0.00047
Maize mixed	SSA	0.00341	0.09188	0.00453	0.01636	0.04129	0.00031	0.02766	0.01824	0.01821	0.08346	0.01306	0.00294
Agro-pastoral millet/sorghum	SSA	0.00010	0.00733	0.00005	0.15099	0.07581	0.00000	0.32683	0.00000	0.00034	0.24220	0.00467	0.00066
Pastoral	SSA	0.00474	0.00563	0.00157	0.15123	0.05296	0.00048	0.35049	0.00066	0.00001	0.21586	0.00106	0.00482
Rice-wheat	SA	0.00549	0.01876	0.02342	0.00000	0.00330	0.01163	0.04780	0.00171	0.00647	0.01150	0.00431	0.00000
Rainfed mixed	SA	0.00214	0.05251	0.05398	0.00006	0.05335	0.00791	0.03492	0.02256	0.02856	0.05616	0.09671	0.00000
Dry rainfed	SA	0.00000	0.03485	0.07233	0.00000	0.08198	0.00000	0.08058	0.00477	0.05162	0.26876	0.01475	0.00000
Highland mixed	MENA	0.14739	0.00714	0.04530	0.00000	0.00007	0.01634	0.00008	0.00575	0.00000	0.02519	0.00649	0.00239
Rainfed mixed	MENA	0.15464	0.00280	0.01208	0.00002	0.00335	0.00895	0.00062	0.00021	0.00000	0.00216	0.00017	0.02018
Dryland mixed	MENA	0.27190	0.00049	0.00982	0.00002	0.00057	0.00978	0.00002	0.00082	0.00000	0.00081	0.00052	0.00481
Pastoral	MENA	0.13266	0.00331	0.00726	0.00004	0.00242	0.00668	0.00003	0.00348	0.00000	0.02154	0.00066	0.00202
Maize-beans (Mesoamerica)	LAC	0.02830	0.08007	0.00310	0.00000	0.00240	0.00079	0.00000	0.00000	0.00007	0.06104	0.00150	0.00169
Large scale cereal-vegetable	EECA	0.18685	0.00139	0.00007	0.00000	0.00000	0.00003	0.00000	0.00974	0.00000	0.00095	0.01998	0.00003
Small scale cereal-livestock	EECA	0.22776	0.00654	0.02603	0.00000	0.00070	0.02009	0.00000	0.00020	0.00000	0.00000	0.00005	0.00101
Extensive cereal-livestock	EECA	0.16105	0.00010	0.00024	0.00000	0.00000	0.00012	0.00000	0.01036	0.00000	0.00043	0.00484	0.00012
Lowland rice	EAP	0.00366	0.02182	0.00000	0.00035	0.02513	0.00014	0.00048	0.00025	0.00016	0.00082	0.02415	0.00167
Upland intensive mixed	EAP	0.00226	0.01719	0.00126	0.00096	0.02400	0.00030	0.00769	0.00036	0.00643	0.00250	0.04914	0.00379
Temperate mixed	EAP	0.00200	0.00692	0.00001	0.00000	0.03213	0.00043	0.00559	0.00008	0.00000	0.00706	0.11167	0.00889

Table 3: DCL crops yield in 18 farming systems

FARMING SYSTEMS	REGION	BARLEY (YIELD kg/ha)	BEAN (YIELD kg/ha)	CHICKPEA (YIELD kg/ha)	COWPEA (YIELD kg/ha)	GROUND NUT (YIELD kg/ha)	LENTIL (YIELD kg/ha)	PEARL-MILLET (YIELD kg/ha)	SMALL-MILLET (YIELD kg/ha)	PIGEON PEA (YIELD kg/ha)	SORGHUM (YIELD kg/ha)	SOYBEAN (YIELD kg/ha)	FABA BEAN (YIELD kg/ha)	TOTAL
Cereal-root crop mixed	SSA	1,184	477	655	638	1,177	759	1,150	751	622	1,011	849	1,617	10,889
Maize mixed	SSA	1,837	525	465	564	724	738	551	1,436	671	859	1,155	1,071	10,595
Agro-pastoral millet/sorghum	SSA	3,107	477	576	365	830	0	736	0	658	769	565	1,771	9,855
Pastoral	SSA	1,254	562	820	217	714	894	471	1,585	604	611	531	1,144	9,408
Rice-wheat	SA	2,087	491	735	0	822	830	1,171	1,046	939	659	1,411	0	10,190
Rainfed mixed	SA	1,559	339	842	1,029	1,063	512	832	850	708	910	1,003	0	9,646
Dry rainfed	SA	0	212	895	0	716	0	704	809	495	687	785	0	5,301
Highland mixed	MENA	1,418	1,912	505	667	2,416	490	1,776	694	0	805	2,383	646	13,710
Rainfed mixed	MENA	915	793	659	722	2,456	906	1,874	823	0	804	1,461	560	11,974
Dryland mixed	MENA	933	1,554	644	759	2,536	942	1,586	1,046	0	1,208	2,313	707	14,230
Pastoral	MENA	1,416	2,529	717	2,302	2,716	689	1,412	721	0	2,019	3,188	2,138	19,846
Maize-beans (Mesoamerica)	LAC	2,866	680	1,535	0	1,459	885	0	0	424	4,571	2,487	706	15,613
Large scale cereal-vegetable	EECA	2,240	1,375	2,051	0	0	1,311	0	1,207	0	1,958	1,373	1,135	12,649
Small scale cereal-livestock	EECA	2,705	1,534	1,036	0	3,195	1,312	0	1,949	0	0	4,131	1,870	17,730
Extensive cereal-livestock	EECA	1,619	1,679	967	0	1,607	971	2,362	1,039	0	1,421	1,149	1,192	14,006
Lowland rice	EAP	4,253	1,074	4,604	1,000	2,964	2,423	1,855	1,027	1,013	3,756	1,764	1,640	27,374
Upland intensive mixed	EAP	3,383	1,008	1,234	969	2,150	1,616	1,775	934	1,041	3,555	1,474	1,640	20,778
Temperate mixed	EAP	4,320	1,423	3,555	0	3,380	1,783	2,384	1,040	0	4,698	1,822	1,640	26,047

Table 4: Cattle population (head 2005 and 2010)

FARMING SYSTEMS	REGION	Cattle Population (head, 2005)	Cattle Population (head, 2010)
Cereal-root crop mixed	SSA	41,036,700	31,938,300
Maize mixed	SSA	38,945,200	33,555,200
Agro-pastoral millet/sorghum	SSA	31,997,700	35,608,700
Pastoral	SSA	26,729,000	34,317,600
Rice-wheat	SA	91,835,504	77,835,904
Rainfed mixed	SA	95,861,104	80,452,200
Dry rainfed	SA	9,270,570	8,765,500
Highland mixed	MENA	6,716,780	6,727,600
Rainfed mixed	MENA	3,401,060	2,867,500
Dryland mixed	MENA	3,572,810	2,588,100
Pastoral	MENA	2,230,120	2,981,300
Maize-beans (Mesoamerica)	LAC	16,577,200	13,324,000
Large scale cereal-vegetable	EECA	16,938,000	8,206,600
Small scale cereal-livestock	EECA	5,228,780	4,028,700
Extensive cereal-livestock	EECA	25,352,900	12,425,700
Lowland rice	EAP	39,531,100	44,108,800
Upland intensive mixed	EAP	39,954,600	47,748,400
Temperate mixed	EAP	20,527,700	22,756,000

Table 5: The farming systems where dryland cereals and grain legumes are concentrated are particularly prone to high temperatures and drought

FARMING SYSTEMS	REGION	DLCAS Crop Area (ha)	Potential Drought Impact Index	Temperature Change 2050
Cereal-root crop mixed	SSA	21,327,541	2,971,040	2.48
Maize mixed	SSA	7,606,508	1,592,730	2.47
Agro-pastoral millet/sorghum	SSA	18,691,342	7,644,810	2.77
Pastoral	SSA	10,808,337	7,409,830	2.73
Rice-wheat	SA	11,282,838	4,431,820	2.83
Rainfed mixed	SA	30,763,078	7,556,180	2.48
Dry rainfed	SA	8,685,308	2,868,150	2.36
Highland mixed	MENA	2,961,344	98,050	3.01
Rainfed mixed	MENA	1,588,829	123,471	2.64
Dryland mixed	MENA	3,840,974	104,013	2.79
Pastoral	MENA	1,000,516	10,668	2.93
Maize-beans (Mesoamerica)	LAC	1,749,799	398,401	2.36
Large scale cereal-vegetable	EECA	6,947,991	86,502	2.82
Small scale cereal-livestock	EECA	2,550,258	1,849	2.82
Extensive cereal-livestock	EECA	9,160,822	17,198	3.31
Lowland rice	EAP	8,778,265	982,407	2.25
Upland intensive mixed	EAP	7,868,661	1,065,610	2.42
Temperate mixed	EAP	6,539,133	1,088,910	2.91

Table 6: The percentage area of each of the 18 priority farming system with soil constraints.

FARMING SYSTEMS	REGION	Acid Soil constraints (MEAN % of farming system)	Soil > 3 months dry season (MEAN % of farming system)	Soil subject to waterlogging (MEAN % of farming system)	Soil with low moisture holding capacity (MEAN % of farming system)	Soil with Low nutrient availability (MEAN % of farming system)	Soil with Salinity constraints (MEAN % of farming system)
Cereal-root crop mixed	SSA	37	1	14	22	19	1
Maize mixed	SSA	27	4	7	14	35	1
Agro-pastoral millet/sorghum	SSA	15	4	8	38	7	3
Pastoral	SSA	5	20	4	30	2	6
Rice-wheat	SA	19	21	7	5	4	23
Rainfed mixed	SA	39	2	3	12	10	2
Dry rainfed	SA	14	0	2	1	1	2
Highland mixed	MENA	2	36	2	2	0	5
Rainfed mixed	MENA	25	13	3	3	0	2
Dryland mixed	MENA	7	38	1	5	0	5
Pastoral	MENA	1	42	1	10	0	8
Maize-beans (Mesoamerica)	LAC	30	1	3	3	14	0
Large scale cereal-vegetable	EECA	17	5	11	6	0	5
Small scale cereal-livestock	EECA	9	31	2	1	1	2
Extensive cereal-livestock	EECA	11	2	15	6	0	1
Lowland rice	EAP	22	0	35	5	30	2
Upland intensive mixed	EAP	23	0	10	1	35	1
Temperate mixed	EAP	10	1	35	2	0	18

Table 7: DCL farming system, population and poverty indicators. The key DCL farming systems are home to about one third of the global population, including an enormous number of people living in poverty

FARMING SYSTEMS	REGION	2010 Population ('000)	2005 Population ('000)	2005 Rural Population ('000)	2005 Urban Population ('000)	Stunted Children ('000)	Stunting Prevalence	Poverty headcount (<$1/day) ('000)	Poverty headcount (<$2/day) ('000))	DCL Crop Area ('000 ha)
Cereal-root crop mixed	SSA	116,472	84,150	69,199	14,951	6,320	39	52,865	73,618	21,328
Maize mixed	SSA	125,279	96,684	72,837	23,847	6,314	41.1	51,310	68,988	7,607
Agro-pastoral millet/sorghum	SSA	70,806	54,864	37,892	16,972	3,133	37	30,899	40,999	18,691
Pastoral	SSA	51,662	39,705	29,677	10,027	3,228	35.5	13,369	20,871	10,808
Rice-wheat	SA	613,984	491,399	365,498	125,901	28,292	51.5	237,306	440,256	11,283
Rainfed mixed	SA	400,921	356,767	249,337	107,430	24,541	62.6	157,816	286,661	30,763
Dry rainfed	SA	47,017	45,600	33,544	12,056	3,610	65.5	18,074	32,620	8,685
Highland mixed	MENA	72,913	67,103	31,036	36,067	1,572	20.4	3,648	11,254	2,961
Rainfed mixed	MENA	47,798	38,815	13,852	24,963	499	16.3	1,666	6,415	1,589
Dryland mixed	MENA	56,966	47,224	18,093	29,132	750	18.7	1,128	4,380	3,841
Pastoral	MENA	38,441	33,845	16,798	17,047	1,668	21.9	988	4,444	1,001
Maize-beans (Mesoamerica)	LAC	88,137	76,106	28,686	47,420	2,838	35.9	4,684	9,278	1,750
Large scale cereal-vegetable	EECA	63,105	65,593	28,474	37,118	319	8.7	1,501	1,178	6,948
Small scale cereal-livestock	EECA	19,852	19,898	8,763	11,135	382	19.6	658	2,175	2,550
Extensive cereal-livestock	EECA	92,121	93,425	26,044	67,381	70	3.7	1,639	2,848	9,161
Lowland rice	EAP	851,260	785,701	496,073	289,627	13,360	31.8	117,021	264,030	8,778
Upland intensive mixed	EAP	501,857	502,323	358,539	143,783	15,427	33.6	84,484	193,653	7,869
Temperate mixed	EAP	285,014	260,574	138,989	121,585	2,594	21.6	36,416	82,927	6,539
TOTAL		**3,543,606**	**3,159,775**	**2,023,332**	**1,136,441**	**114,917**		**815,472**	**1,546,593**	**162,152**

Figure 1: 18 DCL Priority Farming systems

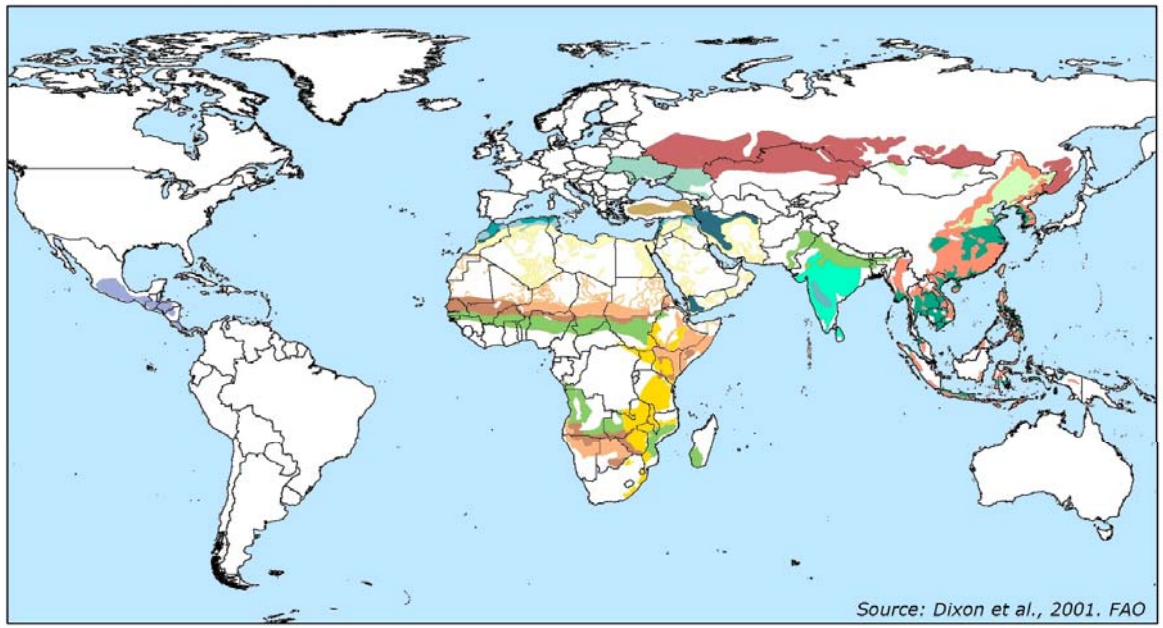


Figure 2: Precipitation and drought

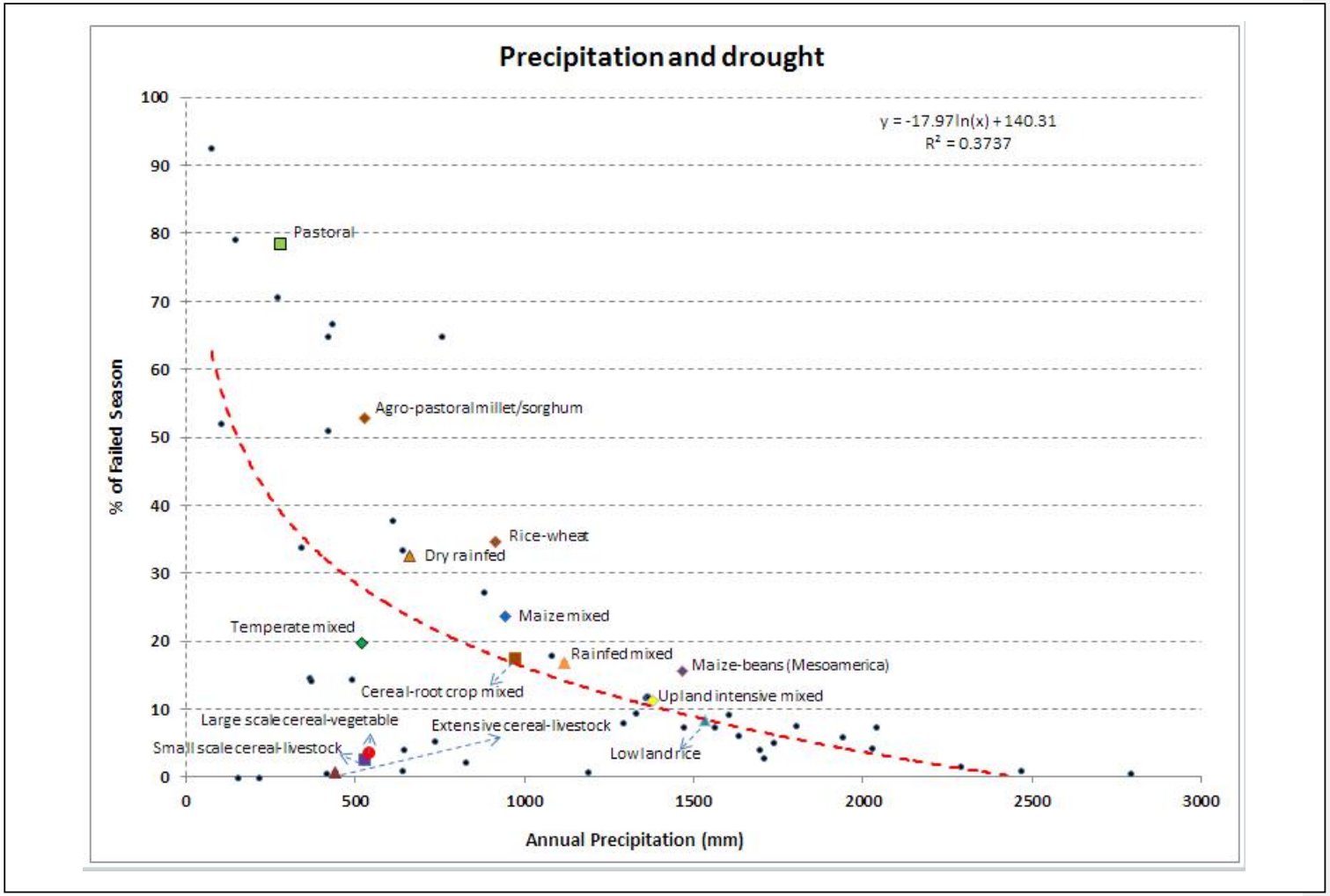


Figure 3: Precipitation and temperature change

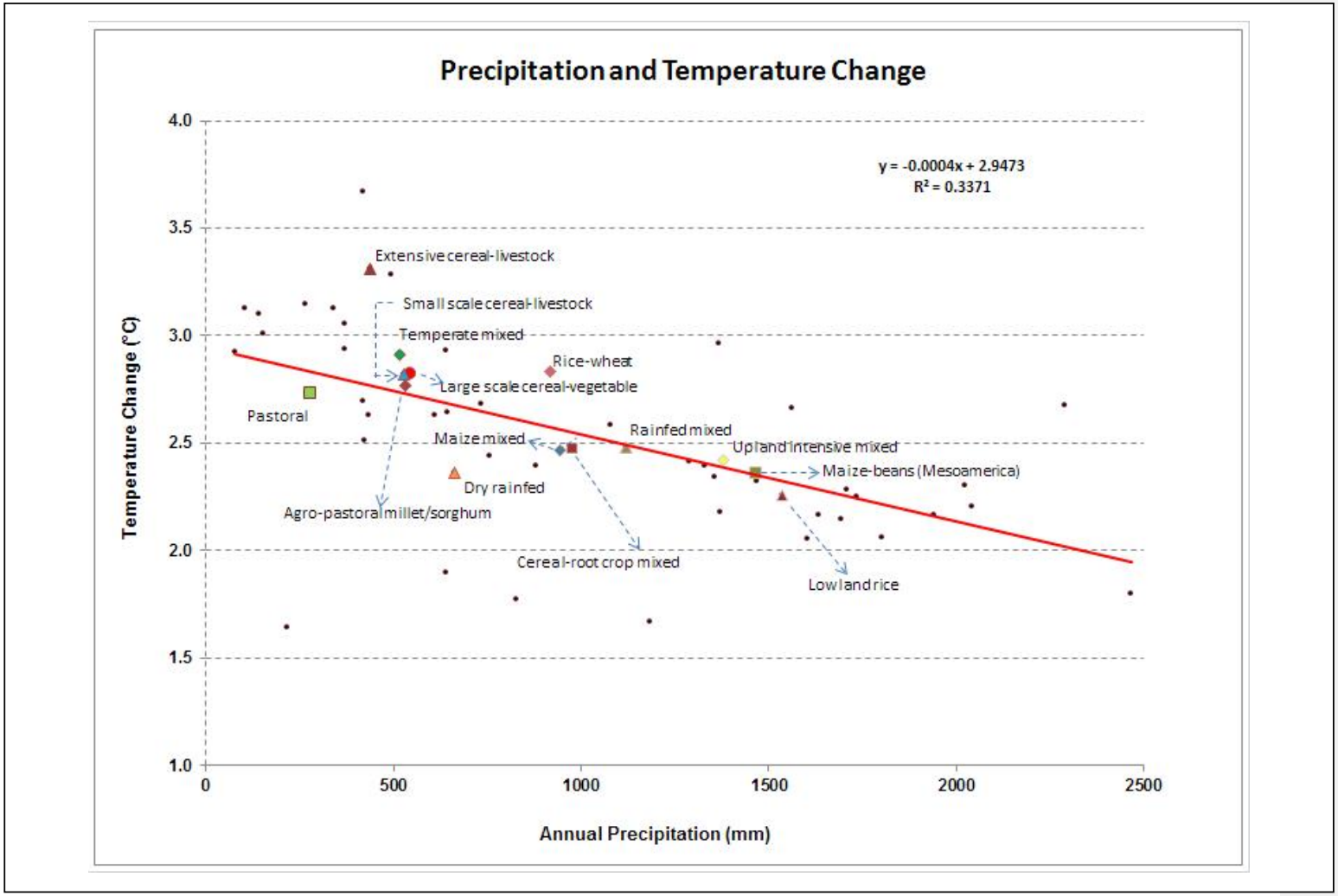


Figure 4: The DCL crops present a number of opportunities for bringing multiple technology options among different crops to the same geographic area. The map shows several core areas where 3 to 5 or more DCL crops are grown together

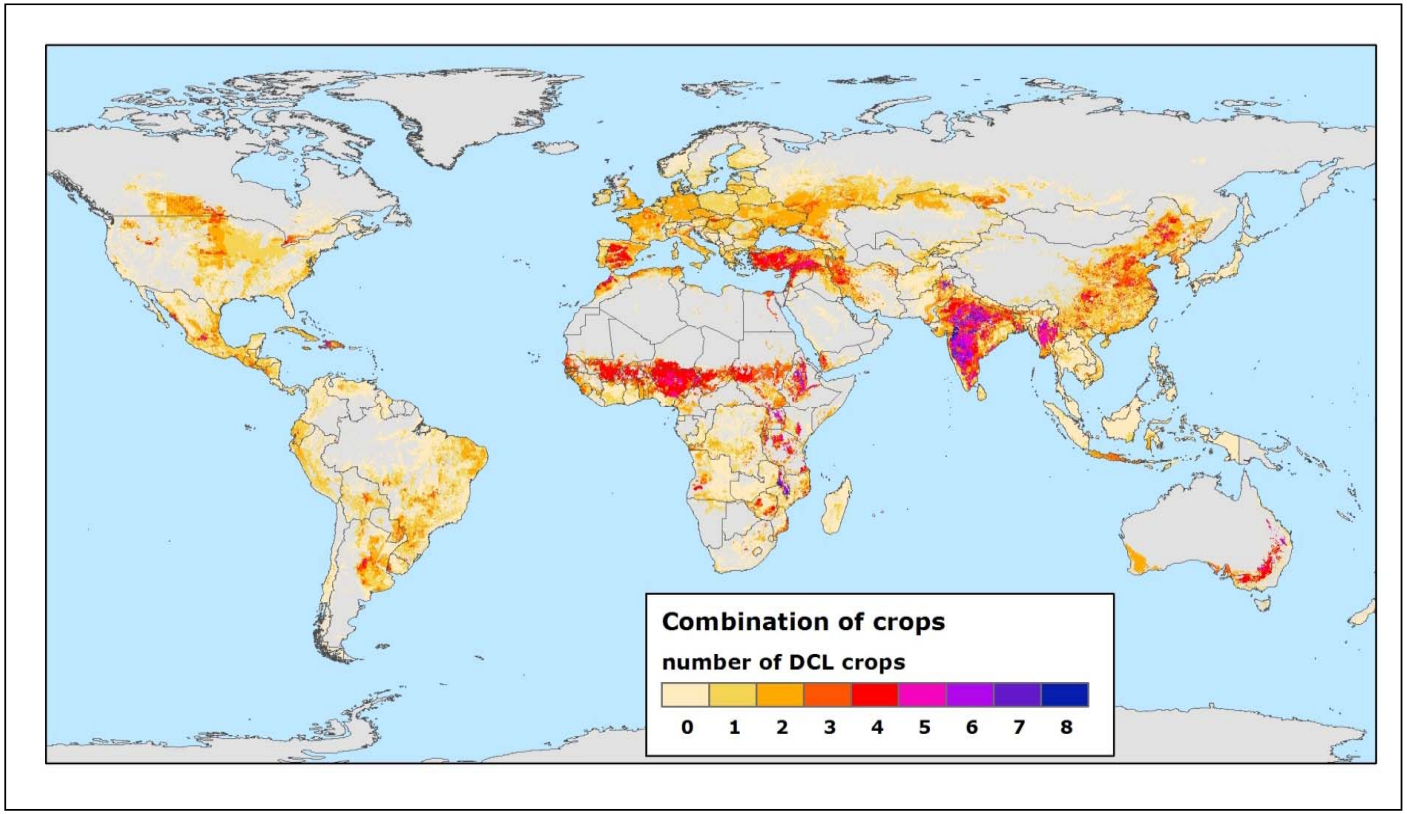
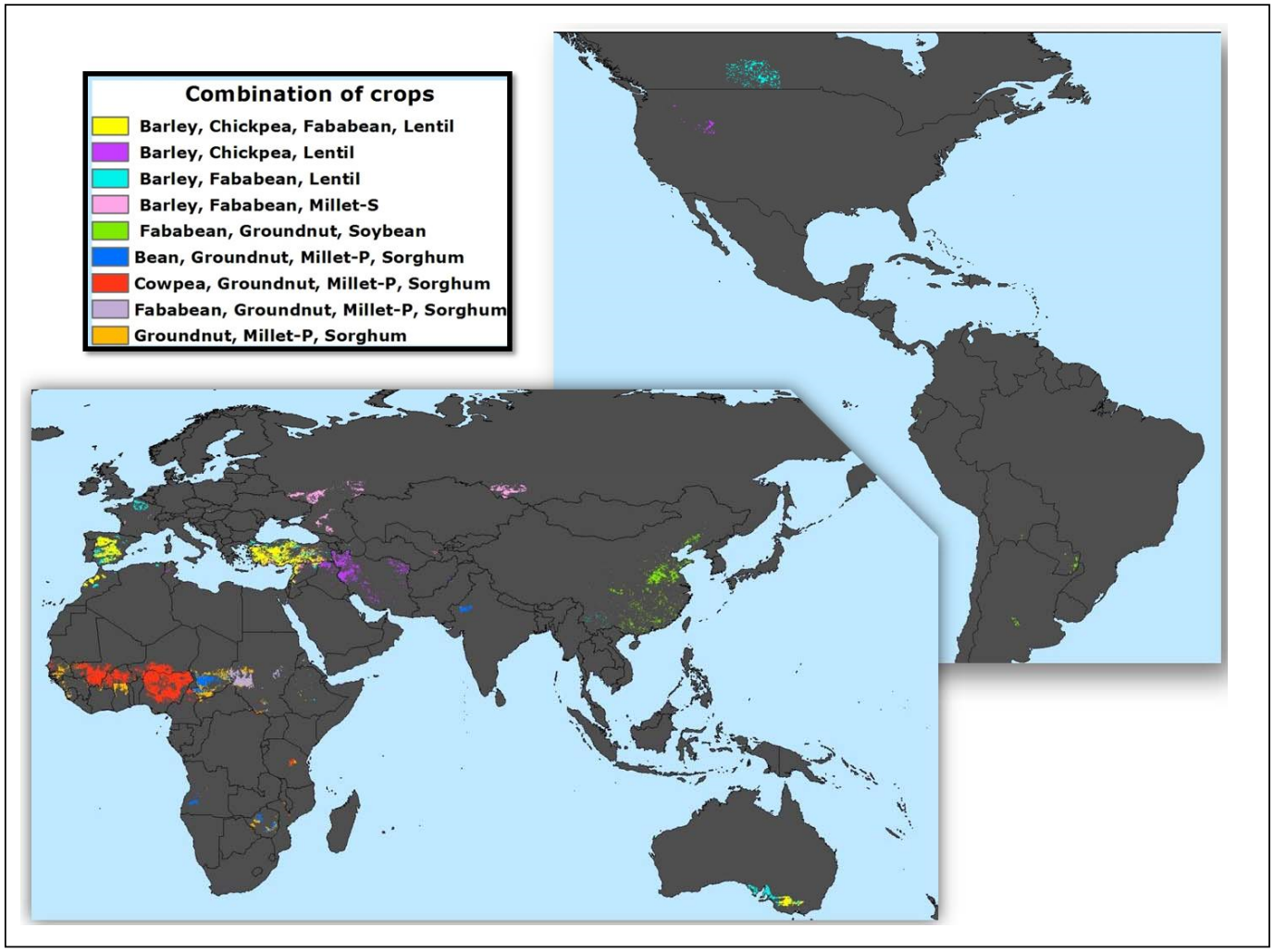


Figure 5: Some of the crop combinations with the largest area.



JUSTIFICATION FOR THE INCLUSION OF
COMMON BEAN, FABA BEAN, FINGER MILLET, GROUND NUT & SOYBEAN

FINGER MILLET

Finger millet [*Eleusine coracana* (L.) Gaertn.] plays an important role in both the dietary needs and incomes of many rural households in Eastern Africa and South Asia, and six countries account for about 64% of the global area. It is nutritionally dense, climate resilient, post-harvest loss resistant and one of the most reliable crops under unpredictable environments.

Table 1. Finger millet area and production in major producing countries.

Country	Area cultivated (ha)	Production (t)	Source
Ethiopia	431,619	807,041	FAO, 2013, 100% FM
Uganda	249,987	276,928	Uganda Census of Agriculture survey, 2008/09
Tanzania	167,288	161,366	FAO, 2013, 50% FM
Kenya	100,000	64,100	FAO, 2013, 100% FM
India	1,350,000	1,984,500	Padulosi et al., 2015
Nepal	250,000	275,000	FAO, 2013
Total	2,548,894	3,568,935	

It is a major stable crop of a number of countries in SSA. In Uganda half of all cereal cropland is producing finger millet. In Ethiopia finger millet is produced by 1, 556, 134 holders and its production is estimated to be 718, 541 tons on an area of 432, 561 hectares of land (CSA, 2012). In Tanzania it is a traditional crop grown in almost all regions of Tanzania and is the fifth most important cereal crop in terms of food and cash earnings.

Finger millet is an important food for expectant women, breastfeeding mothers, and children and for people at risk of diabetes. It is a good source of calcium (358 mg/kg-nutrient; profiling of germplasm accession has indicated values twice higher than this average value) and iron (46 mg/kg), fibre, and amino acids making it important for blood and bone health, better digestion and muscle repair. It contains 40 times more calcium than maize and rice, and 10 times more than wheat. The human body digests finger millet slowly and moderates spikes in blood sugar. Being gluten free, finger millet has a global potential in regions where demand for gluten free products is increasing.

There is significant consumer demand in urban market for finger millet, due to increased health and nutrition awareness, but easy to use product are not available in urban markets because of lack of research and development support. There is scope to capitalize on CGIAR strengthens to address these research gaps and create an enabling environment for supportive policies.

Current market demand for finger millet can be broken down into (1) food; (2) food processing; (3) other uses and; (4) trade. Figures are for ESA, based on 2009-2011 averages from FAOSTAT (Table 2)

Food

- Prices of finger millet are higher than for sorghum (20%) and for maize (40%).
- In ESA, 1.5 million tons (68 %) was used as food.

- Share of finger millet consumed on the farm varies. In central Tanzania (good market linkages), over 80% of finger millet is sold but in Ethiopia the share is just 10%.
- For ESA, urban consumption is 12 % of total production and 88 % of consumption is consumed on-farm (Table 2).
- Urbanization reduces millet consumption per head (average in ESA: 7.2 kg/head/year rural, 3.7 kg/head/year urban) (Table 3).
- Increases in income per head increase consumer demand per head (Ethiopia, Kenya, Tanzania, and Uganda).

Food processing

- In ESA, 20 % is used for food processing, mostly for local beer.
- Tanzania has highest share of millets used for food processing (43% of the available supply).

Other uses

- Only 3 % of total supply is used as feed, reflecting higher price of millet compared to maize.

Trade

- Trade is minimal, except for Kenya where imports averaged 11,000 t in 2009-2011.

Future market demand

- Production in ESA is projected to grow strongly from just 1 million t in 2005 to reach 5 million t by 2050 (Table 4).
- Projections suggest increases will be evenly spread: Uganda (357%), Ethiopia (383%), and Sudan (250%). Uganda will be the biggest producer (2 million t), followed by Sudan and Ethiopia (each with 1.4 million t).
- Projections suggest ESA will become a net exporter of millet by 2050, due to trade surpluses in Ethiopia and Tanzania.
- Four countries – Ethiopia, Sudan, Uganda, and Tanzania – will be the main source of demand.

Conclusions

- Price premiums for finger millet in Ethiopia and Kenya suggest strong market potential.
- Higher prices reduce consumer demand, which rises with income.
- Urbanization reduces millet consumption and urban markets account for only 12 % of total consumption.
- Demand projections suggest strong growth in demand for millets over medium to long term (2015-2050).

Main Bilateral Projects (ICRISAT)

- AOCC/Bio-Innovate (potential phase 2): Finger millet whole genome sequencing
- GCDT: Improving Finger Millet Productivity through Exploitation of Wild Germplasm
- BMGF: HOPE II
- Feed the Future - Accelerated Value Chain Development Program for Kenya (AVCD)
- IFAD: Strengthening Sorghum and Millet Value Chains for Food, Nutritional and Income Security in Arid and Semi-Arid Lands of Kenya and Tanzania (SOMNI)
- BREAD/ABRDC: Development of Essential Genetic and Genomic Resources for Finger Millet
- Government of Karnataka – Integrated genomics-assisted breeding for efficient development of superior finger millet varieties for Karnataka

Bioversity and ICRISAT have research and development programs on finger millet improvement, promotion, use diversification, and upscaling in Africa and Asia. The ICRISAT genebank holds nearly 6,000 finger millet germplasm accessions from 24 countries, conserved for use in research and development. ICRISAT has contributed to the release of more than 15 finger millet varieties in 4 countries in Africa since 2010, with higher yield potential, earliness, lodging resistance, better adaptation to drought stress, and resistance to blast. ICRISAT plays a key role in promoting the diffusion of new finger millet varieties, associated agronomic practices, developing seed systems, value-addition processing, and capacity building in ESA and SA.

ICRISAT works with the African Orphan Crops Consortium (AOOC) to generate a representative whole genome of finger millet, that once publicly available will revolutionize future breeding of this nutritious crop and will open a new chapter in finger millet breeding.

In the past two years ICRISAT has started collaborating with ICAR Institutes in India to undertake basic science research on finger millet including the nutritional profiling of the finger millet germplasm in the breeding program.

Bioversity International has been working with partners for 15 years to promote millet (including finger millet) use and conservation. The inclusion of millet as one of the grains subsidized by the government in India's National Food Security Act—which guarantees a quantity of grain per person at low prices—has also served to highlight the grain. Bioversity International efforts have contributed to improved markets for millet-based dishes. The holistic approach utilised in the promotion of species such as finger millet (together with other underutilized crops) proved to improve incomes, nutritional status, and empowerment, especially of women in India and the Himalayas.

Table 2. Trends in millets utilization, by region and country, 1981-2012 ('000 t)

	1980-82					2009-2011				
Country /region	**Available supply** *(for domestic utilization)*[1]	**Food** [2]	**Feed**	**Food processing** [3]	**Other uses** [4]	**Available supply** *(for domestic utilization)*[1]	**Food**	**Feed**	**Food processing**	**Other uses**
World	25876	20462	2560	305	37	30516	22717	3868	388	358
Africa	7436	5380	724	305	37	15632	11103	1739	388	358
Eastern Africa	1220	780	59	267	0	1467	985	44	309	0
Southern Africa	52	36	10	0	0	71	55	8	0	0
Western Africa	5444	3930	651	30	37	12728	8897	1647	69	358
Southern Africa										
Botswana	2	1	0	0	0	3	2	0	0	0
Namibia	35	31	0	0	0	55	48	0	0	0

South Africa	15	4	10	0	0	13	5	8	0	0
Swaziland						0		0		
Eastern Africa										
Ethiopia	0	0	0	0	0	604	480	0	85	0
Kenya	57	34	5	12	0	71	41	6	14	0
Malawi	8	7	0	0	0	28	26	1	0	0
Mozambique	5	4	0	0	0	45	40	0	0	0
Rwanda	2	2	0	0	0	8	7	0	0	0
Sudan (former)	383	348	0	0	0	675	600	17	0	0
Tanzania	336	146	7	146	0	349	151	7	151	0
Uganda	452	311	46	55	0	269	186	27	33	0
Zambia	16	6	1	7	0	46	17	3	21	0
Zimbabwe	138	108	0	19	0	49	36	0	6	0

Source: FAOSTAT commodity balances

[1] "***Available supply for domestic utilization***' is defined as production + imports + changes in stocks (decrease or increase) – exports

[2] ***'Food '*** is defined as available supply for domestic utilization – feed – seed – waste – food processing and – other uses.

Table 3. Trends in millets trade by region and country, 1981-2012 (000 t)

	Exports					Imports			
Country/region	**1980-82**	**1990-92**	**2000-2002**	**2009-2011**		**1980-82**	**1990-92**	**2000-2002**	**2009-2011**
World	218	207	256	357		264	259	273	412
Africa	36	30	44	6		66	15	58	109
Southern Africa	0	0	0	0		0	0	0	8
Eastern Africa	3	11	4	6		1	1	1	13
Western Africa	29	19	39	1		62	13	54	21
Southern Africa									
Botswana	0	0	0	0		0	3	66	0
Lesotho	-	-	-	-		-	-	-	-
Namibia	0	0	0			0	0	0	2
South Africa	1	0	0	0		1	1	2	6
Swaziland	0	0	0	0		0	0	0	0
Eastern Africa									

Summary of ISPC Commentaries and Responses - DCL

Background:

The ISPC Rating of the DCL Preproposal was as follows:

Overall Rating – **C**
Overall analysis as integral part of CRP portfolio – **B**
Theory of Change (ToC) and Impact Pathway – **B**
Governance and Management – **C**
Flagship 1 – **A**; Flagship 2 – **B**; Flagship 3 – **C**; Flagship 4 – **D**; Flagships 5 to 7 – **B**

The ISPC has indicated the need to prioritize crops, countries and traits in the CRPs DC and GL in its commentary of the Phase I proposal, the extension proposal and the current Phase II proposal. In response to this, the Phase II proposal had reduced its target countries from 37 to 17 in the preproposal, retained all 12 crops, and the traits of focus. The ISPC review of the preproposal recommended that still further prioritization was needed , as well as a clear statement of the scope of the program (whether an ecosystem-based program targeting specific crops or a commodity-based program targeting the drylands). The CRP presented a revised overview document to which the ISPC expressed recognition of the 'up front and direct address' of the concerns, suggested further potential for improvement, and provided recommendations towards the same. While the ISPC commentary was welcome for the identification of important areas needing further attention in the full proposal, the commentary itself was interpreted in two different ways by members of the DCL team: (a) do not reduce program scope, but provide the requested justification, and (b) reduce the number of crops and countries. With this division in the interpretation of the ISPC commentary within the DCL team, the issue of dropping the crops was brought up at the recent DCL writeshop in Dubai (Feb 6 to 8) where the writing team was present. The discussion centered on a CRP proposal that dropped most of the crops in question in the base budget scenario, and included all 12 in the $1.35 MM budget scenario. We discussed the dropping of common bean, faba bean, finger millet and soybean from the program. With this we would also drop the countries Nicaragua and Zambia. There were serious concerns raised on the consequence of dropping these four crops, and the associated Centers presented further justification for inclusion and identified the consequences of dropping these.

Concerns raised:

1. Participation in a CRP is considered important by the four Centers involved (CIAT, ICARDA, ICRISAT, IITA). Dropping crops that are central to the research of the respective Centers without sufficient time for alternative arrangements for inclusion of these in other CRPs places these Centers in a difficult situation.
2. The four Centers involved consider it important to participate in the CRP, especially with the new synergies emerging within the legume research community in the CGIAR through CRP GL.
3. Breeding research of these crops brings significant bilateral funding that helps achieve the overall goals of the CRP when interwoven with other bilaterals and W1/2. Dropping of these crops will lead to the loss of these bilaterals to the CRP.

Consequences of dropping four crops:

1. The CRP will be weakened in the diversification potential it offers in a cereal-legume-livestock system (albeit the CRP only addresses crop improvement and seed systems research of beans and soybeans)
2. The potential contribution of the CRP to the SLOs will be reduced due to the removal of the crop area and population size of the target countries associated with these crops.

   The population below poverty line and the malnourished in all of the target countries of each crop:

Crop	No. of families living below poverty line based on World Bank Data	No. of families facing malnutrion based on World Bank Data
Common Bean	25,705,312	16,027,287
Faba Bean	87,674,468	45,574,929
Finger Millet	88,622,544	50,660,000
Groundnuts	115,669,573	50,277,682
Soybeans	34,151,721	10,200,000
Grand Total	**351,823,618**	**172,739,899**

Impact on SLO targets by dropping five crops from the diversity offered by the DCL cereal-legume-livestock system

Dropped Crop	Land Saved (2022)	Land Saved (2030)	No. of families with increased nutrition (2022)	No. of families with increased nutrition (2030)	No. of families exiting povery (2022)	No. of families exiting povery (2030)
Common Bean	2,947,411	3,736,454	173,892	379,803	176,635	305,510
Faba Bean	124,759	158,158	431,241	845,367	252,961	359,965
Groundnuts	3,092,968	3,920,978	143,873	649,288	76,236	349,366
Finger Millet	1,390,673	1,762,966	382,332	980,756	331,616	679,702
Soybeans	385,600	488,827	90,740	232,258	111,110	229,530
Grand Total	**7,941,410**	**10,067,384**	**1,222,078**	**3,087,473**	**948,558**	**1,924,073**
Proposed target in preproposal	**27 Million Ha**	**35 Million Ha**	**21 Million**	**45 Million**	**8 Million**	**16 Million**

Note: Figures are based on current population, anticipated population growth, anticipated crop yield trends, land area, and appropriate discount factors based on enabling environment. Our calculations correlate well with Irz et al 2001. (http://www.researchgate.net/profile/Xavier_Irz/publication/227851367_Agricultural_Productivity_Growth_and_Poverty_Alleviation/links/0912f50c5916ee7272000000.pdf)

3. Opportunities for synergy and cross-learning such as through PABRA, as example, will be lost for the CRP.
4. Opportunities for leveraging the significant bilaterals attracted on the crop improvement and seed systems front by Dryland Cereals and Grain Legumes will lost to the CRP.

Proposed path forward:

- Include the current diverse mix of cereals and legumes in a cereal-legume-livestock system to provide optimal opportunities for a systems approach to livelihood improvement
- Design the program from a system perspective centered on (1) Improved human nutrition and NRM from a cereal-legume-livestock system, and (2) climate-resilient food production for food security, income and NRM

- Present the program as a multi-commodity program that includes crops co-cultivated for food, feed and/or fodder in varying combinations in the subsistence farming communities of sub-Saharan Africa and South Asia, mostly in dryland ecologies. *(Ten of the twelve crops involved in the CRP are the mandate crops of the CGIAR Centers addressing dry ecologies)*
- Retain all 12 proposed crops in the base budget scenario. For common bean, faba bean, finger millet and soybean use existing and new bilaterals toward operational research budget. Use W1-2 to contribute to strategic research where necessary to ensure strengthening of these bilaterals to CRP goals.
- Enhance the scope of research in an uplift budget scenario, with contributions from W1-2 to research operations of the four crops.
- Retain apparent modularity of the program flagships to facilitate donor-preferred W2 and W3/bilateral support
- Reduce the primary target countries for development to 15 from 17, with Nicaragua and Uzbekistan serving as research hubs due to the presence of multi-CRP activity.

Detailed justification for including common bean, faba bean, finger millet, groundnut and soybean are provided under the section on 'Other Annexes'.